



Revista de Tecnología de
Información y Comunicación en Educación

Online ISSN: 2665-0223

Print ISSN: 1856-7576



Volumen 20, No. 2.
Abril - junio 2026

Universidad de Carabobo
Facultad de Ciencias de la Educación



UNIVERSIDAD DE CARABOBO

Rectora

Jessy Divo de Romero

Vicerrector Académico

Ulises Rojas

Vicerrector Administrativo

José Ángel Ferreira

Secretario

Pablo Aure

Facultad de Ciencias de la Educación

Decana

Ginoid Sánchez de Franco

Director Escuela de Educación

María Auxiliadora González

Dirección de Docencia y Desarrollo Curricular

María Cristina Arcila

Dirección de Investigación y Producción Intelectual

José Álvarez

Dirección de Asuntos Profesorales

Zoraida Villegas

Dirección de Estudios para Graduados

Flor Morales

Dirección de Administración

José Gregario López

Directora-Editora de la Revista Eduweb

Elsy Medina

Consejo de Desarrollo Científico y Humanístico

Vicerrector Académico Presidente

Ulises Rojas

Director Ejecutivo

Aaron Muñoz

Depósito legal: pp200702CA2520

ISSN: 1856-7576

© 2007, Eduweb

Código Revencyt: RVE022

Registrada en el Catálogo Latindex con el número de folio 19424

Directora General/Editora Jefe

Dra. Elsy Medina

Facultad de Ciencias de la Educación, Universidad de Carabobo

Fundadores

Dr. Honmy Rosario

Facultad de Ciencias de la Educación, Universidad de Carabobo

Prof. Jesús A. Zambrano R.

Facultad de Ciencias de la Educación, Universidad de Carabobo

Consejo Editorial

Katiuska Peña

Universidad Nacional Experimental Francisco de Miranda

Ruth Díaz Bello

Universidad Central de Venezuela

Laybet Colmenares

Universidad de Carabobo

Asistente Editorial

Madelen Piña

Universidad de Carabobo

Magaly Briceño

Universidad Experimental Simón Rodríguez

Comité asesor honorario internacional

Dr. Julio Cabero Almenara

Universidad de Sevilla, España

Dra. Verónica Marín.

Universidad de Córdoba, España.

Dr. Francisco Martínez

Universidad de Murcia, España

Dr. Julio Barroso

Universidad de Sevilla, España

Dr. Álvaro Galvis Panqueva

Universidad de los Andes, Colombia

Dr. Jesús Salinas

Universidad de las Islas Baleares, España

Dra. María del Carmen Llorente

Universidad de Sevilla, España

Dr. Yaroslav Tsekhmister.

National Academy of Pedagogical Sciences of Ukraine,
Ukraine.

Asesor legal: Dra. Aura Piña R.

Traductor y redacción en inglés

Juan Carlos Briceño

Universidad de Carabobo, Venezuela.

Melba Noguera

Universidad de Carabobo, Venezuela

Autoedición versión digital

Francisco Antonio Ponte-Rodríguez

Universidad de Carabobo, Venezuela

Comisión de Arbitraje

Hyxia Villegas

Universidad de Carabobo

Freddy Jara

Universidad de Carabobo

Xavier Vargas

Universidad de Carabobo

Juan Manzano

Universidad de Carabobo

Raymond Marquina

Universidad de los Andes

Adelfa Hernández

Universidad Central de Venezuela

Salomón Rivero

Universidad Nacional Experimental Francisco de Miranda

Traductor y redacción en inglés:

Juan Carlos Briceño y Melba Noguera

Universidad de Carabobo

Autoedición versión digital

Francisco Antonio Ponte-Rodríguez

Universidad de Carabobo

Dirección de la Revista: Apartado de Correo 3812, Oficina de correos Trigal Sur, Valencia, Edo. Carabobo. Venezuela.

Revista Eduweb Online ISSN: 2665-0223. Print ISSN: 1856-7576. Editora: Elsy Medina. Editorial contacto: Email: revista.eduweb@uc.edu.ve; editoreseduweb@gmail.com - editada por la Universidad de Carabobo en Venezuela, bajo los términos de la licencia Creative Commons CC-BY 4.0.

La revista Eduweb es una publicación trimestral editada por la Universidad de Carabobo. Es una publicación de ámbito nacional e internacional indizada en el índice de Revistas Venezolanas de Ciencia y Tecnología REVENCYT, en el Catálogo LATINDEX, Actualidad Iberoamericana, Dialnet, Red Iberoamericana de Innovación y Conocimiento Científico REDIB, y en Emerging Sources Citation Index.



Los contenidos de los trabajos publicados en la revista son de entera responsabilidad de los autores.

Versión electrónica de la Revista:

<http://revistaeduweb.org>

Esta edición se produce bajo el auspicio del Consejo de Desarrollo Científico y Humanístico y la Dirección de Postgrado de la Facultad de Ciencias de la Educación de la Universidad de Carabobo.

DE LOS FINES Y PROPÓSITOS DE EDUWEB, REVISTA DE TECNOLOGÍA DE INFORMACIÓN Y COMUNICACIÓN EN EDUCACIÓN

Eduweb, la revista de Tecnología de Información y Comunicación en Educación, es una publicación de carácter nacional e internacional de divulgación del conocimiento, del uso, aplicación y experiencias de las Tecnologías de la Información y Comunicación (TIC) en ambientes educativos. Con la revista se pretende divulgar las innovaciones que en materia de TIC están siendo implementadas y ensayadas en los diferentes niveles y modalidades del sistema educativo venezolano e iberoamericano. De igual manera contribuir a proyectar las experiencias de estudiantes de pre y postgrado, docentes, investigadores y especialistas en TIC en educación en la Universidad de Carabobo y en otras universidades de Venezuela y de otros países de Iberoamérica. Es una revista arbitrada e indexada adscrita al programa de la especialización en Tecnología de la Computación en Educación, de la Facultad de Ciencias de la Educación de la Universidad de Carabobo, registrada bajo el ISSN 1856-7576. Editada en formato impreso y digital.

Visión

Ser un espacio académico-científico de difusión y divulgación de las distintas tendencias del pensamiento universal ubicadas en el área de TIC en ambientes educativos, con altos niveles de calidad académica.

Misión

Promover y facilitar la difusión y divulgación de los productos de las investigaciones y experiencias de los docentes e investigadores de la Universidad de Carabobo y otras universidades del país y del mundo en el área de TIC en ambientes educativos; motivar la participación en redes comunes de información y publicación nacional e internacional; coordinar esfuerzos y velar por la calidad de las publicaciones a fin de procurar elevar el nivel académico del personal docente y de investigación mediante el desarrollo de trabajos de investigación como función esencial en su crecimiento académico.

Objetivos

Servir como órgano de divulgación de las TIC y su influencia en ambientes educativos. Estimular la producción intelectual no solo en los docentes e investigadores de la Universidad de Carabobo, sino también en otros centros de educación e investigación nacional e internacional.

Propiciar el intercambio cultural, académico, científico y tecnológico con otros centros de educación superior en Venezuela y el mundo.

Contenido

Editorial.....	7
La comunicación como herramienta gerencial en los programas educativos del sistema penitenciario venezolano.....	9
Tecnologías emergentes y transformación del discurso gerencial: una visión fenomenológica en organizaciones educativas.....	22
Educación en ingeniería para un futuro más verde: Una revisión de los currículos, las competencias y la pedagogía en la era de la Industria 5.0.....	34
Eficacia del modelo integrado de desarrollo de habilidades de investigación (IRSDM) en la educación superior: un estudio cuasiexperimental en Ucrania	53
Desarrollo de la competencia digital de los futuros profesionales: condiciones psicológicas y pedagógicas en un panorama educativo en rápida transformación	70
Herramientas digitales en la enseñanza de lenguas extranjeras: oportunidades y desafíos	91
Aprendizaje combinado y competencia profesional en la educación superior	104
Eficacia de los entornos de aprendizaje basados en la nube en la formación de futuros especialistas: Un estudio cuasiexperimental.....	119
El entretenimiento educativo como herramienta para desarrollar la competencia profesional en estudiantes de educación superior.....	137
Desarrollando la preparación para el uso de tecnología SMART en futuros profesionales: un enfoque cuasiexperimental	157
Fomentar una identidad investigadora en la formación de futuros docentes en el Reino Unido.....	176
Mejorar la educación en derecho penal, procesal y forense mediante las TIC y la integración de la práctica del CEDH.....	189
Enfoques innovadores potenciados por la tecnología digital en la formación de futuros profesores de lenguas extranjeras.....	208
Innovación pedagógica en la formación de profesores de ciencias: Integrando FizziQ para desarrollar TPACK-21 ...	229
Entornos de aprendizaje inmersivos: Realidad virtual para el desarrollo de habilidades de toma de decisiones en ocupaciones de alto estrés.....	253
Recursos virtuales inteligentes como medio para que los estudiantes de primaria estudien campos educativos.....	272
Sistemas adaptativos basados en Inteligencia Artificial y aprendizaje personalizado: El rol moderador de la IA en la interacción estudiantil universitaria	288
La gamificación como herramienta para aumentar la motivación de los estudiantes en un entorno educativo digital.....	308
Desarrollo de competencias innovadoras entre futuros especialistas en cultura física y deportes a través de la formación digital y orientada a STEAM	322
Prácticas de aprendizaje digital y competencias de investigación: El impacto de las herramientas colaborativas y el Feedback en la educación superior.....	339
Integración de las TIC en la enseñanza de las disciplinas de comunicación social: enfoques pedagógicos y metodológicos	358
El papel de las tecnologías digitales en el avance de la calidad educativa para estudiantes con necesidades educativas especiales: un análisis de la educación superior	378
Fomento de la inclusión vía EdTech: Desarrollo de competencias en futuros docentes mediante laboratorios virtuales, hackatones y tecnologías inmersivas.....	397
Integración de la tecnología digital para el desarrollo de la alfabetización profesional entre los estudiantes de educación superior.....	414
Formación digital para futuros profesionales del derecho en comercio exterior de productos agrícolas: UE y Ucrania.....	434
Tecnologías digitales y formación docente para la educación inclusiva	448

Editorial

Elsy Medina¹

Afiliación autor:

¹ Universidad de Carabobo, Venezuela.
emedina@uc.edu.ve

Cómo citar:

Medina, E. (2026). Editorial. *Revista Eduweb*, 20(2), 7-8.
<https://doi.org/10.46502/issn.1856-7576/2026.20.02.0>

El segundo trimestre de 2026 nos encuentra en un momento decisivo para la educación superior. Si en los primeros meses del año reflexionábamos sobre la aceleración tecnológica y la inteligencia artificial como fuerzas que reconfiguran la experiencia universitaria, hoy constatamos que esa transformación se ha vuelto más visible, más urgente y, sobre todo, más compleja. La educación dialoga con la tecnología, convive con ella, la incorpora, la cuestiona y la resignifica en cada práctica pedagógica, en cada investigación y en cada interacción académica.

Durante abril, mayo y junio, la conversación global sobre educación ha estado marcada por tres fenómenos que atraviesan nuestras instituciones con una intensidad inédita: la expansión de la IA generativa en los procesos de evaluación, la consolidación de ecosistemas híbridos de aprendizaje, y la necesidad impostergable de fortalecer la alfabetización digital crítica en un entorno saturado de información automatizada. Estos temas no son episodios aislados; constituyen el tejido mismo de la educación contemporánea y exigen una reflexión profunda sobre el rumbo que estamos tomando.

La presencia de herramientas capaces de producir textos, resolver problemas complejos o simular razonamientos ha reabierto un debate esencial: ¿Qué significa evaluar en tiempos de inteligencia artificial? Cada vez más docentes se enfrentan al desafío de distinguir entre la respuesta correcta y la comprensión genuina, entre la producción automatizada y la construcción auténtica del conocimiento. La evaluación, entendida como un acto formativo, se desplaza hacia lo interpretativo, lo reflexivo, lo que no puede ser reducido a un algoritmo. Este debate redefine la ética académica, la autoría intelectual y la responsabilidad formativa de nuestras instituciones.

En paralelo, los ecosistemas híbridos de aprendizaje se consolidan como el nuevo estándar de la educación superior. La universidad contemporánea, ese “ecosistema híbrido donde convergen plataformas, algoritmos, entornos virtuales y lenguajes multimodales”, como señalamos en el editorial anterior, se expande ahora hacia experiencias inmersivas, laboratorios remotos, simuladores educativos y aulas aumentadas. La pregunta ya no es si debemos integrar tecnología, sino cómo hacerlo con sentido pedagógico y visión humanista. La tecnología, por sí sola, no garantiza aprendizaje; es la mediación pedagógica la que convierte la herramienta en una experiencia significativa.

A esta transformación se suma un desafío que cada día es más urgente: la alfabetización digital crítica. La proliferación de contenidos generados por IA, la dificultad para distinguir fuentes confiables y la velocidad a la que circula la desinformación exigen nuevas competencias para estudiantes y docentes. No basta con saber usar herramientas digitales; es necesario



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



comprender sus lógicas, sesgos, límites e implicaciones éticas. La educación, en este contexto, se convierte en un acto de lucidez colectiva, en un ejercicio de discernimiento que protege la integridad del conocimiento y la autonomía del pensamiento.

Los artículos reunidos en este número abordan estas problemáticas desde diversas perspectivas: investigaciones sobre evaluación auténtica en tiempos de IA, estudios sobre aprendizaje inmersivo, análisis de políticas digitales, experiencias de innovación pedagógica y reflexiones éticas sobre el uso responsable de tecnologías emergentes. Cada contribución amplía el mosaico de la transformación educativa contemporánea y ofrece claves para comprender un presente que se mueve con rapidez, pero que exige profundidad.

Invitamos a nuestros lectores a recorrer estas páginas con una mirada abierta y reflexiva, como quien se adentra en un territorio donde la palabra revela, sugiere y convoca. Leer con atención, como quien escucha un diálogo silencioso entre la investigación y la experiencia. Permitan que estas investigaciones acompañen su quehacer profesional, despierten nuevas preguntas y abran horizontes allí donde otros solo ven herramientas.

Este segundo número de 2026 aspira a convertirse en un espacio para pensar la educación en diálogo con la tecnología, pero también para recordar que, aun en medio de algoritmos y plataformas, la formación sigue siendo un proyecto profundamente humano. La tecnología amplía nuestras capacidades; la educación, en cambio, nos recuerda quiénes queremos ser. En ese desafío, entre lo que podemos hacer y lo que debemos hacer, se juega el futuro de nuestras instituciones y la misión ética de la universidad.

La invitación es precisa: habitar críticamente este tiempo, construir conocimiento con responsabilidad y permitir que la educación, en su encuentro con la inteligencia artificial, siga siendo una aventura intelectual capaz de renovar nuestra manera de comprender el mundo.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

La comunicación como herramienta gerencial en los programas educativos del sistema penitenciario venezolano

Communication as a management tool in educational programs of the Venezuelan prison system

Joan Carlos Carmona Orozco¹  Tito Alejandro Sánchez Jurado²  Einys Nathaly Fernández Valera³ 

Afiliación autor:

¹ Docente, Universidad de Carabobo, Valencia, Venezuela.

jcarmona@uc.edu.ve

² Docente, Universidad de Carabobo, Valencia, Venezuela.

titoalejandrosanchez@gmail.com

³ Docente, Universidad de Carabobo, Valencia, Venezuela.

enfernandez@uc.edu.ve

Recibido: 15/09/25

Aceptado: 01/03/26

Cómo citar:

Carmona Orozco, J.C., Sánchez Jurado, T.A., & Fernández Valera, E.N. (2026). La comunicación como herramienta gerencial en los programas educativos del sistema penitenciario venezolano. *Revista Eduweb*, 20(2), 9-21. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.1>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

Esta investigación analiza la comunicación como una herramienta gerencial estratégica dentro de los programas educativos del sistema penitenciario venezolano. Bajo una visión humanista alineada con la Agenda 2030 de la ONU, el estudio cuestiona las praxis carcelarias actuales y propone un modelo de gestión educativa inclusiva y equitativa. El hallazgo principal destaca que la comunicación no debe ser solo un canal informativo, sino un eje transformador de conductas disruptivas. Se presenta una construcción epistémica centrada en el uso del error como un principio filosófico de la ética, el cual, apoyado en el uso apropiado de las Tecnologías de la Información y Comunicación (TIC), permite transitar desde el castigo hacia la formación de un nuevo hombre. Este enfoque gerencial busca equilibrar la gerencia educativa con la promoción de oportunidades reales de reinserción para los privados de libertad.

Palabras clave: Comunicación, educación, gerencia, sistema penitenciario.

Abstract

This research analyzes communication as a strategic managerial tool within the educational programs of the Venezuelan penitentiary system. Grounded in a humanistic vision aligned with the UN 2030 Agenda, the study questions current prison praxis and proposes an inclusive and equitable educational management model. The main finding highlights that communication should not be merely an information channel, but a transformative axis for disruptive behaviors. An epistemic construction is presented, centered on the use of error as a philosophical principle of ethics which, supported by the appropriate use of Information and Communication Technologies (ICT), enables a transition from punishment toward the formation of a new man. This managerial approach seeks to balance educational management with the promotion of real reintegration opportunities for incarcerated individuals.

Keywords: Communication, education, management, penitentiary system.

Introducción

En todo entorno social, existen instituciones penitenciarias que tiene la visión y misión de juzgar y sancionar a quienes presentan conductas disruptivas. Estas instituciones pueden ser entendidas como un sistema social de autoridad, donde las personas que ejercen el poder implementan diversos programas o estrategias educativas, a fin de corregir o transformar anti-valores en actitudes basadas en la responsabilidad y la honestidad.

Al respecto, el Código de Ética para La Vida del Ministerio del Poder Popular para Ciencia, Tecnología e Industria Intermedias (2011) sostiene que *“Estas obligaciones se centran en la responsabilidad, de todas las instituciones, los colectivos e individuos, de procurar un desarrollo sustentable en la dimensión ambiental, cultural, social y política”* (p.13). En este sentido, se interpreta que todas las instituciones con fines educativos, públicas o privadas, tienen la corresponsabilidad de diseñar y ejecutar programas de intervención para formar ciudadanos íntegros, capaces de actuar con respecto, empatía, y tolerancia, entre otros.

Sin embargo, para lograr esta formación es indispensable un factor clave que suele omitirse o aplicarse de forma deficiente en los modelos de gestión tradicionales: la comunicación bidireccional. En este orden de ideas, cuando el sistema gerencial actual se limita a una transmisión de órdenes unidireccional, ignora el diálogo como herramienta de entendimiento mutuo, esta desconexión impide que los actores penitenciarios se comprendan realmente, lo que genera un vacío en la resolución de conflictos. En consecuencia, es precisamente en esta carencia de comunicación fluida donde surgen las fricciones que derivan en el error o en fallas punibles, cometidas tanto por los privados de libertad como por las deficiencias operativas del propio sistema carcelario.

En este orden de ideas, la comunicación es uno de los puntos clave que debe consolidarse como un eje central de la gerencia educativa en los sistemas penitenciarios, mediante ella es posible desarrollar competencias comunicacionales-socioeducativas a fin de promover ambientes morales y acuerdos de convivencia, facilitando una transformación real del privado de libertad para su reinserción social. Sin embargo, es importante clarificar que para este proceso se requiere, de forma transversal, conocer profundamente las necesidades del interno, así como su dinámica de organización tanto con sus pares como con las figuras de autoridad.

En este sentido, la reinserción social de los privados de libertad se convierte en un desafío prioritario, pero, para esto es pertinente reflexionar en los programas educativos existentes donde los mismos transiten en una formación humanista y transformadora, alineada con los Objetivos para el Desarrollo Sostenible 2030 y con garantía de una gerencia que priorice la comunicación como puente humano.

En virtud de lo anterior, el presente análisis ofrece una interpretación reflexiva sobre *la educación moral, la comunicación como herramienta gerencial y la educación inclusiva en el sistema penitenciario venezolano de acuerdo con la Agenda 2030*, esto se logró a través de una revisión documental y una triangulación hermenéutica, donde las reflexiones epistémicas buscan aportar soluciones orientadas a la transformación del sistema.

Referentes Teóricos

Antecedentes

Sobre las cárceles se ha venido desplegando estudios que hacen énfasis en su contexto punitivo y su relación con la educación y sus implicaciones sociales. En estos aspectos referenciales serán importante en el presente ensayo investigativo y así de esta forma se presentan los siguientes:

Nardon et al. (2025) en su investigación titulada *La Educación en el Sistema Penitenciario Brasileño*,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Reveló que el nivel educativo de las personas en prisión es muy bajo, y muchas carecen de la oportunidad de completar la educación básica o aprender a leer y escribir. En consecuencia, sus posibilidades de encontrar empleo tras cumplir la condena son escasas, debido a sus antecedentes penales y a la falta de formación profesional. (p. 21).

El aporte de esta investigación afirma la importancia de priorizar en el estado venezolano mecanismos gerenciales que permitan al privado de libertad capacitarse para elevar el nivel educativo a través de programas de formación que eleven no solamente su dignidad sino la oportunidad de subsistir de una mejor manera en la sociedad. La idea es que a través de estos programas educativos se puedan proporcionar habilidades básicas tales como: la escritura, lectura, comunicación, pensamiento crítico, solución de problemas, y cultura general que les ayude a adquirir conocimientos y así consolidar empleos estables para la vida.

Thayla F. Souza e Silva. (2017) en su trabajo titulado: Sistema Penitenciario Y Educación: Una Narrativa Sobre Contexto Penitenciario, Persona Privada De Libertad Y Formación Del Educador, concluyó que,

La educación en el sistema penitenciario enfrenta numerosos desafíos. En primer lugar, existe hacinamiento en las unidades penitenciarias, que precariamente alojan a los reclusos en celdas disponibles, o mejor dicho, no disponibles, ya que apenas caben sus colchones. Por otro lado, la misma unidad enfrenta el reto de implementar una escuela dentro de la misma, con falta de espacio físico y recursos materiales para la construcción de aulas, incluyendo fondos públicos para este fin. Existe escasez de profesionales, tanto docentes como agentes de seguridad que vigilen y protejan a los reclusos, así como la seguridad del propio educador. (p. 108).

El aporte de esta investigación invita a proponer procesos gerenciales tales como la planificación, organización, control y evaluación que garanticen: 1) el buen funcionamiento administrativo. 2) la educada distribución de la infraestructura que permita clasificación del privado de libertad, 3) la mejora de sus condiciones a través de la distribución correcta de los recursos humanos, económicos, entre otros. 4) También aporta un sentido sublime educacional como es la creación de escuelas y propuesta de docentes en consonancia con la transformación del contexto carcelario que además permita la armonía con situaciones de carácter punitivo.

La educación moral en el sistema penitenciario venezolano

Durante el siglo XVIII los delitos cometidos en la sociedad europea condujeron al surgimiento del paradigma o cultura de la cárcel actual, en ese tiempo los suplicios aplicados a los cuerpos de los condenados eran en público, severos en proporción a la infracción y dictados por las leyes; estas formas correctivas tenían la intención de que los ciudadanos tomaran una elección racional para cometer o no delitos; por consiguiente, la idea principal para del sistema penitenciario era el castigo.

Al respecto, Foucault (2009) señala “el castigo ha pasado de un arte de las sensaciones insoportables a una economía de los derechos suspendidos” (p. 20), es decir, se ha afianzado un proceso evolutivo más humanista, el cual se ha basado en el poder a través del castigo y el sometimiento, aunque estos están centrados en el control sobre el privado de libertad, se busca que éste reconozca la superioridad de los operadores penitenciarios, también conocidos como funcionarios administrativos y de seguridad. Estos últimos, igualmente están

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

subordinados a las exigencias de la organización penitenciaria y construyen de manera reproductora el poder organizacional de la misma.

En el mismo orden de ideas, se sostiene que todo proceso educativo dentro de las prisiones se desarrollan desde el uso del poder de quienes ejercen la autoridad gerencial, lo cual lo hacen con la intencionalidad de transformar y reinsertar en la sociedad a un nuevo ser humano, es decir, las relaciones de poder dentro de la educación penitenciaria se manifiestan desde el mando comunicacional que ejerce el *“docente sobre los reos, siempre éstos le reconocen como autoridad dentro y fuera del aula, en los pasillos, desde la celda, en el comedor, oficinas judiciales y cualquier espacio del recinto penitenciario”* (Carmona, 2023, p. 53).

Ahora bien, cabe destacar que en el sistema penitenciario la educación representa un modelo de poder que se ejerce sobre los privados de libertad, sin embargo, una realidad presente es que los internos no comprenden la importancia de la formación integral con un carácter transformador, sino que por el contrario buscan recibir a través de la educación un beneficio judicial para obtener la libertad.

En consecuencia, a lo antes dicho, se infiere que con la autoridad mal concebida dentro del contexto educativo penitenciario, el estudiante privado de libertad manifiesta una aptitud de obstinación, ya que no le da sentido a la visión que debería tener frente su formador: su poder de vivir, de conocer, de construir y reconstruir, de amar, y ser mejor persona.

A lo antes dicho, esta obstinación entenderse, desde la pedagogía social, no como una falta de capacidad, sino como un error conductual derivado de una socialización deficiente. Al respecto, Quintana Cabañas (1997) sostiene que *“la educación social debe enfocarse en corregir estas desviaciones mediante la madurez moral, permitiendo que el individuo reconozca el error no como un fracaso, sino como una desadaptación que puede ser reeducada”* (p. 142).

Asimismo, desde la psicología forense, el tratamiento de este error en el entorno carcelario requiere un enfoque en la competencia social, tal como lo señala Garrido Genovés (2005) *“la intervención debe ir más allá del castigo, buscando que el interno desarrolle habilidades del pensamiento prosocial que le permitan evaluar las consecuencias de sus actos y rectificar su conducta frente a la sociedad”* (p. 88).

Sin embargo, el docente ante esta aptitud del interno debe mantener la perspectiva de la educación moral que explica Durkheim (2013), este afirma que:

La autoridad moral es la cualidad principal del educador porque es a través de la autoridad que simboliza que el deber es el deber. Lo que tiene de puramente el sui generis, es el tono imperativo con el cual habla a las conciencias, el respeto que inspira a las voluntades y que las hace someterse en cuanto se ha pronunciado. Ni que decir tiene que la autoridad vista bajo ese prisma no tiene nada de violento ni de represivo. (p.70)

En este sentido, esto distingue que la autoridad proviene del amor que debe tener el educador hacia el ejercicio de sus responsabilidades dentro del marco del deber ser, y no bajo el esquema del no sometimiento o de la opresión que debe ejercer sobre el privado de libertad.

En definitiva, la educación penitenciaria ha de convertirse en un modelo inclusivo caracterizado con una facultad transformadora del ser humano, y no limitarse a la

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

transmisión de conocimientos; sino que por el contrario el accionar educativo debe fundarse desde las relaciones sociales de la fraternidad, sustentado desde los valores del amor y el respeto al otro, lo cual inclusive, permitirá que la autoridad desarrolle con propiedad la transmisión de saberes, esto se puede sustentar desde la comparación relacional que bosqueja Carmona (2023, p. 56) a través de la figura 1:

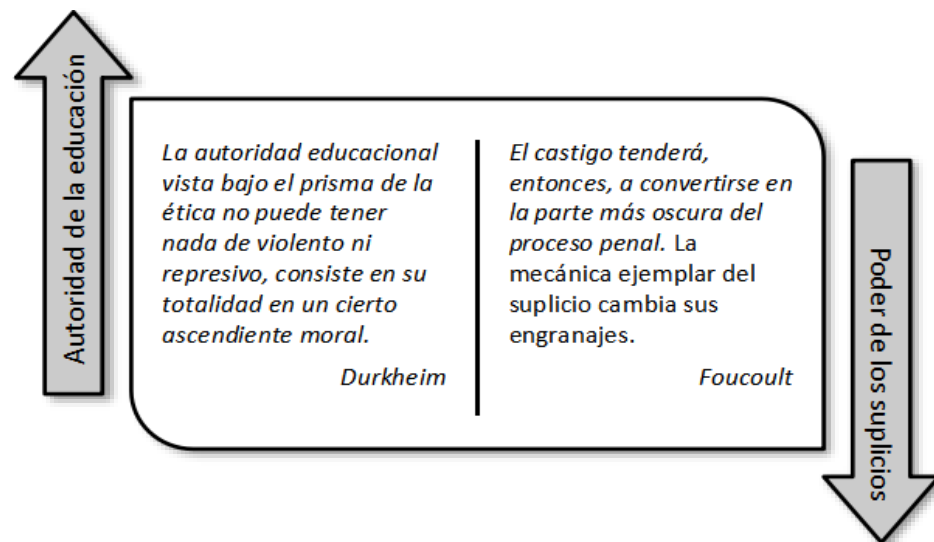


Figura 1. Autoridad Educativa en el Sistema Penitenciario.
Tomado de (Carmona, 2023, p. 56).

En virtud de todo lo anterior, la autoridad particular implica confianza e inclusión como columna vertebral de su estructura, fuera y dentro del quehacer educativo. Es la educación ética en su vertiente meramente social que se vincula primordialmente con el énfasis de la integración y reinserción del privado de libertad en la familia, comunidad, nación o sociedad, entendiéndose como el propósito de la racionalización de la moral ante los dinanismos sociales del contexto de encierro.

Para Durkheim (2013), actuar conforme a unas normas morales emanadas y creadas por la propia sociedad y al obedecer estas normas sociales, es que el privado de libertad no disipa su libertad, sino que la cumple, ya que la integración de este sujeto en la sociedad, le va a permitir realizarse como persona íntegra. No obstante, no basta que el sujeto privado de libertad tenga un espíritu de disciplina y se integre a la sociedad, sino que es necesario además una correcta autonomía de la voluntad, pues su grado de libertad no es más que el alcanzar su propio conocimiento, por lo que la autonomía moral es la comprensión de esos valores éticos de la misma sociedad.

La comunicación como herramienta gerencial en el sistema penitenciario

Los procesos educativos dentro de los sistemas penitenciarios son espacios que han de fomentar la comunicación a fin de promover la transformación de conductas disruptivas de los privados de libertad. Esto implica, la educación en el sistema penitenciario demanda de una gerencia de procesos éticos, dinámicos, tecnológicos, que sean evaluados permanentemente y que sus estrategias sean sustentadas en la búsqueda, creación y obtención de información esencial a la naturaleza humana del contexto.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

En este sentido, la comunicación como herramienta gerencial educativa en el sistema educativo juega un papel importante ya que permite expresar ideas o pensamientos, emociones, no solo de los sujetos aprendices sino también del resto de personas que hacen vida en el sistema penitenciario. De esta manera, se podría gestionar en el marco del desarrollo sostenible, con visión humanista, una constante sincronía en la realización de planes, cambios y proyectos que se elaboren en equipo de trabajo, las cuales vayan dirigidas hacia la transformación de aquellas conductas disruptivas de los privados de libertad.

En la actualidad, los instrumentos más usados para establecer una comunicación entre los integrantes del equipo de trabajo penitenciario son: el internet, los correos electrónicos, telefonía, telefonía celular, mensaje de radio, cámaras, pero, siempre asegurando la supervisión estricta de los mismos, tratando evitar toda forma de imagen corruptora.

Al respecto, cabe señalar que desde año 2016 han implementado dentro de los sistemas carcelarios venezolanos el Sistema Tecnológico de Seguridad Penitenciaria (SITESEP) el cual busca supervisar y controlar las conductas disruptivas de los internos, además, con la implementación de este sistema, visto como una herramienta fundamental e innovadora de la gerencia, ha permitido desde los tiempos de post pandemia del Covid-19 mejorar la efectividad de las audiencias judiciales así como del desarrollo de actividades de atención integral tales como: educación, cultura, deporte y salud; todo lo descrito anteriormente ha sido en miras de incrementar la efectividad de la comunicación gerencial, incluso, los elementos de la justicia y de la pedagogía oportuna para la población privada de libertad.

No obstante, es importante señalar que la evolución tecnológica introducida en las comunicaciones del sistema penitenciario influye en el comportamiento de los privados de libertad en cuanto a sus sentimientos, creencias y pensamientos. En consecuencia, los instrumentos antes señalados son la aproximación del privado de libertad con el mundo, los cuales deben ser válidos y confiables para alcanzar progresos en pro del beneficio de la población vulnerable, ofreciendo la atención oportuna y respetando sus derechos humanos esenciales.

Desde esta perspectiva, es pertinente señalar lo expresado por Bertalanffy (1980) quien destaca que *"la cibernética es una teoría de los sistemas de control basada en la comunicación (transferencia de la información) entre el sistema y el medio circundante..., y en el control (retroalimentación) del funcionamiento del sistema"* (p.20), por ello, la gerencia educativa debe evaluar con retroalimentación estos instrumentos de comunicación y control usados dentro del sistema penitenciario, los cuales permiten integrar y dar coherencia a todos los procedimientos judiciales que regulan los comportamientos de los internos, e incluso, aquellos que están asociados a sus derechos y/o beneficios como privados de libertad.

Finalmente, se puede considerar que las comunicaciones a través de los medios tecnológicos ayudan en el desarrollo gerencial de los procesos de intercambio de la información y la concreción de las relaciones sociales y psicológicas propias de los entes penitenciarios. Esta acción permite que los conocimientos y descubrimientos sociales de penitenciaría puedan ser aplicados a otros contextos carcelarios. Además, a través de ellos se construye una ciencia interdisciplinaria que ofrece sistemas de organización y procesamiento del conocimiento científico.

Así mismo, para mantener la comunicación en el contexto de encierro, generalmente se crean grupos donde el fin común sea la ejecución de las

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

planificaciones que se tienen estipuladas. Esto permite que si hay algo que se deba atender en un momento determinado se le da la debida atención, esto significa una comunicación eficaz para generar la resolución de problemas de forma inmediata y no crear nuevas complicaciones.

En este punto, es crucial entender que la corrección de conductas no debe abordarse como un simple error de procedimiento técnico, sino como un proceso de readaptación social. Desde la pedagogía social, Pérez Serrano (2003) sostiene que “el error conductual en contextos de exclusión es una manifestación de carencias en la socialización primaria, por lo cual la comunicación gerencial debe servir como un andamiaje para que el sujeto reconstruya su escala de valores” (p. 122).

Bajo esta misma línea, la psicología forense aporta que la modificación del comportamiento disruptivo depende de la gestión de la distorsión cognitiva. Según Redondo Illescas (2007):

El error en la conducta delictiva suele estar respaldado por pensamientos justificativos; por tanto, una comunicación eficaz y afable desde la gerencia permite que el interno identifique estas fallas en su razonamiento y desarrolle un pensamiento prosocial que facilite su mejora y reinserción, (p. 54).

De este modo, la corrección inmediata y empática evita que el error se cristalice como un patrón de conducta permanente. Por lo general, la comunicación se provee de forma espontánea en el equipo de trabajo penitenciario, sobre todo, si hay algo que informar o transmitir se utilizan los medios pertinentes y actuales para que la información oportuna llegue de manera inmediata, permitiendo abordar de la mejor forma las distintas situaciones en los momentos precisos y crear cambios significativos en el conjunto de planes y planificaciones, si así lo requiere.

La educación inclusiva en el sistema penitenciario de acuerdo con la Agenda 2030

La educación inclusiva sugiere la idea de desarrollar seres competentes para desenvolverse de forma autónoma, participativa y democrática dentro de una nación al margen de las disparidades educacionales, especialmente en la formación de personas vulnerables como los privados de libertad. En este sentido, apropiarse de la vulnerabilidad de estos apunta, en consonancia con los avances de la época, a nuevos criterios de comprensión de las conductas de las personas que entran en conflicto con las normas sociales, tal como lo es la naturaleza de su fragilidad y sus principales condicionamientos. Sin duda, la intervención educacional es necesaria para transformar al ser humano, ella sirve de medio para la formación de un hombre o mujer nuevo (a), después de todo “*sólo la educación puede servir de instrumento penitenciario*” (Foucault, 2009, p. 314).

Aunado a esto, la Agenda 2030 a través de sus objetivos para el Desarrollo Sostenible, específicamente el número cuatro, propone una educación inclusiva, participativa y equitativa de calidad, donde todas las personas tengan acceso a las diferentes promociones de oportunidades, incluso, se puede indicar que los mismos viabilizan la idea de una nueva visión de actividades humanistas con carácter protagónico de los sujetos, donde a paso firme pueden ser capaces de condicionar otro “statu qua” institucional eficaz en el sistema penitenciario. Para ello, sería necesario crear, fomentar y desarrollar instituciones penitenciarias solidarias con un voluntariado profesional los cuales tengan una formación moral, que en cierto modo aparezca como un contrapoder de las tendencias prisionizantes.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Sin embargo, es razonable recapacitar sobre la educación inclusiva y entender que no se trata de un “contrapoder educativo” radicalmente enfrentado al régimen penitenciario; sino de un proceso reflexivo que impulse un ambiente orientado a la reinserción, que facilite aceptar una convivencia sana basada en valores y el respeto a los derechos humanos, promoviendo una cultura de paz frente a la violencia.

En este marco se plantean dos aspectos: en primera instancia, la educación inclusiva debe promover vínculos que fortalezcan una identidad ética reflexiva donde el privado de libertad logre tomar conciencia de sus actos. La idea es mitigar el efecto deteriorante de la cárcel para desarrollar una personalidad acorde a la moral ciudadana.

Para que esta transición sea efectiva, es necesario abordar lo que la psicología forense denomina el error cognitivo-conductual, según Garrido Genovés (2005), “la educación en el entorno penitenciario debe enfocarse en la modificación de los esquemas de pensamiento que justifican la transgresión, sustituyendo el error de conducta por habilidades de competencia social que permitan al individuo autorregularse de manera prosocial” (p. 112).

Al respecto, cabe mencionar la Agenda 2030 para el Desarrollo Sostenible, la cual establece una visión transformadora hacia la sostenibilidad social, minimizando el efecto de la prisionización hasta llegar a una concepción humanizada del privado de libertad. En segundo lugar, debe tenerse en cuenta que estos lineamientos requieren de docentes con una profunda sensibilidad social y formación técnica. Desde la pedagogía social, se entiende que el error no es una falla permanente, sino una oportunidad de aprendizaje mediada por el educador. Como afirma Pérez Serrano (2003) “el profesional debe actuar como un agente de cambio que utiliza la comunicación y la ética para resocializar a quienes han vulnerado la norma, transformando el conflicto en una nueva narrativa de vida” (p. 145).

Finalmente, para lograr este fin es indispensable que el personal penitenciario sea profesional, con una moral sólida y adaptado a la era de la información. Deben poseer un nivel educativo suficiente y dominar los medios tecnológicos para desempeñar sus funciones de manera óptima, garantizando la dignidad humana y prohibiendo castigos inhumanos o humillantes, los cuales son contrarios a una educación inclusiva sostenida desde la valoración del ser humano para el Desarrollo Sostenible de la Agenda 2030.

Metodología

La investigación es un proceso que requiere de determinados pasos o etapas, no sólo para comprender una realidad o un fenómeno descrito como situación problemática, sino también para aportar a la ciencia un conocimiento verificable. Al respecto, cabe citar a Bunge (2007) quien sostiene:

Mientras, los animales inferiores sólo están en el mundo, el hombre trata de entenderlo; y, sobre la base de su inteligencia imperfecta pero perfectible del mundo, el hombre intenta enseñorearse de él para hacerlo más confortable. En este proceso, construye un mundo artificial: ese creciente cuerpo de ideas llamado “ciencia”, que puede caracterizarse como conocimiento racional, sistemático, exacto, verificable y por consiguiente falible. Por medio de la investigación científica, el hombre ha alcanzado una reconstrucción conceptual del mundo que es cada vez más amplia, profunda y exacta. (p. 9)

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Por consiguiente, el presente escrito se sustenta desde un marco metódico de una revisión documental el cual se basó en la búsqueda y selección de documentos que permitieron acercarse a la desconstrucción del todo del tema a investigar, considerando previamente las palabras claves y sin dejar en el olvido el propósito del estudio; seguidamente, se procedió a la organización y análisis hermenéutico de la información, para de ahí realizar las debidas derivaciones o conclusiones finales.

Las etapas de la metódica consiste en la recolección de información mediante la revisión de diferentes fuentes documentales electrónicas y físicas, luego se clasificó según el propósito del estudio, se extrajo, clasificó y sistematizó la información, posteriormente, se hizo una lectura y relectura de extractos que fueron categóricos para comprender la situación planteada para así proceder a la descripción e interpretación de las unidades temáticas, y por ende, lograr hacer un aporte significativo mediante las conclusiones o reflexiones finales.

Por otra parte, el análisis interpretativo se orientó desde el enfoque hermenéutico de la Teoría Fundamentada (TF), al respecto Schettii & Cortazo (2015) señalan que la TF es "una estrategia metodológica que tiene como propósito generar teoría" (p. 35). Incluso,

Obtención de las notas de campo que se denominan *memos*. Pueden ser producto de observaciones, sus comentarios interpretativos, las entrevistas realizadas, a partir de las cuales comienza la tarea de *codificación y categorización* de la información; el *muestreo teórico* y, finalmente, la *comparación constante* hasta llegar a la *saturación*, que indica que no hay más información a codificar. (Schettii & Cortazo, 2015, p. 34)

Ahora bien, la estrategia metodológica se sustentó desde la revisión documental mediante las lecturas y relectura a fin de extraer datos significativos los cuales seguidamente fueron categorizados y comparados constantemente, este proceso de triangulación de las revisiones documentales con las visiones epistémicas de los investigadores.

En este sentido, se consideró describir y comprender los ejes temáticos que se circunscriben en las palabras clave previamente mencionadas, y en relación de las mismas se dedujeron diversas inferencias lo cual permitió tener un acercamiento reflexivo-analítico sobre la comunicación como herramienta gerencial para la construcción de programas educativos en el sistema penitenciario venezolano desde una educación inclusiva y promoción de oportunidades para los privados de libertad.

Todo lo anterior se pueden fundamentar desde la visión de Bisquerra (1989) quien expresa que el método:

Es el "camino para llegar a un fin". Los métodos de investigación constituyen el camino para llegar al conocimiento científico; son un procedimiento o conjunto de procedimientos que sirven de instrumento para alcanzar los fines de la investigación. Los distintos métodos de investigación son aproximaciones para la recogida y el análisis de datos que conducirán a unas conclusiones, de las cuales podrán derivarse unas decisiones o implicaciones para la práctica. (p. 55)

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Por consiguiente, el método se hace pertinente de todo proceso investigación para acercarse a la realidad y por ende la comprensión del problema, el cual permitirá hacer las debidas reflexiones finales.

Resultados y discusión

El propósito del estudio de circunscribe en un análisis sobre la comunicación como herramienta gerencial en los programas educativos del sistema penitenciario venezolano, esto se ha hecho mediante la descripción y comprensión de las partes temáticas indagadas a través de la revisión documental, permitiendo hacer las debidas comparaciones a la luz teórica y desde la visión epistémica de los investigadores.

En este sentido, es pertinente hacer referencia a la figura 2, donde se muestra un registro ideográfico del tema en disertación, siendo la misma una producción intelectual de los autores en atención a la saturación de la información recolectada.



Figura 2. Registro ideográfico del tema en estudio.
Elaboración propia.

Se tiene la exégesis de que la educación es el principal factor clave para la transformación de una sociedad y por ende la formación de un hombre nuevo, el cual tenga no solo las habilidades y destrezas motrices para desempeñar alguna actividad, sino también las competencias lingüísticas y cognitivas para interrelacionarse con los demás.

Ahora bien, cuando se hace referencia a las competencias lingüística se debe abordar un factor clave el cual es la comunicación, este debe ser uno de los ejes transversales que debe fortalecerse en toda relación humana desde los espacios de la educación, esto implica y trasciende a la gerencia, entendida esta última como el modo o la forma en que se dirige una organización, grupo o sistema. En este orden de ideas, la gerencia educativa es el proceso mediante el cual se dirige a los sujetos partícipes del mismo, e incluso, esto implica la planificación, desarrollo y evaluación de programas educativos que vayan en pro de fortalecer la comunicación y la transformación de un hombre nuevo.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Bajo esta perspectiva, la efectividad de la gerencia educativa en entornos complejos depende de la optimización de los flujos informacionales. En el contexto venezolano, el Sistema de Tecnología de Seguridad Penitenciaria (SITESEP), aunque avanzado en vigilancia, presenta limitaciones en la bidireccionalidad de la información pedagógica. La comunicación gerencial estratégica resuelve estas carencias al transitar de un modelo puramente vertical a uno de red, además, al dinamizar los flujos ascendentes y transversales, la gerencia permite que la data recolectada por el SITESEP no sea solo punitiva, sino insumo para la toma de decisiones curriculares adaptadas a la realidad del interno.

En correspondencia con lo anterior, los sistemas penitenciarios, vistos como organizaciones gerenciales que buscan la transformación del privado de libertad, no escapan de la visión humanista que caracteriza a la educación, asimismo, ellos cuentan una gerencia educativa dentro de su organigrama de atención integral (DGA) los cuales han tenido que enfrentar grandes desafíos como lidiar con las conductas disruptivas de los privados de libertad.

Sin embargo, más allá de estas conductas disruptivas la intencionalidad ha de dirigirse en cómo abordar los errores que estos han cometido desde una visión reflexiva, donde a través de los programas educativos los privados de libertad desarrollen una conciencia crítica sobre sus comportamientos inapropiados y que ellos logren ser reinsertados a la sociedad. Para operativizar esta visión, el sistema de control debe trascender la métrica conductual e incorporar un feedback ético. Este se define no como una sanción, sino como un proceso dialógico de mejora continua. En el sistema de control, este feedback se operativiza mediante protocolos de retroalimentación asertiva, donde el gerente educativo utiliza los indicadores de desempeño para generar espacios de mediación que humanizan la pena y fomentan la autorregulación del individuo.

Pero, lo anterior se logra desde el marco de la educación basada en la comunicación como herramienta gerencial dentro de los sistemas penitenciarios, de ahí que la educación ha de caracterizarse inclusiva, equitativa y promoción de oportunidades.

Como síntesis de la exégesis realizada, se propone un modelo donde la comunicación no es un simple intercambio de datos, sino un eje de transformación conductual. Este planteamiento se operativiza en el **Modelo de Gestión Comunicativa para el Entorno Penitenciario** (ver Figura 3), el cual articula la relación entre la autoridad gerencial y el privado de libertad mediante la mediación ética de las herramientas tecnológicas.

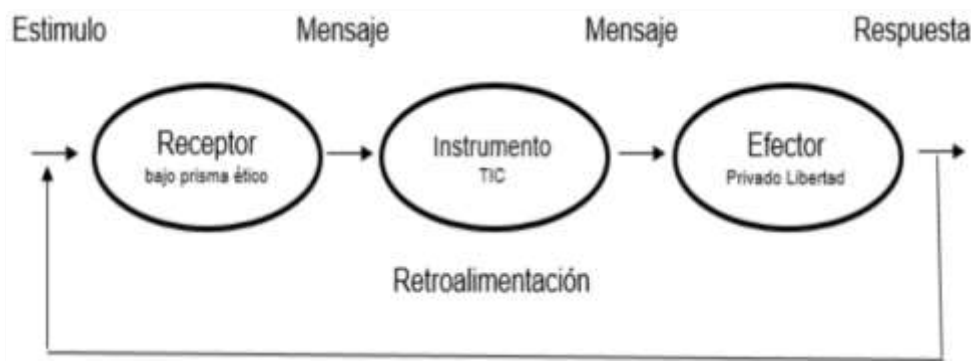


Figura 3. Esquema de comunicación en el sistema penitenciario. Elaboración propia.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

En este esquema, el uso de las tecnologías —como el sistema SITESEP o las plataformas de aprendizaje— trasciende lo instrumental para convertirse en un «refector» de cambio. El modelo demuestra que, al desplazar el foco del castigo punitivo hacia una retroalimentación asertiva, es posible alcanzar una homeostasis ética dentro del recinto. Bajo este escenario, el error conductual deja de ser un motivo de exclusión y se transforma en un insumo de aprendizaje, permitiendo que el sistema penitenciario funcione como un todo organizado y humanista, orientado a la reconstrucción de la subjetividad del interno y su futura reinserción social.

Conclusiones

Epistémicamente, el error es concebido tradicionalmente como un fallo del sistema que desequilibra las relaciones entre quienes lo producen y lo reciben. En el contexto penitenciario, este suele ser un síntoma alarmante que se penaliza o juzga, pero que rara vez se utiliza como un punto de partida para la reflexión. En concordancia con los hallazgos de esta investigación, se sostiene que el hecho educativo debe transformar esta visión, permitiendo que el error sea el motor de una reflexión profunda entre el "ser" y el "deber ser", anclada a una visión humanista y a los objetivos del Desarrollo Sostenible 2030.

En este sentido, si bien los actos punibles deben ser procesados legalmente, el espacio educativo dentro de la prisión tiene la responsabilidad de ofrecer programas de formación centrados en valores, espiritualidad y psicología. El enfoque en el respeto a la vida, la empatía y la tolerancia busca fomentar en el privado de libertad una conciencia crítica y reflexiva de sus propios actos. Como se ha analizado, la comprensión de la conducta humana a través de marcos interpretativos permite que el individuo asuma una conciencia de arrepentimiento y transformación, mitigando la reincidencia.

Bajo una perspectiva sistémica, la institución penitenciaria debe ser entendida como un todo organizado donde los recursos humanos, tecnológicos y éticos coexisten en pro de la resocialización. La incorporación de las modernas teorías de la comunicación y las TIC en este entorno no debe ser meramente instrumental; su fin último es configurar un sistema interdependiente de conocimiento que promueva hábitos de virtud y comportamientos dirigidos hacia el bien común.

Finalmente, la transformación de los privados de libertad representa una labor compleja que exige trascender la descripción teórica. Se requiere que futuras líneas de investigación ausculten el impacto real de la mediación tecnológica en la psique del recluso y su capacidad para reducir la anomia social. La validación empírica del modelo de retroalimentación propuesto en este estudio, mediante investigaciones de corte cuasiexperimental o etnográfico, proporcionará la evidencia científica necesaria para consolidar una gerencia educativa carcelaria basada en un control social humanizado y una homeostasis ética.

Referencias bibliográficas

- Bertalanffy, L. (1980). *Teoría General de los Sistemas*. México, D.F., México: Editorial Fondo de la Cultura Económica.
- Bisquerra, R. (1989). *Métodos de investigación educativa: Guía práctica*. 1ª. Ed. Barcelona, España: CEAC. pp- 55-69.
- Bunge, M. (2007). *La ciencia. Su método y su filosofía*. 1era edición. Caracas, Venezuela: Editorial Buchivacoa.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Carmona, J. (2023). *Constructo teórico gerencial vinculado al sistema penitenciario nacional. aproximación transformadora desde la educación venezolana*. (Tesis Doctoral), Universidad de Carabobo, Venezuela. <https://share.google/4FPD2ryf5TBPSTk3>
- Durkheim, G. (2013). *Educación y sociología*. Barcelona, España: Editorial Península.
- Foucault, M. (2009). *Vigilar y castigar: nacimiento de la prisión*. México, D.F., México: Editorial Siglo XXI.
- Garrido Genovés, V. (2005). *Manual de intervención educativa en readaptación social*. Valencia, España: Tirant lo Blanch.
- Ministerio del Poder Popular para Ciencia, Tecnología e Industria Intermedias. (2011). *Código de Ética para la Vida República Bolivariana de Venezuela*. Recuperado de: http://www2.ula.ve/cdcht/dmdocuments/codigo_etica_%20FONACIT.pdf
- Nardon, A. D., Lanes, F.L. de., & Lanes, L. L. de (2025). Educação no sistema penitenciário brasileiro. *Revista Ibero-Americana de Humanidades, Ciências e Educação*, 11(3), 1847-1862. <https://doi.org/10.51891/rease.v11i3.18513>
- Pérez Serrano, G. (2003). *Pedagogía Social - Educación Social: Construcción científica e intervención práctica*. Madrid, España: Narcea Ediciones.
- Quintana Cabañas, J. M. (1997). *Pedagogía Social*. Madrid, España: Dykinson.
- Redondo Illescas, S. (2007). *Principios de psicología criminológica*. Barcelona, España: Editorial Ariel.
- Schettii, P., & Cortazzo, S. (2015). *Análisis de datos cualitativos en la investigación social. Procedimientos y herramientas para la interpretación de información cualitativa*. Argentina, Buenos Aires: Editorial de la Universidad de la Plata.
- Thayla F. Souza e Silva. (2017). Sistema penitenciario y educación: una narrativa sobre contexto penitenciario, persona privada de libertad y formación del educador. *Revista Senderos Pedagógicos*, 8(1), 101–109. <https://doi.org/10.53995/sp.v8i8.969>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Tecnologías emergentes y transformación del discurso gerencial: una visión fenomenológica en organizaciones educativas

Emerging technologies and the transformation of managerial discourse: a phenomenological view in educational organizations

Desirée Emilia del Valle Pérez Henríquez¹ 

Afiliación autor:

¹ Universidad de Carabobo, Valencia,
República Bolivariana de Venezuela.
pdesve1815@gmail.com

Recibido: 10/02/26
Aceptado: 30/03/26

Cómo citar:

del Valle Pérez Henríquez, D.E. (2026).
Tecnologías emergentes y transformación
del discurso gerencial: una visión
fenomenológica en organizaciones
educativas. *Revista Eduweb*, 20(2), 22-33.
<https://doi.org/10.46502/issn.1856-7576/2026.20.02.2>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Resumen

Este artículo está enmarcado en propósito de develar los rasgos del discurso gerencial mediado por tecnologías emergentes en las organizaciones educativas; el elemento comunicativo resulta vital para los procesos gerenciales, son parte de vitales medios para que los gerentes solventen eventos que se dan en las organizaciones educativas. La gestión estratégica ha influido incluso en el reajuste de los sistemas epistemológicos que intentan promover la comprensión del orden ontológico de la educación en cuanto al discurso gerencial. Se asumen como referencias teóricas, la Teoría de la Acción Comunicativa, Teoría de los Sistemas Sociales, Teoría de la Interpretación; en cuanto a discurso, Teoría de la Atribución y Refuerzo. Se utilizó la metodología cualitativa enmarcada en un paradigma interpretativo y una investigación de campo, con el método fenomenológico hermenéutico. La técnica aplicada fue la observación participativa, entrevista semiestructurada. Para la confiabilidad procedió a categorizar, triangular e interpretar información. El abordaje de las categorías emergentes permitió establecer la configuración de una perspectiva teórica en la consolidación de un discurso gerencial mediado por las tecnologías emergentes del Director de las organizaciones educativas.

Palabras clave: Discurso, gerencia, educación, mediación, tecnologías emergentes.

Abstract

This research aims to reveal the features of managerial discourse mediated by emerging technologies in educational organizations. Using a qualitative approach with a hermeneutic phenomenological method, semi-structured interviews were conducted with three educational managers in Carabobo, Venezuela. Theoretical foundations include Habermas's Communicative Action and Luhmann's Social Systems. Findings reveal a tension between traditional vertical communication and the streamlining potential of digital tools. Results indicate that while emerging technologies facilitate formal written discourse, managerial praxis still faces challenges in empathy and assertive dialogue. The study concludes that technological mediation requires a shift toward transformational leadership to effectively integrate institutional mission with collaborative reality.

Keywords: Discourse, management, education, mediation, emerging technologies.

Introducción

Las Organizaciones Educativas son de gran importancia en la construcción formativa y transformación de los individuos, es el centro de aplicación de habilidades comunicativas del discurso gerencial ante los retos de la vida contemporánea. De acuerdo con la visión de Lysokon et al. (2025) existe en este contexto una responsabilidad social corporativa (RSC) y que debe enfrentar obstáculos que atentan en contra de su integración en el firme propósito de gestionar las decisiones que tienen que ver con la Institución.

La comunicación resulta vital para las relaciones interpersonales de los individuos, basados en los signos lingüísticos, el habla y las expresiones corporales, gracias a la intervención del lenguaje se reconocen diversas perspectivas que convergen en acuerdos comunes con conciencia social. Al respecto, al referirse al contexto educativo, Londoño Vásquez & Rivas Campo (2024) afirman que “las prácticas discursivas constituyen un aspecto fundamental de la comunicación” (p.2). Cabe agregar, que desde esta concepción ontológica, la teoría de la acción comunicativa mediante el lenguaje los seres humanos pueden llegar a interpretar el mundo, el entendimiento y el consenso.

Uno de los nudos críticos más significativos que se presentan en el contexto gerencia es la falta de coherencia y claridad en el discurso directivo; la Inteligencia Artificial puede ofrecer modelos de lenguaje avanzados que pueden servir de reflejo crítico para los Directores; de la misma forma, las tecnologías emergentes pueden mitigar la interpretación errónea de los códigos lingüísticos y prestar apoyo a los Directivos en función de evaluar con criterios claros el clima organizacional en relación con elementos de la acción comunicativa. La comprensión mutua del contexto institucional y las estrategias que brinda, desde el punto de vista social la Inteligencia Artificial democratizan el acceso a la información y ofrecen en un contexto democrático común, medios más efectivos para una comunicación cetrada en una gerencia integral dentro de la institución educativa.

El gerente educativo de hoy amerita formación académica de manera integral y holística para afrontar las diferentes realidades sociales que se están presentando en la actualidad a nivel educativo, enfocados en un discurso reflexivo y transformador a través de una comunicación eficaz, para que se dé la reconfiguración de la comunicación del discurso del docente. Al respecto, Molodtsova et al. (2025) afirman que la abrupta evolución de tecnologías emergentes, exigen una conciencia integral que asocie investigación empírica y teórica; por ello, resulta esencial valorar cómo influye la Inteligencia Artificial en la apropiación y consolidación de competencias profesionales.

La presente investigación tiene como objetivo de develar los rasgos del discurso gerencial mediado por tecnologías emergentes en las organizaciones educativas. Se plantean los nudos críticos que existen en la acción comunicativa del discurso gerencial en las organizaciones educativas en cuanto a: el vocabulario del gerente educativo, diálogos poco asertivos, falta de coherencia y congruencia entre lo que dice y hace, sin activación de palabras de reconocimiento frente al esfuerzo de las actividades realizadas por su grupo de docentes, pocas habilidades: como comunicador, promotor, activador y reconocedor de talento en relación a la conducción y direccionamiento de las organizaciones educativas. En este sentido, se plantea la posibilidad de mediación con tecnología emergente para la optimización de este discurso.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Se justifica el propósito de esta investigación desde una perspectiva pedagógica, social, psicológica, aportes a otros estudios y sus enfoques epistemológicos, axiológicos y ontológicos de la investigación. En el marco teórico lo constituye: los antecedentes internacionales y nacionales los cuales están relacionados con las variables de estudio, se desarrollan los enfoques teóricos que sustentan el presente estudio la Teoría de la Acción Comunicativa propuesta por Habermas (2010), la Teoría de la Interpretación desarrollada por Ricoeur (2006) en cuanto a discurso, Teoría de la Atribución y Refuerzo de Robbins & Coulter (2010).

Posteriormente se realiza un recorrido metodológico con un tipo de investigación cualitativa el cual se deriva del enfoque interpretativo, la metodología del presente estudio se organizó según los propósitos de la investigación fenomenológica y hermenéutica. El subconjunto de los informantes está constituido por tres docentes en ejercicios en función directiva del Municipio Naguanagua del Estado Carabobo. El instrumento realizado para compilar la información es una entrevista semiestructurada de tres preguntas de amplio espectro. Por consiguiente, la realidad mediante el abordaje cualitativo de los hallazgos con la interpretación hermenéutica, la categorización, triangulación es develada para comprobar la importancia de la influencia de la acción comunicativa en el discurso gerencial del director en las organizaciones educativas a través de los constructos mediados por tecnología emergente.

Referentes teóricos o revisión de literatura

La exploración de literatura científica en este artículo parte de una visión sobre el Discurso Gerencial del director en las Organizaciones Educativas contextualizado en los aportes teóricos de diversos autores. En este contexto, la acción comunicativa es la principal fuente de desarrollo de las instituciones educativas a través de las relaciones interpersonales, mediante el intercambio o retroalimentación de ideas, información que se da mediante el uso de los signos lingüísticos que pueden ser verbales o no verbales.

Al respecto Robbins (2004), define la comunicación como “el proceso en que dos o más personas intercambian y entienden información” (p. 284). Es por ello, que el gerente educativo o el director debe instituir los elementos más apropiados o acordes en su discurso gerencial, en el cual se empleen palabras claras y de factible, una clara comunicación con todo su colectivo de docentes e interactuar con todos ellos con el fin de tener una comunicación eficaz en la institución educativa. Goleman (2002) plantea “saber escuchar, clave de la empatía, es también crucial para la comunicación”. (p 220).

En relación con lo anterior, el director también debe saber escuchar de así influir significativamente en las los vínculos de interacción de sus docentes de manera asertiva y buscar el equilibrio en la organización educativa; sin embargo, Correa Guevara (2024) asegura que los directores y docentes no siempre asumen funciones para abordar los enfoques emegentes en el contexto de la gestión organizacional hacia una visión holística y transofrmadora en el seno de la institución como centro de comunicación constructiva con el fin de valorar significativamente la calidad de los procesos educativos.

Al respecto, y por contraste, Bateman & Snell (2009), señala que, “la comunicación es un componente fundamental de la efectividad administrativa y un correcto desempeño en el trabajo” (p.536). El director líder para desempeñar sus cuatro funciones principales: la planeación, dirección, organización y control; se apoya en

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

la comunicación siendo este el medio primordial encargado de compartir la toma de decisiones, coordinar o dirigir grupos de trabajo.

De acuerdo con la perspectiva de Astonitas Manayay et al. (2024), aunque las habilidades esenciales para ser un directivo eficaz se transforman a la par con el entorno social y educativo, se pueden definir ciertas constantes en el perfil de un director eficiente y eficaz. En el contexto educativo, se realizan constantemente y de manera permanente relaciones interpersonales entre los directivos y los facilitadores del aprendizaje, quienes tienen la responsabilidad de propiciar un ambiente armonioso y el reto de transformar a los estudiantes formándose de manera integral como personas en la sociedad que vivimos. En relación con lo expuesto, López Herrera et al. (2024) afirman, al referirse al director educativo y sus funciones, que la actividad más significativa es mediar en forma cercana la mejora de la comunidad escolar al atender oportunamente sus necesidades académicas inmediatas.

Es importante señalar, que el discurso gerencial que lleva a cabo el director promueve la excelencia en las acciones que demuestran la eficacia en su ámbito educativo, desde múltiples cristales que representan visiones: éticas, humanísticas y democráticas; conducente a la equidad e inclusión social dentro de las organizaciones educativas. La gerencia educativa demanda una redefinición desde su origen, su ejecución y su teoría ya que en la actualidad está desfasada del acontecer mundial, inclusive se ha evidenciado un reajuste en los sistemas teóricos que pretenden expresar el orden ontológico, gnoseológico y teológico de la educación. En relación con lo expuesto, vale la pena mencionar a Crocetta Yanuario (2025) quien ofrece posibilidades para la resolución exitosa de inconvenientes con la situación vinculada con la actualización gerencial, éste asegura que las tecnologías emergentes, conforman una base de agilización de los procesos con mayor efectividad en el tratamiento de las vicisitudes de los usuarios.

En relación con lo expuesto, Ortega & Martín (2025) exponen que el papel del profesorado es clave en el proceso de actualización. Afirman que “para que la digitalización sea una herramienta inclusiva, es necesario que el personal docente sea capaz de adaptar su función educativa a capacidades y necesidades” (p. 37). Sobre la base de una actitud innovadora y un conjunto de acciones y estrategias sólidas, puede lograrse un avance en el contexto de la gerencia educativa contemporánea.

Al dar continuidad a los argumentos anteriores, la UNESCO (2011) demuestra que en América Latina, la evaluación de la educación y sus procesos, son espacio de encuentro para solucionar problemas y reconocer las gestiones de las políticas públicas de las naciones., sus estructuras curriculares a establecer en cada país, en el ámbito gerencial se definen las destrezas para el desarrollo e inspección de la gerencia educativa.

Al respecto, Ibáñez (2002) manifiesta que acto similar sucede con la acción comunicativa del discurso gerencial en las instituciones educativas, ya que formulan diferentes proyectos que buscan afinidad en lo estratégico de las diferentes áreas disciplinarias y la trascendencia de los sistemas educativos, en el contexto de la dinámica mundial; que igualmente generaran cambios radicales e impactantes en el currículum la didáctica y las concepciones educativas.

Considerando los argumentos anteriores, es preciso hacer referencia a los aportes de Lozano Rodríguez(2025) para quien “los profesores de la industria 4.0 deben ser personas altamente preparadas, acostumbrados a trabajar en equipo y con una

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

amplia formación” (p.288). La función del gerente educativo va más allá del control, la ejecución, la planificación; es la visión de un tejido complejo de establecimiento de los objetivos, planes y sentido de responsabilidad del director en las instituciones educativas, con la vinculación de la misión y visión, para lograr la motivación y participación de todo el colectivo docente en la implementación de las actividades escolares. En el seno de la contemporaneidad se encuentran aspectos de importancia que van caracterizando la función del director, al respecto el Programa Nacional de Formación Avanzada en Educación (Ministerio del Poder Popular para la Educación Universitaria, Ciencia y Tecnología, 2018), señala:

“el desarrollo de las actividades de las directoras, directores, supervisoras y supervisores, priva la desarticulación y la falta de planificación. Según la Consulta por la Calidad Educativa, la conformación de equipos se ha dado con personas con poca experiencia de aula, sin criterios a nivel comunicacional, de liderazgo, de participación y compromiso institucional y educativo”. (pág. 627)

En el marco de la observación anterior, el discurso gerencial carece de palabras de reconocimiento al esfuerzo que realizan los docentes para realizar sus actividades, diálogos pocos asertivos, vocabulario y expresiones del gerente desmotivadoras. Al respecto, Meza Mejía et al. (2022) aseguran que en los contextos gerenciales es urgente “promover acciones democráticas de gestión y de empoderamiento” (p.245). Sin duda, la gerencia educativa está afectada por el discurso empleado por los directores, la escucha, al acción comunicativa y falta de correspondencia entre lo que dicen y lo que hacen, en la actualidad se presentan una serie de debilidades por parte del director, al respecto el Programa Nacional de Formación Avanzada en Educación (Ministerio del Poder Popular para la Educación Universitaria, Ciencia y Tecnología, 2018) señala que:

El tipo de relación comunicativa que prevalece en las funciones de supervisión y dirección con las y los docentes, es autoritaria, vertical y punitiva, con menoscabo de su profesionalismo, no se socializan las políticas educativas y carecen de estrategias efectivas para orientar las escuelas. (p. 627).

Frente a la realidad expuesta en la revisión teórica, la contemporaneidad se ha caracterizado por la aparición de rasgos emergentes que influyen en la vida cotidiana de los seres humanos, relacionados con tecnologías emergentes que prestan apoyo en muchas de las tareas diarias que desempeñan los individuos en contextos formales e informales. Las posibilidades de mediación de las tecnologías emergentes en el contexto del discurso gerencial de las instituciones educativas son objeto de exploración en el quehacer investigativo actual.

Se evidencia que la inclusión de tecnología emergente en el contexto de la gerencia de los directores es una necesidad expresa, tal como lo aseguran Valenzuela Sabogal et al. (2024):

El estudio señala varios problemas en la incorporación efectiva de las TIC en el aula, incluyendo limitaciones en la infraestructura y en la capacitación del profesorado. Estas barreras pueden atenuar los potenciales beneficios pedagógicos de las herramientas digitales. Se recomienda que las intervenciones tecnológicas sean acompañadas de políticas robustas que aseguren el desarrollo profesional continuo de los educadores y la actualización de la infraestructura escolar. (p. 24)

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Por esta razón y sobre la base de la recomendación de los mencionados autores, se incluyen tecnologías emergentes en el quehacer gerencial de los directores y se registra su dinámica con miras a ofrecer aportes significativos que garanticen la transferibilidad en el futuro.

Metodología

El desarrollo de la metodología se ha materializado a partir de las ideas de Martínez (1996), para quien la perspectiva metodológica es “una vía para alcanzar conocimientos seguros y confiables y, en el caso de que éstos sean demostrables, también ciencia, la elección de una determinada metodología implica la aceptación de un concepto de “conocimiento” y de “ciencia”, es decir, una opción epistemológica (teoría del conocimiento) previa; pero esta opción va acompañada, a su vez, por otra opción, la opción ontológica (teoría sobre la naturaleza de la realidad)”. (p. 66) La presente investigación fue realizada considerando la investigación cualitativa. Al respecto, Taylor & Bogdan (1997), opinan que “la frase metodología cualitativa se refiere en su más amplio sentido a la investigación que produce datos descriptivos: las propias palabras de las personas, habladas o escritas, y la conducta observable” (p. 19). En concordancia con los anteriores argumentos, Martínez (2007) expone que:

La investigación cualitativa implica una nueva forma de pensar, de mirar al mundo y de abordaje innovador sin reduccionismos metódicos, de esta manera, surge un enfoque integrador, plurimetodológico, centrado en un sistema activo para unir, vincular, recomponer y contextualizar, apto para comprender y explicar la estructura e interrelaciones en un todo totalizante. (p.33)

Seguidamente, se expone el método asumido en la investigación, entendiéndose como método los pasos y procedimientos que llevan al logro de los objetivos, cada método se caracteriza por su finalidad y aplicación. Es importante que el investigador tenga conocimiento bibliográfico de la finalidad del método que seleccione en su investigación, para el abordaje del mismo, permitiendo una triada coherencia entre lo que se tiene y el fenómeno en estudio permitiendo precisar el enfoque del investigador, permitiendo claridad epistémica, brindando seguridad al investigador y rigurosidad a la indagación. En la selección del método del presente estudio involucra al sujeto que investiga y a los sujetos informantes en una realidad centrada en los procesos de interacción discursiva; así se hace necesario enmarcarse en los paradigmas cualitativo e interpretativo, desde un enfoque fenomenológico – hermenéutico con miras a la comprensión de la multidimensionalidad del fenómeno a partir de sus propios significados. El método fenomenológico aborda una situación real que depende de la manera en la que vive y percibe el sujeto, cuya realidad intrínseca y particular, única e irrepetible de cada individuo. Martínez (2014) asume que la fenomenología

“es el estudio de los fenómenos tal como son experimentados, vividos y percibidos por el hombre. Husserl funda la fenomenología (1962, orig. 1913; 1970, orig. 1936) acuñó el termino Lebenswelt (mundo de vida, mundo vivido) para expresar la matriz de este mundo vivido con su propio significado” (p. 137).

Al considerar esa definición conceptual, es esencial hacer referencia a que en todo estudio el investigador de manera consciente o inconsciente utiliza el método hermenéutico, debido a la propia naturaleza interpretativa, encontrando significado a lo que está observando. El método fenomenológico-hermenéutico, se basa en lo

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

interpretativo ya que busca entender el mundo vivido de los significados de la realidad de los individuos que están en estudio, descubrir la interpretación de las palabras, la comunicación escrita y oral, el comportamiento gestual o expresiones de los individuos, al respecto Martínez (2006) señala que “el significado de las cosas, interpretar lo mejor posible las palabras, los escritos, los textos, los gestos y, en general, el comportamiento humano, pero conservando su singularidad en el contexto del cual forma parte” (p. 102).

González (2013), hace reflexiones sobre los sujetos de investigación y afirma que “este criterio del estudio responde a lo que se refiere a individuos o sujetos tomados para la indagación, siendo oportuno aclarar que para la metodología cualitativa esta selección pasa a ser llamada sujetos significantes” (p. 88). Los métodos cualitativos no se valen de la representación numérica ni cuantificable, siendo un hecho intencional, que está directamente vinculado con la observación y la selección de sujetos que contribuyan a dar información de gran importancia para el estudio que se está investigado; por lo dicho anteriormente la muestra será no probabilístico o intencional la cual está focalizada en los informantes claves. Al respecto, Martínez (2014), señala que un informante clave “puede desempeñar una función decisiva en una investigación: introduce al investigador ante los demás, le sugiere ideas y formas de relacionarse, le previene de los peligros, responde por él ante el grupo y, en resumen, le hace de puente con la comunidad” (p. 86)

La presente investigación incluye a tres docentes con función directivas de las organizaciones educativas del Municipio Naguanagua, Estado Carabobo, que resultan claves considerando algunos aspectos como la observación participativa y encuentros previos. Estos sujetos, cada uno con más de 10 años de experiencia en entornos gerenciales, incluyen las tecnologías emergentes en el desarrollo de sus actividades de gerencia educativa y apoyan sus acciones con la orientación de herramientas de Inteligencia Artificial. Las técnicas mayormente utilizadas en investigaciones cualitativas son la observación directa o participativa y la entrevista semiestructurada, lo que indica que las preguntas que se realicen al sujeto significativo sean abiertas y guiadas, están orientadas a compartir experiencias por los diferentes participantes del que hacer educativo, al respecto Rusque (1999) señala que el investigador “que utiliza cualquiera de las dos técnicas, debe ir lentamente al comienzo, formulando preguntas no directas, estableciendo rapport y adaptándose a los participantes, antes que preocuparse por los objetivos investigativos” (p. 189).

La observación es una técnica vital para el abordaje analítico de rasgos y cualidades así como de los registros de las acciones y actitudes de las personas, objetos o sucesos que se van a investigar, de tal manera que se visualicen o capten de forma sistemática, cualquier situación en función a los objetos de estudio. Martínez (2014), de fine la observación participante como

“la técnica clásica primaria y más usada por los investigadores cualitativos para adquirir información. Para ello, el investigador vive lo más que puede con las personas o grupos que desea investigar, compartiendo sus usos, costumbres, estilos y modalidades de vida”.(p. 89).

Al valorar el concepto anterior, puede asegurarse que la observación participativa es aquella en el que el investigador se sumerge en la investigación como modo vivencial en los grupos de tal manera que se interrelacione con ellos, su cultura y las formas de vida que marcan estilos y comportamientos. La entrevista es la técnica capital de los estudios cualitativos, el guion es el instrumento técnico que tiene

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

importancia epistemológica en este enfoque. La entrevista semiestructurada se realiza a partir de una guía de preguntas que están formuladas por el investigador para aplicarla a un interlocutor. Al respecto, Arias (2012) señala que en la entrevista semiestructurada:

Aun cuando existe una guía de preguntas, el entrevistador puede realizar otras no contempladas inicialmente. Esto se debe a que una respuesta puede dar origen a una pregunta adicional o extraordinaria. Esta técnica se caracteriza por su flexibilidad. Además de sus instrumentos específicos, tanto la entrevista estructurada como la no estructurada pueden emplear instrumentos tales como el grabador y la cámara de video. (p. 74)

La entrevista semiestructurada se fundamenta en una conversación dialógica espontánea, coloquial, complementadas con otras técnicas. La interacción se va generando a partir de ese momento entre el investigador y su interlocutor. Una vez recolectada la información se procedió a categorizar, organizar las estructuras generales de categorías que permitieron la teorización y triangulación posterior de la información, considerando criterios de producción científica formal que garantizan la excelencia del estudio.

Resultados y discusión

El aporte de las tecnologías emergentes como la Inteligencia Artificial en el seno de la gerencia educativa oscila entre lo ontológico, lo gnoseológico y lo teleológico, en vista de que el ser, el conocer y las finalidades del discurso gerencial se conjugan en una sola acción para generar la agilización de la gestión y la confianza en las decisiones asumidas por los directores. Seguidamente, se ofrece una tabla con las categorías emergentes ya estructuradas.

Tabla 1.
Categorías emergentes estructuradas.

Macro categoría	Dimensiones observadas	Categorías específicas	Criterio de abordaje cualitativo asociado
Pensamiento divergente y expresividad	-Improvisación situacional. -Recursos retóricos de autoridad. -Comunicación paralingüística.	-Respuestas ante lo imprevisto. Intución Vs. Planificación. Manejo de estrés verbal. -Palabras "ancla" para reotmar el control. Metáforas de poder. Tono de voz y énfasis. -Valor del silencio. Gestualidad. Pausas intencionales.	Análisis del discurso y hermenéutica.
Fundamentos de la acción comunicativa	-Dimensión axiológica. -Dimensión epistemológica. -Intersubjetividad.	-Valores explícitos Ética discursiva Negociación Vs. Imposición. -Referencias normativas. Referencias empíricas. Noción de verdad consensuada. -Adaptación de códigos lingüísticos. Empatía discursiva. Reconocimientos contextuales.	

Fuente: Elaboración propia.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

La manifestación de la interioridad propuesta por Habermas (2010) permite el reconocimiento de un sujeto auténtico que es capaz de dar prioridad a la veracidad ante lo imprevisto para demostrar que su discurso se encuentra libre de manipulación por su integridad y genuinas intenciones. La presencia de elementos que van más allá del código lingüístico es considerada por este autor como validadora de la sinceridad del mensaje. El manejo de la referencia como consenso racional y no como coacción constituye otro elemento de triangulación que vale la pena mencionar en este proceso de contraste. Las referencias empíricas y normativas se vinculan con el mundo objetivo y con el mundo social que subyace en las propuestas teóricas vinculadas con la acción comunicativa. El valor del acceso a la realidad a partir del lenguaje sustenta epistemológicamente la visión de las categorías integrales expuestas a la luz de la acción comunicativa.

Evidentemente, los aportes de la tecnología emergente, se centran en lo concreto, en el discurso escrito generado con una formalidad centrada en el deber ser; sin embargo, existe un elemento contextual que trasciende los beneficios de esta tecnología, además de un elemento psicológico que es parte de los sujetos que asumen la función directiva. Categorías como la negociación de verdad consensuada, las referencias normativas, el manejo verbal y las respuestas a lo imprevisto constituyen puntos que fortalecen la gestión y que forman parte de la tecnología; sin embargo, las diferencias individuales que son parte de la condición humana y de los aspectos psicológicos de los sujetos manifiestan elementos observables que tienden a orientarse a una gerencia tradicional. Esta brecha entre lo conceptual y lo intangible debe ser profundizada en el futuro.

Conclusiones

El abordaje fenomenológico de los rasgos cualitativos y categorías, permite relacionar el propósito de la investigación con el marco de concepciones y creencias que marcan la acción de los directivos. El contexto temporal conectado con el campo experiencial, se amalgama con la planificación y los actos que marcan las pautas de desempeño en la institución educativa. Sobre la base de una cultura que matiza el pensamiento, el directivo despliega su planificación y determina las metas organizacionales y de aprendizaje que el personal a su cargo debe apoyar con su trabajo.

El componente estratégico y procedimental de dirección que va de la mano con la acción de los directivos en el contexto institucional van de la mano con la práctica gerencial misma en la que se manifiestan formas de pensar y valores implícitos que se vinculan con el constructo gestión institucional. El apoyo de las tecnologías aporta un marco intersubjetivo a la interacción entre el directivo y sus colaboradores de manera tal que tiende a optimizar los procesos relacionados con la comunicación integral.

Las interacciones entre los directivos, los docentes y hasta los representantes se matizan de los tonos que la gestión sugiere en el marco contextual de la institución educativa. El personal directivo marca la pauta para la mediación de las prácticas gerenciales dentro de la escuela. Al realizar el abordaje fenomenológico y generar un proceso de reducción, se devela que la cultura del personal directivo, los procesos de planificación de los aprendizajes considerando la temporalidad y la acción ontológica, interactúan dinámicamente hasta lograr una relación intersubjetiva que van más allá de las respuestas formales.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Este constructo ha develado los componentes que contribuyen a la adecuada interpretación del significado profundo de la misión educativa o lograr una mayor capacidad de análisis estratégico en los actores. Inicialmente, la forma de pensar del directivo y sus acciones, fueron valorados como obstáculos que impiden el trabajo centrado en la misión y la visión institucional, ya que una planificación de un gerente institucional desde lo que se cree conveniente, tienen a consolidar una perspectiva gerencial tradicional, centrada en el contenido de los documentos escritos y en las habilidades de los actores para descifrarlos y cumplirlos. En esto aspectos, la tecnología constituye una base esencial para la generación de discursos escritos formales comprensibles para todos.

La tecnologías emergentes permiten al directivo rescatar la visión institucional y la vinculan con la realidad del personal a su cargo; de esta forma, se logra acceder a procesos superiores de gestión, como la inferencia estratégica, la anticipación a problemas y las posibilidades de generar nuevas soluciones a partir de lo ya vivido, mediante los procesos creativos e innovadores.

Las tecnologías también pretenden superar esa visión tradicional de elementos intersubjetivos tan importantes como los saberes ya consolidados del personal y la experiencia laboral previa de los colaboradores. De esta manera, anteriormente se pensaba al personal docente como un sujeto que debía ser preparado y formado desde “cero”, obviando su experiencia profesional y el tiempo dedicado al trabajo de aula.

El énfasis institucional en el aprendizaje del sistema normativo, el código, los procedimientos, el componente formal, la identificación de estructura (normativa), reafirma esa visión centrada en el documento y en su contenido descifrable por parte de una persona que “tiene la habilidad” de hacerlo, gracias al conocimiento sólido del sistema y plasmado directamente con el apoyo de las tecnologías.

En repetidas ocasiones, las acciones del personal directivo han dejado de lado la realidad del contexto y el mundo afectivo del personal docente. Un solo directivo asoma esta posibilidad, pero la obstaculiza y le aporta poca significación cuando afirma que institucionalmente se deben cumplir con exigencias de gestión para la identificación de información expresa en el documento, que representa un nivel de cumplimiento formal, pero que no engloba el todo de la gestión como realidad integral y necesaria para los docentes.

Otro aspecto de la realidad que afecta al docente en relación con las funciones que literalmente debe cumplir son las estrategias de dirección, que son el producto de la experiencia previa directivo y de su desempeño dentro de la escuela. Esta visión y estas acciones son transmisibles y recursivas y se dan en los profesionales de la docencia, sus representantes y los sujetos que hacen vida en la institución para convertirse en asunto intersubjetivo.

La realidad anteriormente descrita, con el apoyo de tecnologías emergentes, dejan abiertas las puertas para un cambio: Si el directivo reflexiona sobre su propia gestión y las estrategias de dirección (el liderazgo transformacional vs. el transaccional) podrá integrar sus elementos personales en perfecta concordancia con la realidad institucional; entonces, una transformación esencial podría generarse a partir una transformación de fondo que emerja de las visiones de los directivos, la reorientación organizativa a partir de la planificación estratégica y operativa y, como complemento significativo, la revisión de las estrategias directivas, en las que se consideren actividades de: Socialización y colaboración estratégica, transferencia de conocimientos y habilidades, inferencia (análisis de escenarios) y

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

creatividad (búsqueda de soluciones), integración y valoración de sentimientos (clima organizacional, motivación). Esto permitirá la formación docente contextualizada sobre la base de la reflexión sobre un tipo de gestión más coherente y que dé respuesta a sus necesidades y a su vida profesional en el plano institucional. Sobre la base de lo expuesto, se debe apuntar a la mejora de la praxis gerencial para la transformación educativa con el apoyo tecnológico si se valora la coherencia como eje esencial del proceso.

Referencias bibliográficas

- Arias, F. (2012). *El Proyecto de Investigación*. 5° Edición. Caracas, Venezuela: Editorial Episteme.
- Astonitas Manayay, C., Rojas Chávez, M. Y., & Ortega Cabrejos, M. Y. (2024). Estrategias de habilidades gerenciales para mejorar la gestión educativa de los directores en las instituciones educativas. *Revista Científica UISRAEL*, 11(2), 81-94. <https://doi.org/10.35290/rcui.v11n2.2024.1095>
- Bateman T., & Snell, B (2009). *Administración, Liderazgo y Colaboración en un Mundo Competitivo*. (8a ed.). México, D.F., México: McGraw-Hill.
- Correa Guevara, M. V. (2024). El director como gerente social holístico, escuelas estatales municipio Juan José Mora, estado Carabobo. *Revista EDUCARE - UPEL-IPB - Segunda Nueva Etapa 2.0*, 28(1), 53-77. <https://doi.org/10.46498/reduipb.v28i1.2096>
- Crocetta Yanuario, V. R. (2025). La gerencia evaluativa en el ámbito de la tecnología emergente. *Aula Virtual*, 6(13), e437. <https://doi.org/10.5281/zenodo.15257244>
- Goleman, D. (2002). *La inteligencia Emocional en la Empresa*. Buenos Aires, Argentina: Vergara Editor.
- González, Y. (2013). *Abordaje de la Metodología Cualitativa y la Investigación Acción- Acción para la Transformación Social*. 2°. Venezuela, Guayana: Editorial Dabosan
- Habermas, J. (2010). *Teoría de la acción comunicativa*. Madrid, España: Trotta.
- Ibáñez, J. (2002). *Interpretación y Análisis. Más allá de la Sociología*. Madrid, España: Editorial Siglo XXI.
- Londoño Vásquez, D. A., & Rivas Campo, Y. (2024). Convergencia de las prácticas discursivas y las prácticas pedagógicas en la formación docente. *Apuntes Universitarios*, 14(1), 1-18. <https://doi.org/10.17162/au.v14i1.1585>
- López Herrera, L. A., Naranjo Aguay, W. W., Yépez Ortiz, S. R., & Pisco Mantuano, J. E. (2024). Liderazgo Gerencial en el Sistema Educativo Actual: Repensando el Nuevo Rol Directivo. *Revista Social Fronteriza*, 4(5), e45409. [https://doi.org/10.59814/resofro.2024.4\(5\)409](https://doi.org/10.59814/resofro.2024.4(5)409)
- Lozano Rodriguez, E. (2025). *Experiencias y desafíos en gerencia educativa*. Bogotá, Colombia: Ediciones Uniandes.
- Lysokon, I., Vasyliuk, T., Kulinka, Y., Bilozir, O., & Karytka, V. (2025). Higher education institution management: social responsibility in the context of global challenges. *Revista Eduweb*, 19(3), 35-50. <https://doi.org/10.46502/issn.1856-7576/2025.19.03.3>
- Martínez, M. (1996). *Comportamiento Humano*. Nuevos Métodos de Investigación. México, D.F., México: Trillas.
- Martínez, M. (2006). *Ciencia y arte en la metodología cualitativa*. (2a ed.). México, D.F., México: Trillas.
- Martínez, M. (2007). *Evaluación cualitativa de programas*. México, D.F., México: Trillas.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Martínez, M. (2014). *Ciencia y Arte en la metodología cualitativa. Métodos Hermenéuticos, Métodos Fenomenológicos, Métodos Etnográficos*. México, D.F., México: Trillas.
- Meza Mejía, M.d.C., Ortega Barba, C.F., & Cobela Vargas, J.F. (2022). Tendencias investigativas sobre liderazgo y dirección escolar. Revisión sistemática de la producción científica. *Revista Fuentes*, 24(2), 234-247. <https://doi.org/10.12795/revistafuentes.2022.19797>
- Molodtsova, V., Hrechanyk, N., Guoxi, R., Khoroshailo, O., & Fadyeyeva, I. (2025). The significance of artificial intelligence in fostering professional competencies of the future: a systematic review. *Revista Eduweb*, 19(2), 280–295. <https://doi.org/10.46502/issn.1856-7576/2025.19.02.19>
- Ministerio del Poder Popular para la Educación Universitaria, Ciencia y Tecnología (2018). *Programa Nacional de Formación Avanzada en Educación*. Gaceta Oficial de la República Bolivariana de Venezuela, N.º 41.378, 16 de abril de 2018. Recuperado de <https://www.notilogia.com/gaceta-oficial-n-41-378-establece-prorroga-a-los-procesos-de-institutos-autonomos-de-policias-del-municipio-y-estados/>
- Ortega, N., & Martín, A. (2025). *La transición digital en centros educativos. Planificación estratégica y visión de futuro*. Barcelona, España: Editorial de la Fundació Universitat Oberta de Catalunya.
- Ricoeur, P. (2006). *Teoría de la interpretación. Discurso y excedente de sentido*. México, D.F., México: Siglo XXI.
- Robbins, S (2004). *Comportamiento Organizacional*. (4a ed.). México, D.F., México: Pearson Educación.
- Robbins, S., & Coulter, M. (2010). *Administración*. (10a ed.). México, D.F., México: Pearson Educación.
- Rusque, A. (1999). *De la diversidad a la unidad en la investigación cualitativa*. Caracas, Venezuela: FACES/UCV.
- Taylor, S., & Bogdan, R. (1997). *Introducción a los Métodos Cualitativos de Investigación*. España. Editorial Paidós.
- UNESCO. (2011). *Manual de gestión para directores de instituciones Educativas*. Lima, Perú: UNESCO.
- Valenzuela Sabogal, G.M., Barahona Rodríguez, C.Y., Medina Vizcaino, L.V., & Angulo García, J.A. (2024). Incidencia tecnológica en la transformación digital del área educativa de los colegios públicos de Facatativá. *Revista Eduweb*, 18(2), 9-25. <https://doi.org/10.46502/issn.1856-7576/2024.18.02.1>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Educación en ingeniería para un futuro más verde: Una revisión de los currículos, las competencias y la pedagogía en la era de la Industria 5.0

Engineering education for a greener future: A review of curricula, competencies, and pedagogy in the era of industry 5.0

Carlos Gómez Chacón¹ 

Afiliación autor:

¹ Doctoral Student in Education; Assistant Professor, School of Computer Engineering, Universidad Católica Andrés Bello, Caracas, Venezuela. cgomezch@ucab.edu.ve

Recibido: 19/04/26
Aceptado: 30/05/26

Cómo citar:

Gómez Chacón, C. (2026). Engineering education for a greener future: A review of curricula, competencies, and pedagogy in the era of industry 5.0. *Revista Eduweb*, 20(2), 34-52.
<https://doi.org/10.46502/issn.1856-7576/2026.20.02.3>

Resumen

Este artículo está dirigido a profesores, diseñadores instruccionales y personal académico que deseen integrar la educación en sostenibilidad en las instituciones de educación superior. En él se analizan los últimos avances en materia de cambio climático y educación en sostenibilidad, con especial atención a la ingeniería, y se centra en tres dimensiones: el diseño curricular, las competencias y las estrategias pedagógicas. Basándose en una revisión semisistemática de la literatura académica de 2020 a 2025, el estudio explora la integración de la sostenibilidad en los planes de estudios y analiza marcos para evaluar la eficacia de la educación en sostenibilidad. Destaca las competencias en sostenibilidad y las habilidades ecológicas que los ingenieros necesitan para abordar el cambio climático, y examina su conexión con tendencias recientes como la Industria 5.0. Además, el artículo describe las principales metodologías de enseñanza utilizadas en la educación sobre el cambio climático y la sostenibilidad. Se identifican varios retos, como la tensión entre la sostenibilidad débil y la fuerte, las críticas al marco STEM, la brecha de género y la falta de alineación entre los programas académicos y las demandas de la industria. La brecha de género no es solo un desequilibrio demográfico, sino que también puede contribuir al bajo nivel de compromiso con el medio ambiente observado entre los estudiantes. Al mismo tiempo, el concepto de desarrollo sostenible ha sido criticado por su énfasis en el crecimiento económico, que algunos autores identifican como la raíz de la crisis medioambiental.

Palabras clave: cambio climático, desarrollo sostenible, enseñanza superior, ingeniería.

Abstract

This article is directed towards faculty members, instructional designers, and academic staff who wish to integrate sustainability education into higher education institutions. It studies recent developments in climate change and sustainability education, with emphasis on engineering, and focuses on three dimensions: curriculum design, competencies, and pedagogical strategies. Based on a semi-systematic review of academic literature from 2020 to 2025, the study explores the integration of sustainability into curricula and discusses frameworks for assessing the effectiveness of sustainability education. It highlights sustainability competencies and green skills which engineers need to address climate change, and examines their connection to recent trends such as Industry 5.0. Furthermore, the article describes the main teaching methodologies used in climate change and sustainability education. Several challenges are identified, such as the tension between weak and strong



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



sustainability, critiques of the STEM framework, the gender gap, and misalignment between academic programs and industry demands. The gender gap is not only a demographic imbalance, it may also contribute to the low level of commitment to the environment observed among students. At the same time, the concept of sustainable development has been criticized for its emphasis on economic growth, which some authors identify as the root of the environmental crisis.

Keywords: climate change, engineering, higher education, sustainable development.

Introduction

According to current scientific evidence, climate change is one of the greatest threats to humanity (Kemp et al., 2022). The latest Intergovernmental Panel on Climate Change (IPCC) report warns that if greenhouse gas emissions are not significantly reduced in the coming decades, global temperatures will rise by 2°C above pre-industrial levels within this century (Allan et al., 2023). National climate targets, updated in 2025, encompass diverse mitigation and adaptation strategies. These, in turn, drive the demand for professionals with ecological competencies across the energy, construction, and agriculture sectors (UNFCCC, 2025).

Education is essential in addressing climate change, both for developing the skills necessary for the transition to a sustainable industry and for cultivating informed citizens (Secretary of State for Energy Security and Net Zero, 2025). Between 2023 and 2024, global demand for workers with green skills grew at twice the rate of supply (LinkedIn, 2024). If this trend continues, it is estimated that by 2030, 20% of green-skilled job positions will remain unfilled. A recent study identified the sectors with the highest demand for green-skilled jobs as utilities, construction, manufacturing, and technology, information, and media (LinkedIn, 2024). However, the transition will also require emerging technologies and new types of industries, making green skills a constantly evolving set of competencies (Cook & Elliott, 2025). Startups accelerate the shift to sustainability through innovation. With venture capital for green startups hitting €74 billion in 2021 (Dechezleprêtre & Kelly, 2025), education must prioritize both green skills and the complex thinking required for sustainable entrepreneurship.

This article explores the challenge of training engineers with the skills needed to develop solutions for climate change mitigation and adaptation, as well as to lead the transition toward a more sustainable society. The first step in addressing this question is to review existing research; therefore, this study conducts a semi-systematic analysis of the literature on the teaching of sustainability and climate change in engineering.

Rationale

Engineers are responsible for designing and developing solutions for climate change mitigation and adaptation; therefore, it is necessary to transform engineering education to teach competencies related to climate science, environmental impacts, and the design of resilient systems (Martin et al., 2022). Furthermore, engineers will have to solve problems both within and beyond the boundaries of their own discipline (Van den Beemt et al., 2020). An example of this is the design of photovoltaic systems, which requires simulation skills to measure their impact on the power grid and meteorological skills to estimate environmental effects, such as shading and dust, on panel performance (Bamisile et al., 2025).

Although ethics has been part of engineering education since the 1970s, it has become more important today because production processes are more globally interconnected and have far-reaching consequences for the environment, communities, and future generations. For example, cobalt is one of the main elements in lithium-ion batteries, but more than half of this metal's extraction takes place in the Democratic Republic of the Congo, where a significant portion (15–20%) is mined from artisanal mines that can cause permanent damage to the health of communities (Banza Lubaba Nkulu et al., 2018).

Literature review

Several articles have examined the relationship between sustainable development competencies, pedagogical strategies, and systems thinking. The following table presents a comparison of previous studies, showing the contribution of each and its differences with the present work.

Table 1.
Related Work.

	Scope	Methods	Findings
Saakwor Batsa et al., 2025	To evaluate the design and implementation of Action Competence and participatory pedagogies worldwide.	Systematic review.	An analysis of contributing factors to the development of action-competence.
Lozano & Barreiro-Gen, 2022	To systematically connect sustainability competencies with pedagogical strategies.	Hermeneutics and grounded theory.	A framework that links competencies and pedagogical strategies through a matrix structure.
Kioupi & Voulvoulis, 2022	To develop a process for educational institutions to design curricula based on the Sustainable Development Goals.	Systems thinking.	A participatory framework that enables the design and evaluation of curricula for sustainable development.
Lozano & Barreiro-Gen, 2022	To investigate the relationship between sustainability competencies and pedagogical strategies.	Survey and principal component analysis (PCA).	A system for teaching sustainability that groups competencies with pedagogical strategies.
Anapey, 2024	To align global sustainability indicators with higher education curricula, including Indigenous cultural practices.	Interviews with a purposive sample of 11 students.	Students demonstrated greater knowledge of competency-based education than of pedagogical approaches and sustainability goals.
Owuondo, 2023	To align educational objectives in the Global South with the Sustainable Development Goals (SDGs).	Review and analysis of academic literature, policy documents, and organizational reports.	Identifies challenges such as inadequate infrastructure and cultural heterogeneity; recommends the implementation of monitoring and evaluation mechanisms.
Ncube et al., 2026	To review the literature on the integration of Education for Sustainable Development (ESD) in higher education, with emphasis on leadership, pedagogy, and curriculum development.	Systematic review of academic literature from 2015 to 2025.	Transformative and participatory leadership is essential for promoting interdisciplinary pedagogies and sustainability competencies.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Druker-Ibanez, & Caceres-Jensen, 2022	To investigate the integration of Indigenous knowledge into sustainability education.	Systematic literature review.	The study identifies distinct pathways and challenges for integrating Indigenous and Western knowledge, highlighting that while resource gaps exist, leveraging specific Indigenous knowledge features enhances student identity and learning outcomes.
This study	To analyze sustainability education across different curriculum levels.	Semi-systematic literature review.	A schematic view of curricula for sustainable development that supports decision-making across different curriculum levels.

Note. Table created by the author.

Methods

A documentary analysis was performed to know the current trends in the teaching of climate change and sustainability in engineering, reviewing academic articles to identify the contents that are taught, the underlying theories, models, and schemes, the pedagogical strategies, and any other characteristic of the education of these topics without any previous conception or particular expectation of what was going to be found.

A semi-systematic literature review was conducted to identify the main themes regarding the teaching of climate change. Snyder (2019) posits that while the objective of a systematic review is to analyze all works surrounding a research problem, usually in a statistical way, the semi-systematic review examines common themes in studies conducted by different research groups and among different disciplines to contrast and compare them. In this work, only articles published in the last five years (from 2020 until the date of editing of this article) were taken into account, given that the objective is to investigate the state of the art in this subject.

The reviewed literature is heterogeneous in terms of methodologies and theoretical approaches. It includes works originating in different disciplines, such as Education for Sustainable Development (ESD), ecology, and competency-based education. Although all address environmental education, they do so from distinct ethical positions, ranging from instrumentalist to intrinsic approaches. This wide range of concepts makes a systematic review unsuitable, due to the differences in meaning. By contrast, thematic analysis allows the description and comparison of these diverse perspectives.

Open access articles indexed on the Google Scholar platform and those available in full text on the EBSCOhost platform were consulted, using the following search terms:

- **Google Scholar:** education engineering “climate change” OR sustainability
- **EBSCOhost:** education AND engineering AND (“climate change” OR sustainability)

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

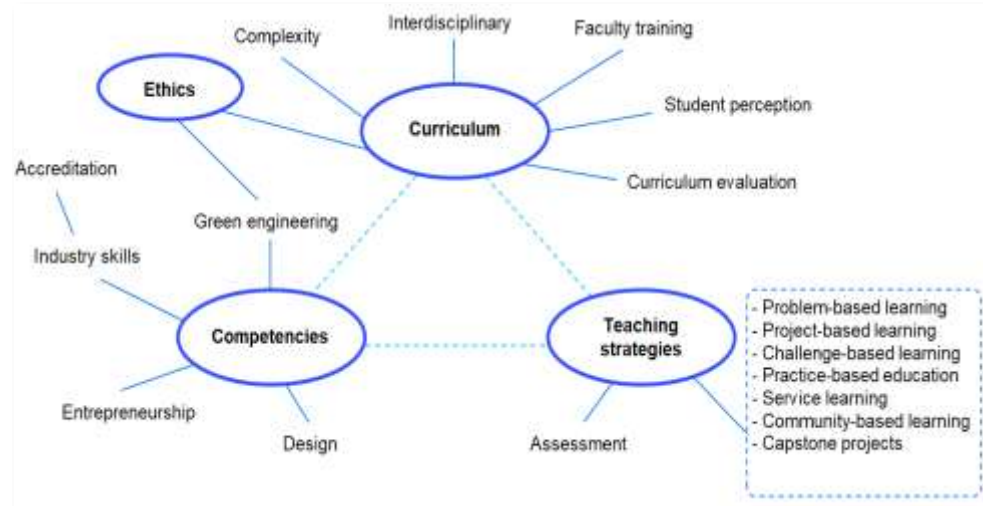


Figure 1. Main Themes Identified in the Literature.

Note. Figure created by the author

The first 60 documents were taken into account in order of relevance yielded by each query. Google Scholar determines the ranking of the documents considering the relative frequency of the search terms within the full text, as well as how many times they have been cited and how recently. EBSCOhost evaluates the presence of the terms in the subject, title, keywords, abstract, and full text of the article.

This process yielded an initial set of 64 works, of which 20 that were not directly related to higher education were excluded, resulting in 44 articles. During the analysis stage, additional sources were consulted to reinforce some theoretical concepts, as well as works cited within the chosen articles.

In the analysis, common concepts were identified in the set of works that served as thematic axes to organize the discussion, according to a classification of a maximum of two levels formed by themes that may contain subthemes. This hierarchy is presented in Figure 1. Below, the analysis is developed, explaining for each element its relevance in the context of the teaching of climate change and sustainability in engineering.

Results and discussion

The themes identified in the literature are organized into four main categories: curriculum, competencies, pedagogical strategies, and ethics.

Curriculum

The UN 2030 Agenda defines 17 sustainable development goals to guide a transition of countries toward a growth model that promotes human rights and respects the balance with the environment. Education for sustainable development (ESD) seeks to train students in the complex economic, social, and environmental problems that must be faced to advance in the SDGs between now and 2030 (Shahidul, 2020).

In general, there are two ways to incorporate ESD into the curriculum: the first is to include one or two sustainability subjects, which is considered the naive approach

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

(Nikolić & Vukić, 2021). The second is to transform the curriculum to integrate the values, contents, and competence of sustainability (Guerenabarrena-Cortazar et al., 2021). However, this requires major institutional changes; therefore, the first type of integration is usually chosen (Nikolić & Vukić, 2021).

Numerous researchers have integrated sustainability content into existing subjects at the institution. For example, Ashraf & Alanezi (2020) explore the micro-curriculum technique where they analyze the content of basic and engineering subjects to add topics on environmental problems and their solutions. Zuin et al. (2021) report that several universities have incorporated Green Chemistry and Sustainable Chemistry competencies by adjusting the curriculum and didactic strategies to promote systems thinking and ecological reflection. Yuan et al. (2024) demonstrate that by incorporating knowledge and didactic experiences about sustainability into the curriculum, students' interest in this discipline increases, depending on their self-efficacy.

In addition to promoting teaching and research in sustainability, higher education institutions must lead by example by reducing their environmental impact through improvements such as the use of renewable energies and waste recycling, and by disclosing these achievements within the university community and in the communities around them (Žalėnienė & Pereira, 2021).

Complexity

The word complexity comes from the Latin *plecto*, which means to bind, to weave. In complex problems, several elements interact, as if they were part of a fabric and were connected by a thread (Sigahi & Sznclwar, 2022). Classical engineering, which is based on reductionism, mechanism, and on breaking down a problem into its parts, is insufficient to solve poorly structured problems and understand complex phenomena.

Complexity engineering emerged in response to the limitations of classical engineering and is understood as the development of solutions grounded in complexity science to meet societal needs (Sigahi & Sznclwar, 2022). In the educational context, it is essential to design engineering competencies that address complexity (Hadgraft & Kolmos, 2020). Alliances such as the Washington Accord and ABET have already incorporated complex problem-solving and systems design competencies. Furthermore, there is a need to train professionals capable of acting as leaders and project managers who ensure sustainability and reinforce safety principles in design—namely, safe-by-design systems (Jamieson et al., 2021).

Interdisciplinary engineering education

Interdisciplinary education in engineering seeks to integrate theories, knowledge, and techniques from various disciplines within a unified framework (Van den Beemt et al., 2020). Its primary motivations include the resolution of complex problems, the development of entrepreneurial competencies, the formation of socially responsible engineers, and the enhancement of disciplinary programs—through the cultivation of skills such as creativity, project management, and teamwork (Van den Beemt et al., 2020).

From a pedagogical perspective, it is possible to design projects involving students from the same discipline (e.g., mechanical engineering) encouraging exploration beyond their primary field, or to include participants from diverse areas of engineering, the natural sciences, and the social sciences (Van den Beemt et al.,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

2020). With regard to assessment, it is advisable to divide projects into stages that each require concrete deliverables, helping students remain focused on achievable objectives. Evaluation tools should be designed from the perspective of all disciplines, and active involvement from all team members should be encouraged.

Faculty training

Faculty training to teach sustainability and climate change is a fundamental component of education for sustainable development (Shahidul, 2020). Leal Filho et al. (2021) surveyed researchers and educators from higher education institutions across 45 countries. While most respondents reported having sufficient preparation to teach climate change-related concepts and acknowledged having received or attained training for it, only a minority (12%) received such training from their universities. According to 51% of respondents, a major challenge in teaching climate change lies in the lack of faculty expertise.

Leal Filho et al. (2021) present several case studies of universities that have developed faculty training and other initiatives related to climate change. At the Royal Institute of Technology (KTH), all faculty members with leadership roles have been trained on how to integrate sustainability and climate change into their programs (KTH, 2025). The University of Hamburg implemented a climate change training program for more than 3,000 academic staff members (Leal Filho et al., 2021). Martínez Valdivia et al. (2023) demonstrated the importance of active pedagogies in teacher training through a systematic literature review.

Curriculum evaluation and student perception

Various tools have been developed to measure students' perceptions, behaviors, knowledge, and attitudes toward climate change. These instruments can be employed to evaluate the state of climate change education within an institution and to inform curricular enhancements. There are several approaches to assessing the integration of sustainability into the curriculum (Guerenabarrena-Cortazar et al., 2021):

- Evaluating the overarching principles and objectives related to sustainability as outlined in the institution's strategic plans and academic programs—i.e., at the highest levels of curriculum design.
- Assessing the sustainability competencies that students have actually acquired throughout their academic careers (Mazur & Walczyna, 2022), alongside their perceptions and attitudes toward sustainability.
- Analyzing course syllabi to determine the extent to which sustainability-related goals, competencies, or content are included (Guerenabarrena-Cortazar et al., 2021).

Segalàs Coral, & Sánchez Carracedo (2020) proposed a comprehensive framework for curriculum evaluation across various levels, which includes: defining discipline-specific competencies, validating teaching strategies for sustainability, identifying faculty training needs, and assessing students' sustainability competencies.

The following instruments measure student sustainability behaviors, perceptions, and attitudes:

- A survey to assess students' perceptions of sustainable development and innovation (Fourati-Jamoussi & Dubois, 2021), based on the AFC (Apparent,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Merge, Cut) and Biohead (Biology, Health, and Environmental Education for Better Citizenship) scales.

- A questionnaire designed to evaluate the curricular emphasis on sustainability, teaching strategies, students' professional self-efficacy, and career expectations (Yuan et al., 2024).
- A survey assessing students' perceptions, attitudes, career expectations, and knowledge regarding sustainability and climate change (Aleixo et al., 2021; Taboada-González, & Aguilar-Virgen, 2024).
- A survey measuring students' attitudes and behaviors related to sustainability (Biancardi et al., 2023).

Competencies

Competence-based education is an approach aimed at developing student skills aligned with the capacities required in the professional field (Ortiz-Marcos et al., 2020; Gervais, 2016). The skills required to innovate in response to climate change evolve alongside technological development. Hermann and Bossle (2020) assert that "The definition of sustainable development ... introduces dynamic features since needs will change along with the future shifts society will face" (p. 3). In a seminal work, Wiek et al. (2011) identified the following key competencies for sustainable development:

- Systems thinking competence
- Anticipatory competence
- Normative competence
- Strategic competence
- Interpersonal competence

In a more recent study, Perpignan et al. (2020) highlighted four additional competencies:

- Critical thinking
- Interdisciplinary collaboration
- Problem-solving ability
- Self-awareness

In addition, global competence is defined as the ability to address local, global, and intercultural issues, interact effectively with individuals from diverse cultural backgrounds, and take action for the common good and sustainable development (Ortiz-Marcos et al., 2020).

While these are common competencies for practicing sustainability in engineering, several authors have proposed discipline-specific competencies, such as for chemical engineering (Zuin et al., 2021; Jamieson et al., 2021) and software engineering (Semerikov et al., 2020).

Green skills

Beyond training in technologies to mitigate climate change, higher education institutions can promote values and competencies essential for building sustainable communities. Based on a survey conducted in an engineering training program, Biancardi et al. (2023) identified six pillars through which academia can foster sustainable communities: "sustainable education, energy (and resource) independence, subsidies in support of the green economy, initiatives aimed at

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

reducing the carbon footprint, energy community development, and new green professional opportunities" (p. 1).

Although the literature typically associates green skills with STEM education, two additional kinds of capabilities are needed: green life skills and skills for green transformation (Kwauk & Casey, 2022). The former involve educating individuals about climate change, its causes, and solutions to cultivate greener ways of being, thinking, and acting. The latter focus on collective action to transform our relationships with others and with nature, aiming for more just economic, political, and social structures (Kwauk & Casey, 2022).

Industry skills, accreditation, and Industry 4.0

Engineering program competencies must align with the knowledge, skills, and values demanded by industry (Byrne, 2023; Ortiz-Marcos et al., 2020). Universities and companies that are incorporating sustainability emphasize the need for a broader concept that encompasses ethics, uncertainty, complexity, equity, and interdisciplinary and global collaboration (Byrne, 2023).

Byrne (2023) analyzed documents from five engineering accreditation agencies (such as ABET and EUR-ACE) and found that these agencies address sustainability with varying levels of depth and scope. At the undergraduate level, accreditation requirements may restrict some universities from rapidly integrating the SDGs into their curricula (Weissbrodt et al., 2020).

Industry 4.0, introduced at the Hannover Fair in 2011, focuses on cyber-physical production systems (CPPS), which are manufacturing systems capable of self-organization through artificial intelligence, secure data collection and transmission, and human collaboration. These systems offer the flexibility needed to adapt to changing requirements and process optimization (Xu et al., 2021; González-Pérez et al., 2023). Industry 5.0, a concept proposed by the European Union in 2021, addresses the limitations of Industry 4.0, particularly its emphasis on automation and artificial intelligence over social justice and sustainability (Mazur & Walczyna, 2022). The distinction between the two lies in that "Industry 4.0 is considered to be technology-driven, whereas Industry 5.0 is value-driven" (Xu et al., 2021, p. 1). According to Mazur & Walczyna (2022), Industry 5.0 highlights the importance of research and innovation to place technology at the service of humanity while respecting planetary boundaries. These authors propose a competence model for Industry 5.0 encompassing the domains of systems thinking, knowledge, action, emotions, values, and ethics.

Entrepreneurship

In addition to the key competencies already mentioned, several authors emphasize the importance of incorporating entrepreneurship into climate change education (Hermann & Bossle, 2020; Huang et al., 2022; Shekhar et al., 2024). Entrepreneurs possess competencies that enable them to identify externalities in industrial production and markets—that is, social costs that are not accounted for—and to develop solutions that mitigate these externalities while creating value (Hermann & Bossle, 2020).

Engineering students often face difficulties in entrepreneurship, which requires out-of-the-box thinking, whereas engineering education typically emphasizes adherence to established rules and standards (Varadarajan, 2023). Students are interested in

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

pursuing ventures that not only yield economic profit but also generate positive societal impact and promote the common good (Shekhar et al., 2024). Moreover, individuals are more likely to identify entrepreneurial opportunities for sustainable development if they possess knowledge of natural and community environments—underscoring the importance of teaching these areas to drive social change through entrepreneurship.

Design

Design thinking is an iterative process for developing solutions that generate social impact and address complex problems through innovation (Shekhar et al., 2024; Varadarajan, 2023). One application of design thinking involves developing community-based projects that enable students to observe, understand, and propose solutions to environmental and social challenges (Grimal et al., 2020). Sánchez-Parkinson et al. (2023) document service-learning experiences where students frequently encountered cultural differences within communities and define intercultural maturity as the ability to understand, think, and act while being aware of cultural differences and respectful of them.

Eco-design is defined as the discipline that integrates environmental considerations into the design process to minimize ecological impacts throughout a product's life cycle (Perpignan et al., 2020). According to Grimal et al. (2020), this discipline aligns with the concept of “strong sustainability,” whereas the notion of sustainable development as proposed by institutions like the UN is considered “weak sustainability” because it remains embedded within a capital-intensive socioeconomic market.

Integrating design into engineering education presents a challenge because “teaching creativity to engineering students creates a paradoxical situation where they have to exhibit qualities of a non-conformist (break the rules) while conforming to the disciplinary rules and standards” (Varadarajan, 2023, p. 687). The students face a contradiction when they try to resolve open problems, because their learning style has been influenced by the positivist paradigm of engineering, while resolving ill-structured problems requires a constructivist approach. A solution to this dilemma is the perspective of Complex Responsive Processes (CRP), which distances itself from both positivist and constructivist models and acknowledges “the paradoxical nature of everyday life in organizations, and the importance of paying attention to these paradoxes” (Varadarajan, 2023, p. 694) to better understand the situation.

Ethics

The ethics of climate change have been addressed from various perspectives, including environmental ethics (Rolston III, 2020), political philosophy (Cerutti, 2016), and consequentialism (Attfield, 2015). The reviewed literature revealed three key ethical positions regarding climate change education, which are presented below.

Peace engineering

Traditional engineering is a discipline with a top-down approach, based on complying with pre-established technical requirements, in contrast to an open and collaborative discipline that seeks to satisfy the social and environmental needs of the communities to whom it is directed. Peace is not defined as the absence of conflict, but as the relationship between individuals and social groups grounded in honesty, respect, and justice. Peace engineering commits to social justice, which

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

lacks a rigid definition and encompasses non-violence, reflexivity, action, and critical thinking (Jordan et al., 2021).

Critique of the STEM approach

Kwauk & Casey (2022) argue that the STEM approach is insufficient to address climate change, as it omits essential capabilities such as collaborative thinking, coping with emotions, creativity, and empathy (Monteiro & Sousa, 2024). They denounce that green skills “have nearly become synonymous with STEM skills” (p. 2). Instead, such skills should encompass abilities that can transform systems of inequality and inequity, which keep populations excluded within a structure of vulnerability, and of social and economic marginalization.

One notable area of inequality is gender: girls represent only 35% of students in STEM-related fields globally, a disparity consequence of cultural norms, social norms, lack of policies, and lack of opportunities (Kwauk & Casey, 2022).

According to Kwauk & Casey (2022), the climate crisis constitutes an adaptive challenge rooted in unjust economic and social systems. The solution lies in transforming the beliefs, values, worldviews, and paradigms that sustain these structures.

Critique of the concepts of sustainability, development, and sustainable development

The concept of sustainable development originated in the World Commission on Environment and Development (WCED) (also known as the Brundtland Commission) and consists of development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 16). This statement is imprecise because it does not define the needs of the present, nor those of the next generations, nor the relative importance between them. Griggs et al. (2013) offered a more exact definition as “the development that meets the needs of the present while safeguarding Earth’s life-support system, on which the welfare of current and future generations depends” (Griggs et al., 2013, p. 2). This approach still needs to clarify where the line is drawn between present and future well-being (Hummels & Argyrou, 2021).

Misiaszek & Rodrigues (2023) deconstruct the concept of sustainable development by posing two critical questions: How do higher education faculty define sustainability? And how do they define development? Two important aspects emerge: first, the issue of *development for whom*, since one group’s advancement may come at the expense of others or of nature itself. Second, whether development is taught in conjunction with sustainability, as this connection is essential for promoting environmental sustainability grounded in justice.

Teaching strategies

Climate change requires addressing complex problems and raising students’ awareness of social and ethical dilemmas. In this regard, various student-centered, contextual, practice-based, and digital pedagogical strategies have been promoted for its teaching (Hadgraft & Kolmos, 2020; Mann et al., 2021; Van den Beemt et al., 2020). In general, strategies that allow students to influence their own learning process have been shown to increase motivation and improve outcomes, resulting

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

in lower dropout rates, greater development of competencies, and increased knowledge retention (Hadgraft & Kolmos, 2020).

There have also been efforts to empirically determine which pedagogical strategies are most suitable for developing different sustainability competencies. Based on these competencies, expected learning outcomes can be defined, followed by the development of pedagogical experiences whose results can be measured through pre- and post-questionnaires (Segalàs Coral & Sánchez Carracedo, 2020). Another method involves surveying educators to identify which types of strategies they apply for each type of competence (Lozano et al., 2023).

Technology-mediated learning includes the use of techniques such as computer simulations, virtual laboratories, virtual and augmented reality, and artificial intelligence (Negi, 2024; Hassan et al., 2024). Another available technological resource is open-source software, including learning platforms and simulation tools; students may also be encouraged to create open educational resources or contribute to open-source software projects (Li et al., 2023).

The following is a list of the main pedagogical strategies proposed in the reviewed literature for teaching climate change and sustainability:

- **Problem-based learning:** Instructors present authentic problems that have been carefully designed or selected to align with the learning objectives, and students resolve them through inquiry and research (Van den Beemt et al., 2020; Hicks, 2022).
- **Project-based learning:** Students work in teams to tackle a real-world, open-ended problem by defining the stages, developing solutions, and presenting them to stakeholders. The project may be part of a course, integrated across several subjects, or function as a standalone unit within the curriculum, thus enabling the implementation of projects of varying sizes and learning goals (Van den Beemt et al., 2020; Hadgraft & Kolmos, 2020).
- **Challenge-based learning:** Students form interdisciplinary teams to solve real-world problems, often linked to community or industry, and develop concrete solutions through interaction and collaboration with stakeholders (Doulougeri et al., 2024). Martínez-Acosta et al. (2022) developed a theoretical framework linking SDGs with this methodology.
- **Practice-based education:** Students engage in real-world contexts by taking on roles within companies or organizations, allowing them to work and learn in a situated manner. Typically, they are guided by a professional in the field who acts as a mentor, supporting them in the process of becoming socially and environmentally responsible engineers (Mann et al., 2021).
- **Service learning:** In this strategy, students lead community service activities as part of a course or project, with a focus on social justice and environmental responsibility (Segalàs Coral, & Sánchez Carracedo, 2020; Sánchez-Parkinson et al., 2023). It is also conceived as a tool for social and political transformation (Segalàs Coral, & Sánchez Carracedo, 2020; Hirsch et al., 2023).
- **Community-based learning:** A hybrid of project-based learning and service learning, in which students co-create innovative solutions in collaboration with stakeholders while also contributing to public education and social change (Hicks, 2022).
- **Capstone projects:** Abd-Elwahed & Al-Bahi (2021) developed a framework for integrating sustainability tools and indicators—such as the 6R principles (Recycle, Reduce, Reuse, Remanufacture, Redesign, and Recover) and Life Cycle Assessment (LCA)—into final-year engineering projects.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Conclusions

While the reviewed literature shows broad consensus on curricular approaches, competencies, and pedagogical strategies, several points of divergence remain. These are discussed below, along with recommendations that may serve as a foundation for future research.

Weak vs. strong sustainability

While some studies take for granted the United Nations' sustainable development framework, others criticize it for promoting economic growth and continuous development, factors that are argued to be at the root of the environmental crisis. Educational institutions and academic programs must choose between these approaches or present both under a pluralistic perspective (Tryggvason et al., 2023). Attfield (2015) asserts that "without sustainable development, environmental problems will predictably worsen. However, its attainment involves a restructuring of international trade and finance, and thus of international relations" (p. 3).

Comparison of learning strategies

Most studies advocate for active, student-centered teaching strategies such as project-based learning. However, these methods might be better positioned as complementary to, rather than substitutes for, direct instruction (Montanero Fernández, 2019). There is a need for more empirical studies comparing the effectiveness of different instructional approaches, including direct instruction, in sustainability education.

Technological competencies

Although there is consensus regarding general sustainability competencies—such as systems thinking and anticipatory skills—it is necessary to design competencies related to specific technologies that are currently relevant. These include renewable energy, green manufacturing processes for cement, steel, and other materials, as well as sustainable urban development.

Critique of the STEM approach

Climate change mitigation constitutes an adaptive challenge and therefore requires a societal transformation that cannot be achieved through a STEM-focused approach alone. It is essential to change prevailing beliefs and values that perpetuate injustice and social inequality. This calls for competencies such as entrepreneurship, empathy, disruptive thinking, and political responsibility.

Gender gap

While girls represent only 35% of students enrolled in STEM-related fields globally (Kwauk & Casey, 2022), it has been shown that "women are more likely to believe that they have an obligation to address sustainability-related issues in their future careers and are more willing to do so" (Yuan et al., 2024, p. 5). Reducing gender inequality can help transform the dominant values and skills within engineering. To close this gap, it is necessary to re-educate social and cultural norms, improve gender-sensitive programs and policies, and expand specific training opportunities for women (IRENA, 2020).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The role of design in engineering

Many studies advocate for interdisciplinary approaches and the integration of design skills within engineering education. However, others highlight the challenges engineering students face when engaging with these approaches. It may be necessary to segment or personalize engineering education to accommodate two types of students: those with creative skills, vision, and leadership potential, and those who prefer a more reductionist approach.

Alignment with industry skill demands

In connection with the previous point, it is crucial to maintain continuous collaboration with industry in order to monitor the skills and professional profiles required for sustainability. Beyond emerging trends such as Industry 5.0 and interdisciplinary collaboration, fieldwork-based research is needed to identify the actual competencies practiced in industry. Such collaboration also facilitates the development of both technical and soft skills in the workplace aligned with sustainability goals.

Assessment

Although existing evaluation frameworks are available (Segalàs Coral, & Sánchez Carracedo, 2020), future research could focus on the development and application of standardized metrics for assessing sustainability competencies. Advancements in this area could be integrated into international monitoring and reporting mechanisms, such as National Communications under the UNFCCC and the United Nations' Voluntary National Reviews.

Acknowledgements

The author wishes to thank Dr. Fabio Chacón for his valuable comments on an earlier draft of this manuscript.

Bibliographic references

- Abd-Elwahed, M. S., & Al-Bahi, A. M. (2021). Sustainability awareness in engineering curriculum through a proposed teaching and assessment framework. *International Journal of Technology & Design Education*, 31(3), 633–651. <https://doi.org/10.1007/s10798-020-09567-0>
- Aleixo, A. M., Leal, S., & Azeiteiro, U. M. (2021). Higher education students' perceptions of sustainable development in Portugal. *Journal of Cleaner Production*, 327, 129429. <https://doi.org/10.1016/j.jclepro.2021.129429>
- Allan, R. P., Arias, P. A., Berger, S., Canadell, J. G., Cassou, C., Chen, D., ... & Zickfeld, K. (2023). Intergovernmental Panel on Climate Change (IPCC). Summary for Policymakers. In *Climate change 2021: The physical science basis. Contribution of Working Group I to the sixth assessment report of the Intergovernmental Panel on Climate Change* (pp. 3–32). Cambridge University Press. <https://doi.org/10.1017/9781009157896.001>
- Anapey, G. M. (2024). Achieving education for sustainable education learning outcomes: an integrated model for higher education in the global South. *International Journal of Educational Reform*. <https://doi.org/10.1177/10567879241270503>
- Ashraf, M. W., & Alanezi, F. (2020). Incorporation of sustainability concepts into the engineering core program by adopting a micro curriculum approach: A case

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- study in Saudi Arabia. *Sustainability*, 12(7), 2901. <https://doi.org/10.3390/su12072901>
- Attfeld, R. (2015). *Ethics of the global environment*. Edinburgh University Press. <https://doi.org/10.1515/9780748654826>
- Bamisile, O., Acen, C., Cai, D., Huang, Q., & Staffell, I. (2025). The environmental factors affecting solar photovoltaic output. *Renewable and sustainable energy reviews*, 208, 115073. <https://doi.org/10.1016/j.rser.2024.115073>
- Banza Lubaba Nkulu, C., Casas, L., Haufroid, V., De Putter, T., Saenen, N. D., Kayembe-Kitenge, T., ... & Nemery, B. (2018). Sustainability of artisanal mining of cobalt in DR Congo. *Nature sustainability*, 1(9), 495–504. <https://doi.org/10.1038/s41893-018-0139-4>
- Biancardi, A., Colasante, A., D'Adamo, I., Daraio, C., Gastaldi, M., & Uricchio, A. F. (2023). Strategies for developing sustainable communities in higher education institutions. *Scientific Reports*, 13(1), 1–19. <https://doi.org/10.1038/s41598-023-48021-8>
- Byrne, E. P. (2023). The evolving engineer; professional accreditation sustainability criteria and societal imperatives and norms. *Education for Chemical Engineers*, 43, 23–30. <https://doi.org/10.1016/j.ece.2023.01.004>
- Cerutti, F. (2016). Climate ethics and the failures of 'normative political philosophy'. *Philosophy & Social Criticism*, 42(7), 707–726. <https://doi.org/10.1177/0191453715626755>
- Cook, T., & Elliott, D. (2025). Green skills gap—A way ahead. *Frontiers in Sociology*, 10, 1577037. <https://doi.org/10.3389/fsoc.2025.1577037>
- Dechezleprêtre, A., & Kelly, P. (2025). *Venture capital, innovation and business success in cleantech startups: The new green economy*. OECD Publishing. <https://doi.org/10.1787/ba73f647-en>
- Doulougeri, K., Vermunt, J. D., Bombaerts, G., & Bots, M. (2024). Challenge-based learning implementation in engineering education: A systematic literature review. *Journal of Engineering Education*, 113(4), 1076–1106. <https://doi.org/10.1002/jee>
- Druker-Ibanez, S., & Caceres-Jensen, L. (2022). Integration of indigenous and local knowledge into sustainability education: a systematic literature review. *Environmental Education Research*, 28(8), 1209–1236. <https://doi.org/10.1080/13504622.2022.2083081>
- Fourati-Jamoussi, F., & Dubois, M. J. (2021). *Développement durable et innovation dans la formation d'ingénieurs: quelle perception des enseignants d'UniLaSalle?*. Cahiers COSTEC. <https://hal.science/hal-03255971v1>
- Gervais, J. (2016). The operational definition of competency-based education. *The Journal of Competency-Based Education*, 1(2), 98–106. <https://doi.org/10.1002/cbe2.1011>
- González-Pérez, L., Ramírez-Montoya, M., & Enciso-Gonzalez, J. (2023). Education 4.0 maturity models for society 5.0: systematic literature review. *Cogent Business & Management*, 10(3), 1–27. <https://doi.org/10.1080/23311975.2023.2256095>
- Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M. C., Shyamsundar, P., ... & Noble, I. (2013). Sustainable development goals for people and planet. *Nature*, 495(7441), 305–307. <https://doi.org/10.1038/495305a>
- Grimal, L., Marty, P., Perez, S., Troussier, N., Perpignan, C., & Reyes, T. (2020). Case study: Located pedagogical situations to improve global sustainable skills in engineering education and universities. *Procedia CIRP*, 90, 766–771. <https://doi.org/10.1016/j.procir.2020.02.136>
- Guerenabarrena-Cortazar, L., Olaskoaga-Larrauri, J., & Cilleruelo-Carrasco, E. (2021). Integration of sustainability in engineering and architectural studies

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- in Spanish universities. *Sustainability*, 13(14), 8044. <https://doi.org/10.3390/su13148044>
- Hadgraft, R. G., & Kolmos, A. (2020). Emerging learning environments in engineering education. *Australasian Journal of Engineering Education*, 25(1), 3–16. <https://doi.org/10.1080/22054952.2020.1713522>
- Hassan, N. H., Rahim, N. A. A., Hoong, A. L. S., & Mostafa, K. (2024). A Conceptual Study on Utilization of Artificial Intelligence (AI), Virtual Reality (VR) and Augmented Reality (AR) on Green Education: Effectiveness and Engagement. In *International Conference on Intelligent Manufacturing and Robotics* (pp. 270-278). Singapore: Springer Nature Singapore.
- Hermann, R. R., & Bossle, M. B. (2020). Bringing an entrepreneurial focus to sustainability education: A teaching framework based on content analysis. *Journal of Cleaner Production*, 246, 119038. <https://doi.org/10.1016/j.jclepro.2019.119038>
- Hicks, A. L. (2022). The role of community-based learning in teaching about industrial ecology and sustainability in the context of engineering education: A case study from the field. (2022). *Journal of Industrial Ecology*, 26(3), 1136–1146. <https://doi.org/10.1111/jiec.13224>
- Hirsch, J., Yow, R., & Wu, Y.-C. S. (2023). Teaching students to collaborate with communities: Expanding engineering education to create a sustainable future. *Engineering Studies*, 15(1), 30–49. <https://doi.org/10.1080/19378629.2023.2176767>
- Huang, Y. M., Silitonga, L. M., & Wu, T. T. (2022). Applying a business simulation game in a flipped classroom to enhance engagement, learning achievement, and higher-order thinking skills. *Computers & Education*, 183, 104494. [10.1016/j.compedu.2022.104494](https://doi.org/10.1016/j.compedu.2022.104494)
- Hummels, H., & Argyrou, A. (2021). Planetary demands: Redefining sustainable development and sustainable entrepreneurship. *Journal of Cleaner Production*, 278, 123804. <https://doi.org/10.1016/j.jclepro.2020.123804>
- IRENA. (2020). *Wind Energy: A Gender Perspective*. IRENA.
- Jamieson, M. V., Lefsrud, L. M., Sattari, F., & Donald, J. R. (2021). Sustainable leadership and management of complex engineering systems: A team based structured case study approach. *Education for Chemical Engineers*, 35, 37–46. <https://doi.org/10.1016/j.ece.2020.11.008>
- Jordan, R., Agi, K., Arora, S., Christodoulou, C. G., Schamiloglu, E., Koechner, D., ... & Lehr, J. (2021). Peace engineering in practice: A case study at the University of New Mexico. *Technological Forecasting and Social Change*, 173, 121113. <https://doi.org/10.1016/j.techfore.2021.121113>
- Kemp, L., Xu, C., Depledge, J., Ebi, K. L., Gibbins, G., Kohler, T. A., ... & Lenton, T. M. (2022). Climate endgame: Exploring catastrophic climate change scenarios. *Proceedings of the National Academy of Sciences*, 119(34). <https://doi.org/10.1073/pnas.2108146119>
- Kioui, V., & Voulvoulis, N. (2022). The contribution of higher education to sustainability: the development and assessment of sustainability competences in a university case study. *Education Sciences*, 12(6), 406. <https://doi.org/10.3390/educsci12060406>
- KTH. (2025). *Sustainability objectives and measures for education 2021-2025*. <https://acortar.link/VxSj8M>
- Kwauk, C. T., & Casey, O. M. (2022). A green skills framework for climate action, gender empowerment, and climate justice. *Development Policy Review*, 40, 1–19. <https://doi.org/10.1111/dpr.12624>
- Leal Filho, W., Sima, M., Sharifi, A., Luetz, J. M., Salvia, A. L., Mifsud, M., ... & Lokupitiya, E. (2021). Handling climate change education at universities: an

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- overview. *Environmental Sciences Europe*, 33(1), 109. <https://doi.org/10.1186/s12302-021-00552-5>
- Li, H., Huang, Z., Yang, T., Zhang, W., Chen, M., Li, Z., & Ren, K. (2023). Individual sustainability competence development in engineering education: Community interaction open-source learning. *PLoS ONE*, 18(11), 1–19. <https://doi.org/10.1371/journal.pone.0294421>
- LinkedIn. (2024). *Global Green Skills Report 2024*. <https://acortar.link/T3VLP0>
- Lozano, R., & Barreiro-Gen, M. (2022). Connections between sustainable development competences and pedagogical approaches. In *Competences in Education for Sustainable Development: Critical Perspectives* (pp. 139-144). Cham, Switzerland: Springer International Publishing.
- Lozano, R., Barreiro-Gen, M., D'amato, D., Gago-Cortes, C., Favi, C., Martins, R., ... & Gladysz, B. (2023). Improving sustainability teaching by grouping and interrelating pedagogical approaches and sustainability competences: Evidence from 15 Worldwide Higher Education Institutions. *Sustainable Development*, 31(1), 349–359. <https://doi.org/10.1002/sd.2396>
- Mann, L., Chang, R., Chandrasekaran, S., Coddington, A., Daniel, S., Cook, E., ... & Smith, T. D. (2021). From problem-based learning to practice-based education: A framework for shaping future engineers. *European Journal of Engineering Education*, 46(1), 27–47. <https://doi.org/10.1080/03043797.2019.1708867>
- Martin, M. J., Diem, S. J., Karwat, D. M. A., Krieger, E. M., Rittschof, C. C., Bayon, B., Aghazadeh, M., Asensio, O., Zeilkova, T. J., Garcia-Cazarin, M., Alvelo Maurosa, J. G., & Mahmoud, H. (2022). The climate is changing. Engineering education needs to change as well. *Journal of Engineering Education*, 111(4), 740–746. <https://doi.org/10.1002/jee.20485>
- Martínez Valdivia, E., Pegalajar Palomino, M. D. C., & Burgos-Garcia, A. (2023). Active methodologies and curricular sustainability in teacher training. *International Journal of Sustainability in Higher Education*, 24(6), 1364-1380. <https://doi.org/10.1108/IJSHE-05-2022-0168>
- Martínez-Acosta, M., Membrillo-Hernández, J., & Cabañas-Izquierdo, M. R. (2022). Sustainable Development Goals Through Challenge-Based Learning Implementation in Higher Education – Education for Sustainable Development (ESD). In E. Vilalta-Perdomo, J. Membrillo-Hernández, R. Michel-Villarreal, G. Lakshmi, & M. Martínez-Acosta (Eds.), *The Emerald Handbook of Challenge Based Learning*. Emerald Publishing Limited. <https://doi.org/10.1108/978-1-80117-490-920221012>
- Mazur, B., & Walczyna, A. (2022). Sustainable development competences of engineering students in light of the industry 5.0 concept. *Sustainability*, 14(12), 7233. <https://doi.org/10.3390/su14127233>
- Misiaszek, G. W., & Rodrigues, C. (2023). Six critical questions for teaching justice-based environmental sustainability (JBES) in higher education. *Teaching in Higher Education*, 28(1), 211–219. <https://doi.org/10.1080/13562517.2022.2114338>
- Montanero Fernández, M. (2019). Métodos pedagógicos emergentes para un nuevo siglo: ¿Qué hay realmente de innovación? *Teoría de la Educación: Revista Interuniversitaria*, 31(1), 5–34. <https://doi.org/10.14201/teri.19758>
- Monteiro, F., & Sousa, A. (2024). Decentring engineering education beyond the technical dimension: Ethical skills framework. *London Review of Education*, 22(1), 1–21. <https://doi.org/10.14324/LRE.22.1.23>
- Ncube, B., Yeboah, G., & Pandey, P. (2026). Education for sustainable development in higher education: a systematic review of leadership, pedagogy and curriculum design. *International Journal of Sustainability in Higher Education*, 1-32. <https://doi.org/10.1108/IJSHE-08-2025-0945>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- Negi, S. K. (2024). Exploring the impact of virtual reality and augmented reality technologies in sustainability education on green energy and sustainability behavioral change: A qualitative analysis. *Procedia Computer Science*, 236, 550-557. <https://doi.org/10.1016/j.procs.2024.05.065>
- Nikolić, V. M., & Vukić, T. M. (2021). Sustainable development as a challenge of engineering education. *Thermal Science*, 25(3A), 1921-1933. <https://doi.org/10.2298/TSCI200726304N>
- Ortiz-Marcos, I., Breuker, V., Rodríguez-Rivero, R., Kjellgren, B., Dorel, F., Toffolon, M., Uribe, D., & Eccli, V. (2020). A framework of global competence for engineers: The need for a sustainable world. *Sustainability*, 12(22), 9568. <https://doi.org/10.3390/su12229568>
- Owuondo, J. (2023). Advancing sustainable development in the Global South: Aligning education with the SDGs for lasting impact. *International Journal of Research and Innovation in Social Science*, 7(10), 1116. <https://dx.doi.org/10.47772/IJRISS.2023.701090>
- Perpignan, C., Baouch, Y., Robin, V., & Eynard, B. (2020). Engineering education perspective for sustainable development: A maturity assessment of cross-disciplinary and advanced technical skills in eco-design. *Procedia CIRP*, 90, 748-753. <https://doi.org/10.1016/j.procir.2020.02.051>
- Rolston III, H. (2020). *A new environmental ethics: the next millennium for life on Earth*. New York, EE.UU: Routledge. <https://doi.org/10.4324/9781003036746>
- Saakwor Batsa, A., Li, S., & Khajuria, A. (2025). Action Competence in Sustainable Development (ACiSD): A systematic review of the contributing factors and learning strategies. *International Journal of Development and Sustainability*, 14(1), 29-70. <https://doi.org/10.63212/ijds24100801>
- Sánchez-Parkinson, L., Burleson, G. E., Holloway, J. P., Sienko, K. H., Moses, N. D., Daly, S. R., Conger, A., & Meadows, L. (2023). Intercultural Experiences of Engineering Students During Immersive Design Projects. *International Journal for Service Learning in Engineering*, 18(1), 35-51. <https://ojs.library.queensu.ca/index.php/ijse/article/view/16083>
- Secretary of State for Energy Security and Net Zero. (2025). *United Kingdom of Great Britain and Northern Ireland's 2035 Nationally Determined Contribution*. <https://acortar.link/p0Lzdj>
- Segalàs Coral, J., & Sánchez Carracedo, F. (2020). Educating for sustainable development goals in spanish engineering degrees. *Proceedings of SEFI 2020: 48th Annual Conference "Engaging engineering education", The Netherlands*, 485-497.
- Semerikov, S., Striuk, A., Striuk, L., Striuk, M., & Shalatska, H. (2020). Sustainability in Software Engineering Education: A case of general professional competencies. *Proceedings of The International Conference on Sustainable Futures*, 166. <https://doi.org/10.1051/e3sconf/202016610036>
- Shahidul, M. I. (2020). Engineering education for achieving sustainable development goals by 2030: Revealing the paths for challenging climate change and Covid 19. *Sci.Int. (Lahore)*, 32(4), 403-410. <https://www.sci-int.com/pdf/637316132626985289.pdf>
- Shekhar, P., Dominguez, H., Lee, J. W., & Augustin, S. (2024). Investigating mechanical engineering students' approaches to opportunity recognition process. *International Journal of Mechanical Engineering Education*, 52(1), 43-62. <https://doi.org/10.1177/03064190231169129>
- Sigahi, T. F. A. C., & Szelwar, L. I. (2022). Exploring applications of complexity theory in engineering education research: A systematic literature review. *Journal of Engineering Education*, 111(1), 232-260. <https://doi.org/10.1002/jee.20438>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

- Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of business research*, 104, 333–339. <https://doi.org/10.1016/j.jbusres.2019.07.039>
- Taboada-González, P., & Aguilar-Virgen, Q. (2024). The Perception of Undergraduate Students from Different Educational Systems on Sustainability. *SAGE Open*, 14(2), 1–10. <https://doi.org/10.1177/21582440241243153>
- Tryggvason, Á., Öhman, J., & Van Poeck, K. (2023). Pluralistic environmental and sustainability education—a scholarly review. *Environmental Education Research*, 29(10), 1460–1485. <https://doi.org/10.1080/13504622.2023.2229076>
- UNFCCC. (2025). *2025 NDC Synthesis Report*. <https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs/2025-ndc-synthesis-report>
- Van den Beemt, A., MacLeod, M., Van der Veen, J., Van de Ven, A., Van Baalen, S., Klaassen, R., & Boon, M. (2020). Interdisciplinary engineering education: A review of vision, teaching, and support. *Journal of engineering education*, 109(3), 508–555. <https://doi.org/10.1002/jee.20347>
- Varadarajan, S. (2023). Contradictions and paradoxes in design-centric engineering education: A complex responsive processes perspective. *International Journal of Technology & Design Education*, 33(2), 685–716. <https://doi.org/10.1007/s10798-022-09744-3>
- WCED. (1987). *Our Common Future*. World Commission on Environment and Development. Oxford University Press.
- Weissbrodt, D. G., Winkler, M. K., & Wells, G. F. (2020). Responsible science, engineering and education for water resource recovery and circularity. *Environmental Science: Water Research & Technology*, 6(8), 1952–1966. <https://doi.org/10.1039/D0EW00402B>
- Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: a reference framework for academic program development. *Sustainability science*, 6, 203–218. <https://doi.org/10.1007/s11625-011-0132-6>
- Xu, X., Lu, Y., Vogel-Heuser, B., & Wang, L. (2021). Industry 4.0 and Industry 5.0—Inception, conception and perception. *Journal of manufacturing systems*, 61, 530–535. <https://doi.org/10.1016/j.jmsy.2021.10.006>
- Yuan, W., Ma, Y., Deng, Y., & Liu, X. (2024). Factors Affecting Sustainability-Related Career Expectations among Engineering Undergraduates in China: An Empirical Study Based on a Modified College Impact Model. *Behavioral Sciences*, 14(5), 409. <https://doi.org/10.3390/bs14050409>
- Žalėnienė, I., & Pereira, P. (2021). Higher education for sustainability: A global perspective. *Geography and Sustainability*, 2(2), 99–106. <https://doi.org/10.1016/j.geosus.2021.05.001>
- Zuin, V. G., Eilks, I., Elschami, M., & Kümmerer, K. (2021). Education in green chemistry and in sustainable chemistry: Perspectives towards sustainability. *Green Chemistry*, 23(4), 1594–1608. <https://doi.org/10.1039/D0GC03313H>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Eficacia del modelo integrado de desarrollo de habilidades de investigación (IRSDM) en la educación superior: un estudio cuasiexperimental en Ucrania

Effectiveness of the integrated research skills development model (IRSDM) in higher education: a quasi-experimental study in Ukraine

Volodymyr Yatsenko¹  Oksana Protas²  Olena Striliuk³  Anna Chepeliuk⁴  Andrii Rybalko⁵ 

Afiliación autor:

¹ Candidate of Pedagogical Sciences, Senior Researcher, Senior Researcher of the Department of Geography and Economics, Department of Geography and Economics, Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine. yatsenko_v@ukr.net

² Doctor of Pedagogical Sciences, Professor, Professor of the Department of Social Pedagogy and Social Work, Faculty of Education, Vasyl Stefanyk Carpathian National University, Ivano-Frankivsk, Ukraine. oksana.protas@cnu.edu.ua

³ PhD in History, Associate Professor, Associate Professor of the Department of World History and International Relations, T. H. Shevchenko National University "Chernihiv Colehium", Chernihiv, Ukraine. olenastriliuk@ukr.net

⁴ Candidate of Pedagogical Sciences, Associate Professor, Associate Professor of the Department of Theory and Methods of Physical Education and Sports Drohobych Ivan Franko State Pedagogical University, Faculty of Human Health and Natural Sciences, Drohobych, Ukraine. anna.chepelyuk79@gmail.com

⁵ Candidate of Pedagogical Sciences, Associate Professor, Associate Professor of the Department of Chemistry and Physics, Department of Chemistry and Physics, Educational and Scientific Institute of Agroecology and Land Management, National University of Water and Environmental Engineering, Rivne, Ukraine. a.v.rybalko@nuwm.edu.ua

Recibido: 01/02/26

Aceptado: 30/04/26

Cómo citar:

Yatsenko, V., Protas, O., Striliuk, O., Chepeliuk, A., & Rybalko, A. (2026). Effectiveness of the integrated research skills development model (IRSDM) in higher education: a quasi-experimental study in Ukraine. *Revista Eduweb*, 20(2), 53-69. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.4>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

 Open Acces

Resumen

El propósito del estudio fue determinar el impacto del modelo integrador del autor, construido sobre una combinación de aprendizaje basado en proyectos, aprendizaje basado en la indagación, aprendizaje basado en la investigación y enfoques de laboratorios de investigación digital, en el nivel de desarrollo de la competencia investigativa de los solicitantes de educación. El estudio se implementó como un cuasi-experimento con la formación de grupos de control y experimental en el diseño de pre-prueba/post-prueba. La muestra total consistió en 248 estudiantes, que se dividieron en grupos experimentales (n = 124) y control (n = 124). La intervención duró un semestre (14 semanas) e incluyó cuatro módulos consecutivos destinados a desarrollar las habilidades de formulación de un problema científico. Los resultados mostraron un aumento en las habilidades de investigación en el grupo experimental en comparación con el grupo de control, lo que confirmó la efectividad del modelo IRSDM. Los mayores cambios positivos se registraron en los componentes de formulación de problemas de investigación, pensamiento analítico y trabajo con fuentes académicas. Las conclusiones destacan que la novedad científica del estudio consistió en el desarrollo y prueba empírica de un modelo integrador de formación de competencias investigativas en el contexto educativo ucraniano.

Palabras clave: aprendizaje basado en proyectos, competencia investigadora, cuasi-experimento, modelo de aprendizaje integrado, tecnologías educativas digitales.

Abstract

The study aimed to determine the impact of the author's integrative model, combining Project-Based Learning, Inquiry-Based Learning, Research-Based Learning, and Digital Research Labs, on learners' research competence development. The study was implemented as a quasi-experiment, with control and experimental groups formed in a pre-test/post-test design. The total sample consisted of 248 students, divided into an experimental (n = 124) and a control (n = 124) group. The intervention lasted one semester (14 weeks) and included four consecutive modules aimed at developing skills in formulating a scientific problem, working with sources, and methodological literacy. The author's scale of research skills was used to assess the results. The results showed greater improvement in research skills in the experimental group than in the control group, confirming the effectiveness of the IRSDM model. The greatest positive changes were recorded in the components of research problem formulation, analytical thinking, and working with academic sources. The conclusions emphasize that the study's scientific novelty lies in the development and empirical testing of an integrative model. From a practical perspective, the proposed model can be adopted by higher education institutions seeking to

modernize research training and enhance students' readiness for academic and professional challenges.

Keywords: digital educational technologies, integrated learning model, Project-Based Learning, quasi-experiment, research competence.

Introduction

In the 21st century, the formation of students' research skills has become one of the main factors in ensuring the quality of higher education. In the global academic space, the transition from a translational model of learning to a research-oriented paradigm is increasingly clearly outlined. Within its framework, students were not passive recipients of knowledge. They turned into active subjects of knowledge who were able to formulate scientific problems, critically analyze information, interpret data and present the results of their own research. In this context, research skills (research skills / research competencies) integrated various aspects of the cognitive, informational, methodological and communicative components, forming the basis for academic autonomy and professional mobility of future specialists.

International studies of recent years have demonstrated the effectiveness of innovative pedagogical approaches aimed at developing research competencies, in particular inquiry-based learning, problem-based learning, course-based undergraduate research experiences (CURE), and formative research (investigación formativa) (Valeriano Carrasco & James Wilfredo, 2023). The experience of Latin American countries has become important, where, in the context of transformational changes in educational systems, the search for models that combine academic standards, digitalization of education and contextual socio-cultural features has been implemented (Spector, 2025; Vovchasta et al., 2024). The studies that have been conducted have demonstrated that the systematic implementation of research-oriented courses, interdisciplinary projects and digital tools has significantly contributed to increasing the level of critical thinking, information literacy and academic independence of learners (Castillo-Martínez & Ramírez-Montoya, 2021).

At the same time, in the current conditions of Ukraine, the development of students' research skills is also becoming relevant. The educational system operates in conditions of military challenges, digital transformation and the need to integrate into the European scientific and educational space (Khryk et al., 2021; Turchyn et al., 2023). This has led to increased requirements for the quality of training of specialists who must reproduce knowledge and critically evaluate information, work with different types of sources and make informed decisions in conditions of uncertainty and complex situations. In addition, the spread of information threats and disinformation has actualized the importance of research skills as a component of academic integrity and information security (Aliyeva et al., 2023; Bohomaz et al., 2023; Boichenko et al., 2023). Despite the active implementation of digital technologies and the reform of higher education in Ukraine, the issue of the holistic integration of research-oriented approaches into the educational process remains insufficiently researched. Existing practices are often fragmentary and do not provide high-quality formation of research competencies. This has created the need to develop and empirically test integrated pedagogical models.

The purpose of the article was to develop and experimentally test the effectiveness of an integrated model of research skills development, which was created on the basis of international pedagogical approaches for the further development of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

research competencies of higher education students in Ukraine. Accordingly, the main tasks of the study were the theoretical substantiation of the integrated model of research skills development based on the analysis of international experience, and the empirical assessment of the level of development of research skills of education students before and after the implementation of the model (according to the quasi-experimental pre-test / post-test design with a control group).

It is also proposed to confirm or refute the following hypotheses:

H1. The use of the Integrated Research Skills Development Model (IRSDM) significantly increased the level of research skills among students.

H2. Students in the experimental group demonstrated a statistically significant increase in the level of research skills between the pre-test and the post-test, while in the control group such changes were insignificant.

Literature Review

In the international scientific discourse of the last decade, research skills (research skills / research competencies) have been analyzed from the perspective of understanding the integrative component of university learning outcomes. They encompass the ability to formulate scientific questions, conduct a critical analysis of the literature, apply appropriate methods of data collection and processing, understand the results and present them in understandable and acceptable forms. In modern models of the competency approach, research skills have been combined with cognitive, methodological, informational and communicative components.

Systematic reviews of publications in 2021–2024 demonstrated the fact that research competencies are increasingly integrated into the curricula of bachelor's, master's and postgraduate programs (Adeoye & Jimoh, 2023; Campos-Ugaz et al., 2022). The existence of such an approach undoubtedly corresponded to the concept of “research-informed teaching”, which involved involving students in elements of scientific activity from the first years of study (Guzmán-Valenzuela et al., 2023; Marín et al., 2025). At the same time, special attention is paid to the development of metacognitive strategies, the ability for self-regulated learning, and critical thinking as prerequisites for effective research activities.

In international practice, a number of approaches have been developed that have shown effectiveness in developing research skills (Mubarak & Selimin, 2023; Karpliuk et al., 2024).

The capabilities of Inquiry-based learning were based on involving students in independently formulating a problem, putting forward hypotheses, and finding solutions through the analysis of empirical data. Studies have shown that the systematic use of IBL increased the level of analytical thinking, argumentation ability, and skills in working with sources (Ratnawati & Idris, 2020; Sobarzo-Ruiz, 2023). This approach has become especially popular in STEM education, although it has also been increasingly used in social and humanitarian disciplines.

Problem-based learning is considered a model that promotes the integration of theoretical knowledge and practical research skills. Within the framework of PBL, students worked on real or close to real problems that required a thorough analysis of sources, the formation of an evidence base, and the presentation of results (Tapullima-Mori et al., 2025; Vélez Jiménez et al., 2022). Meta-analyses have shown the positive impact of PBL on the formation of critical thinking skills and

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

interdisciplinary integration of knowledge.

The CURE model involved integrating a research component directly into the structure of the course. Unlike individual research projects, CURE ensured the mass involvement of students in research activities. Empirical studies have shown that such courses generally had a positive impact on academic motivation, confidence in one's own research abilities, and the ability to independently plan scientific work (Ampa & Nurqalbi, 2021; Dighliya, 2024). The concept of investigación formativa (formative research) was actively developed, which involved the gradual formation of research skills through the integration of elements of scientific work into regular academic disciplines. Existing studies have shown that such a model contributed to an increase in the level of information literacy, academic writing, and the ability to independently search for scientific sources (Hryn et al., 2024; Mora-Pablo & González, 2025). However, despite the active development of these approaches, it has been proven that their implementation in educational practice has been mostly fragmented. Individual methods (IBL, PBL, CURE, digital tools) are used in isolation, without proper integration into a single pedagogical system. This limits their synergistic potential and does not ensure the formation of students' research skills.

Moreover, researchers emphasized that the need for institutional support and training of teachers to implement research-oriented methods was extremely important (Okolie et al., 2021).

The modern development of research skills is impossible without the formation of information and digital literacy. Recent studies have shown that educators often used digital tools fragmentarily and without proper critical assessment of sources (Songkram et al., 2024; Uribe-Tirado & Machin-Mastromatteo, 2024). The integration of information literacy courses into curricula has contributed to the development of skills in searching, selecting and analyzing scientific information. In addition, digital learning environments, online platforms and data analysis tools have expanded the possibilities of involving students in research activities (Salinas Velastegui et al., 2023). Modern universities have actively introduced digital modules for the preparation and support of writing diploma and master's theses. This approach has showed positive influence the quality of academic texts and the methodological soundness of research.

Despite the growing number of studies devoted to the development of research skills in higher education, the analysis of the current scientific literature has pointed out the existence of some gaps. First of all, there was no single operationalization of the concept of "research skills" in scientific works (Sernaqué et al., 2023). In different studies, this term covered different components: from critical thinking and information literacy to narrowly methodological skills. Primarily, examples of this situation were the lack of a clear differentiation between the concepts of research skills, research competencies, inquiry competence and academic literacy, etc (Meissner & Shmatko, 2018). In addition, most publications were based on short-term pedagogical interventions (semester courses, individual PBL or IBL modules), while the long-term impact of innovative approaches on the academic trajectory of students was not sufficiently investigated (Koyuncuoglu, 2020). This closed the prospect for further research on the proposed issue. Thus, there is a scientific and practical gap associated with the lack of integrated models that would combine effective pedagogical approaches within a single structured system and provide a long-term impact on the development of students' research skills.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

In this sense, the development of holistic pedagogical solutions that would ensure the integration of research-oriented approaches, digital tools, and interdisciplinary teaching methods has become particularly relevant.

Therefore, international studies will demonstrate the effectiveness of such approaches as Project-Based Learning, Inquiry-Based Learning, Research-Based Learning and digital laboratories in the development of individual components of research activities (Alberto et al., 2024). However, the analysis of modern publications has shown the fragmentation of the use of these approaches. In most cases, they were implemented in isolation, which limited their synergistic potential. Therefore, there was a need to create an integrated model. The proposed model provided for the structured implementation of problem-based, research and digital learning within a single system. The model became a certain pedagogical construct that was focused on measurable learning outcomes and experimental verification of effectiveness. Unlike existing approaches, the proposed model aims to integrate different pedagogical strategies and is focused on achieving measurable learning outcomes that are subject to empirical verification.

Methodology

Research design

The research design involved conducting a quasi-experimental study with control and experimental groups in a pre-test/post-test design. This study determined the cause-and-effect relationships between the implementation of the Integrated Research Skills Development Model (IRSDM) and the main changes in the system of research skills of higher education students.

The division into groups was made on the basis of academic study groups/streams (cluster approach), since individual randomization was organizationally difficult in the conditions of the real educational process.

Experimental group (EG): training using the IRSDM.

Control group (CG): training according to the traditional program/usual approaches, i.e., teaching took place here without specially structured IRSDM research training.

The intervention lasted 14 weeks (one semester) and was integrated into the corresponding educational course/module. Measurements were carried out twice: Pre-test (T1) at the beginning of the semester; Post-test (T2) after the intervention.

IRSDM was designed based on the international approaches PBL, Inquiry-Based Learning, Research-Based Learning and Digital Research Labs and implemented on the basis of 4 consecutive modules.

This approach was chosen intentionally to avoid disrupting the natural educational process in Ukrainian higher education institutions. Individual randomization of students was not possible due to organizational, ethical, and administrative constraints, as it would have required restructuring of existing academic groups and schedules. Therefore, the use of intact groups (cluster allocation) ensured the validity of the study.

Participants

The total number of study participants was 248 students studying in higher and

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

professional pre-higher education institutions of Ukraine. Students of educational programs of the humanitarian and socio-pedagogical direction were involved in the study. Disciplines that provided for the implementation of research tasks were integrated into the curricula of the group participants. In general, the sample was drawn up on the basis of purposeful selection and the following criteria were taken into account: 1. the possibility of integrating experimental methods into the educational process; 2. the presence of disciplines with a research component; 3. consent of the administration and teachers to implement the intervention; 4. voluntary informed consent of students. After the sample was formed, the participants were divided into experimental (EG) and control (CG) groups at the level of academic groups (cluster approach). The distribution was balanced: experimental group (EG): $n = 124$; control group (CG): $n = 124$.

The experimental group studied based on the author's IRSDM model. However, the control group mastered the educational material using the traditional method without the purposeful integration of research and digital modules.

In order to ensure the internal validity of the study, a preliminary test was conducted, which made it possible to determine the differences between the groups at the initial stage.

Table 1.
Characteristics of the study participants

Indicator	EG (n=124)	CG (n=124)	Загалом (N=248)
Mean age (M $\pm$ SD)	19.8 $\pm$ 1.2	19.9 $\pm$ 1.1	19.85 $\pm$ 1.15
1st year students	62 (50%)	60 (48.4%)	122 (49.2%)
2nd year students	62 (50%)	64 (51.6%)	126 (50.8%)
Women	82 (66.1%)	79 (63.7%)	161 (64.9%)
Men	42 (33.9%)	45 (36.3%)	87 (35.1%)
Previous experience in scientific work	38 (30.6%)	35 (28.2%)	73 (29.4%)

Note: M is the mean; SD is the standard deviation.

The sample size ($N = 248$) is sufficient for the application of parametric methods of statistical analysis (t-test, ANCOVA) and factor analysis of the research skills scale. These indicators exceeded the minimum requirements for ensuring statistical power (power ≥ 0.80 with an average effect $d \approx 0.5$).

Integrated model of research skills formation

The authors of the article developed an integrated model of research skills formation as an important innovative pedagogical system aimed at the formation of research competence of students based on the integration of internationally proven approaches: Project-Based Learning (PBL), Inquiry-Based Learning (IBL), Research-Based Learning (RBL) and the Digital Research Labs methodology.

Unlike previous and traditional forms of organizing learning, which were based on the preparation of a final written work, IRSDM provided for the formation of such skills as research thinking, methodological literacy and digital academic competence. This was carried out on the basis of the implementation of sequential educational modules.

The model is based on the following principles: integration, phasedness, research involvement and academic integration, digitalization.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

IRSDM was carried out over one semester (12–14 weeks), which consisted of four interconnected modules:

Module 1. Formulation of the problem and research question. This module provides for the analysis of current educational/social issues; the formation of a research question, the definition of the object, subject and purpose of the study and the development of critical thinking in applicants.

The structure of the model provided a gradual transition from basic research skills to more complex analytical and interpretive competencies. This approach was consistent with the logic of scaffolded learning and the gradual development of research competence.

Module 2. Working with sources and academic integrity. This stage provides for the search for scientific sources in international databases; assessment of the reliability of sources. The basics of citation and bibliography management were also covered. This stage also includes the use of digital tools (reference managers, academic search engines).

Module 3. Implementation of a mini-study (PBL + Inquiry). This stage includes the selection of data collection methods; development of tools (questionnaire, observation, etc.); collection and primary processing of data. Group project work is also provided.

Module 4. Interpretation and academic presentation of results. At this final stage, the analysis of results and the construction of arguments were carried out. Participants also visualized the data. A research report was prepared, and some participants made a scientific poster.

Research procedure

The study was conducted over one academic semester (14 weeks). The overall work involved three consecutive stages: preparatory, intervention and final.

From week 1 to 2, the preparatory stage lasted, during which the consent of the participants was obtained, initial testing was conducted. Teachers were also trained in the implementation of the IRSDM over a period of 1–2 weeks through a short methodological workshop. The training included an explanation of the model structure, detailed instructions for each of the four modules, sample tasks, and uniform assessment criteria. This ensured consistency in the application of the model across academic groups and minimized variability. At this stage, the assessment criteria for both groups were also unified. The pre-test included a diagnostic scale of research skills and a short practical task on formulating a research problem.

From week 3 to 13, the intervention stage lasted. The experimental group (EG) studied based on the author's IRSDM model, which included four consecutive modules (presented above). In general, the training took place through problem-oriented task methods; group project work; digital research tools; step-by-step methodological support. The control group (CG) was trained according to the traditional course program, which included a lecture-seminar form of work. The duration of the training load in both groups was the same.

At week 14, a final stage was held, during which a re-test (post-test) and evaluation

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

of mini-research projects were carried out using a standardized rubric. Final quantitative indicators were also collected. The obtained data were prepared for statistical analysis.

Measurement tools

Various quantitative and performative tools were used to assess the effectiveness of IRSDM.

An author's scale of research skills was developed, consisting of 25 statements grouped into 5 main subscales: 1. Formulation of a scientific problem. 2. Working with academic sources. 3. Methodological literacy. 4. Analysis and interpretation of data. 5. Academic communication. The assessment was carried out using a 5-point Likert scale (1 - completely disagree; 5 - completely agree). The validity and reliability of the scale were also tested, and the following indicators were obtained: Cronbach's α for the overall scale: ≥ 0.85 ; α for subscales: ≥ 0.78 ; KMO ≥ 0.80 ; Bartlett's test of sphericity ($p < .001$); EFA with varimax rotation was conducted.

The evaluation of mini research projects was carried out according to an analytical rubric, which included 4 criteria.

Problem formulation – 10 points
Working with sources – 10 points
Methodological literacy – 10 points
Justification of conclusions – 10 points
Maximum score – 40.

The assessment was carried out by two independent experts. Inter-expert agreement was carried out on the basis of the intraclass correlation coefficient (ICC ≥ 0.80).

Additionally, data were collected on research experience; digital literacy and average academic score. These variables were used as covariates in ANCOVA.

Data analysis

Statistical data processing was carried out on the basis of SPSS (version XX). Before the main analysis, data completeness and normality of distribution were checked (Shapiro–Wilk test). Since the distribution of research skills indicators did not have critical deviations from normal ($p > .05$), parametric methods were used for further analysis. To assess the internal consistency of the scale, the Cronbach's α coefficient was calculated: ($\alpha \geq 0.85$). Construct validity was tested based on exploratory factor analysis (EFA): KMO ≥ 0.80 ; Bartlett's test of sphericity — $p < .001$; The obtained factor structure corresponded to the theoretically defined components of research competence. To determine the homogeneity of the experimental (EG) and control (CG) groups before the intervention, the following was conducted: Independent samples t-test for pre-test indicators. No statistically significant differences between the groups were found at the initial stage ($p > 0.05$).

To insert the dynamics of the development of research skills in each group, the following was used: Paired samples t-test (comparison of pre-test and post-test). Also, Independent samples t-test (post-test) was conducted to compare the results in both groups. ANCOVA was also conducted, in which: dependent variable — post-test result; The independent variable is the groups, and the covariate is the pre-test

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

score. The intervention effect indicator was determined based on partial eta squared (η^2): The evaluation of mini-research projects was carried out using: Independent samples t-test (total score) and ICC calculation (inter-rater agreement test). An ICC coefficient ≥ 0.80 was defined as a high level of agreement.

Results and Discussion

Results

Research competence is one of the main meta-competences, which allows to ensure the ability of the student to independently learn, critically analyze information and produce new knowledge. Within the framework of this study, the effectiveness of the author's model was determined by comparing the results of the experimental and control groups according to the indicators of the formation of research skills. Before the intervention, the experimental and control groups were compared based on the indicator of the formation of research skills. The results of the independent samples t-test did not reveal statistically significant differences.

Table 2.

Comparison of indicators of research skills before the intervention

Indicator	EG (n=124) M $\pm$ SD	CG (n=124) M $\pm$ SD	t (246)	p
General level of research skills	3.21 $\pm$ 0.48	3.18 $\pm$ 0.51	0.84	0.402
Problem formulation	3.15 $\pm$ 0.52	3.12 $\pm$ 0.49	0.52	0.601
Working with sources	3.18 $\pm$ 0.50	3.14 $\pm$ 0.53	0.63	0.529
Methodological literacy	3.19 $\pm$ 0.55	3.17 $\pm$ 0.57	0.29	0.772
Data analysis	3.23 $\pm$ 0.47	3.20 $\pm$ 0.51	0.49	0.625
Academic communication	3.29 $\pm$ 0.46	3.26 $\pm$ 0.48	0.57	0.568

After the semester intervention, the level of development of research skills of higher education students was re-measured. The results of independent samples t-test showed the presence of intergroup differences in the integral indicator of research competence. The average score of the experimental group exceeded the corresponding indicator of the control group.

Table 3.

Comparison of EG and CG results after the intervention (Post-test)

Indicator	EG (n=124) M $\pm$ SD	CG (n=124) M $\pm$ SD	t (246)	p	Cohen's d
General level of research skills	4.12 $\pm$ 0.46	3.68 $\pm$ 0.51	7.41	<.001	0.87
Problem formulation	4.18 $\pm$ 0.52	3.74 $\pm$ 0.56	6.58	<.001	0.79
Working with sources	4.20 $\pm$ 0.48	3.71 $\pm$ 0.53	7.02	<.001	0.85
Methodological literacy	4.05 $\pm$ 0.55	3.62 $\pm$ 0.57	6.03	<.001	0.74
Data analysis	4.07 $\pm$ 0.51	3.63 $\pm$ 0.59	6.45	<.001	0.78
Academic communication	4.10 $\pm$ 0.47	3.70 $\pm$ 0.52	6.11	<.001	0.75

As can be seen from the table, after the intervention, all indicators of research competence in the experimental group exceeded the corresponding indicators of the control group ($p < .001$). The effect sizes (Cohen's d ranging from 0.74 to 0.87) indicate a strong practical impact of the intervention on student learning outcomes. According to conventional controls, these values correspond to significant effects, confirming that the IRSDM model led to improvements in research skills. The largest

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

effect was recorded for working with sources ($d = 0.85$), formulating a scientific problem ($d = 0.79$) and analytical skills ($d = 0.78$). These results support hypothesis H1 on the model's effectiveness.

Figure 1 shows the dynamics of changes in the level of research skills in the experimental and control groups before and after the intervention. As can be seen from the graphic visualization, at the initial stage (pre-test) the average scores of both groups were almost identical. After the semester intervention, the experimental group had an increase in the average score. The visualization clearly reflects the pronounced effect of the implementation of the IRSDM model.

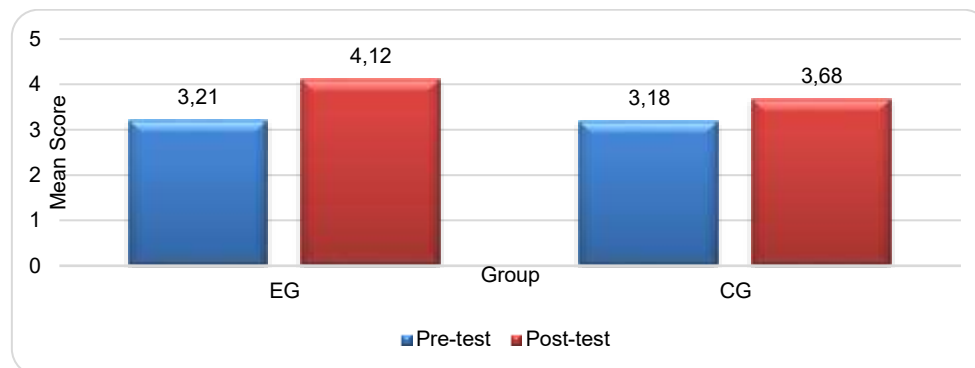


Figure 1. Changes in general research skills (before and after)

To control for the potential impact of baseline differences in research skills, an analysis of covariance (ANCOVA) was conducted, with posttest as the dependent variable, group as the independent variable, and pretest as the covariate. This approach allowed us to isolate the effect of the IRSDM model based on statistical adjustment for baseline differences. The results showed that the group effect remained statistically significant: $F(1, 245) = 52.36$, $p < .001$, partial $\eta^2 = .18$. The resulting partial η^2 value indicated a large effect size. Thus, the observed improvement in research skills was due primarily to the intervention, rather than to baseline group differences.

At the next stage, changes in the level of research skills within each group between the initial (pre-test) and final (post-test) measurements were studied. For this, paired samples t-test was conducted. The results showed positive dynamics in the experimental group.

Table 5.

Intra-group dynamics of research skills indicators (Pre–Post)

Group	Pre-test M ± SD	Post-test M ± SD	t	p	Cohen's d
EG (n=124)	3.21 ± 0.48	4.12 ± 0.46	15.84	<.001	1.42
CG (n=124)	3.18 ± 0.51	3.68 ± 0.51	1.94	.054	0.17

Thus, in the experimental group, an increase in the level of research skills was recorded ($t = 15.84$, $p < 0.001$). The value of Cohen's $d = 1.42$ indicated a large effect of the intervention. In the control group, a positive trend is noticeable, but it did not reach the level of statistical significance ($p = 0.054$). In addition, the effect size was minimal ($d = 0.17$), which corresponds to a small effect. Thus, the results obtained confirm the hypothesis H2 and indicate that the dynamics in the experimental group are the result of the systematic implementation of the model.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Thus, the results presented in Table 5 support hypothesis H2 and indicate that the increase in the experimental group was not due to chance. Furthermore, the very large effect size (Cohen's $d = 1.42$) indicated a significant impact on the development of students' research skills.

The next part of the study involved determining the components of research competence that developed most under the influence of the model. The comparison was carried out between the pre-test and the post-test indicators in the experimental group using a paired samples t-test. The analysis showed that positive dynamics are noticeable for all components. However, the intensity of changes was not the same.

Table 6.

Dynamics of development of research competence components in the experimental group

Component	Pre-test M $\pm$ SD	Post-test M $\pm$ SD	t	p	Cohen's d
Problem formulation	3.15 $\pm$ 0.52	4.18 $\pm$ 0.52	13.94	<.001	1.25
Working with sources	3.18 $\pm$ 0.50	4.20 $\pm$ 0.48	14.62	<.001	1.31
Methodological literacy	3.19 $\pm$ 0.55	4.05 $\pm$ 0.55	11.48	<.001	1.03
Data analysis and interpretation	3.23 $\pm$ 0.47	4.07 $\pm$ 0.51	12.16	<.001	1.09
Academic communication	3.29 $\pm$ 0.46	4.10 $\pm$ 0.47	11.73	<.001	1.05

Figure 2 shows the data of the performative evaluation of the mini-research projects of the learners based on the involvement of four criteria and the integral indicator.

Visual analysis indicated the superiority of the experimental group in all components of the evaluation.

A particularly pronounced difference is observed in the integral indicator of the quality of the research project.

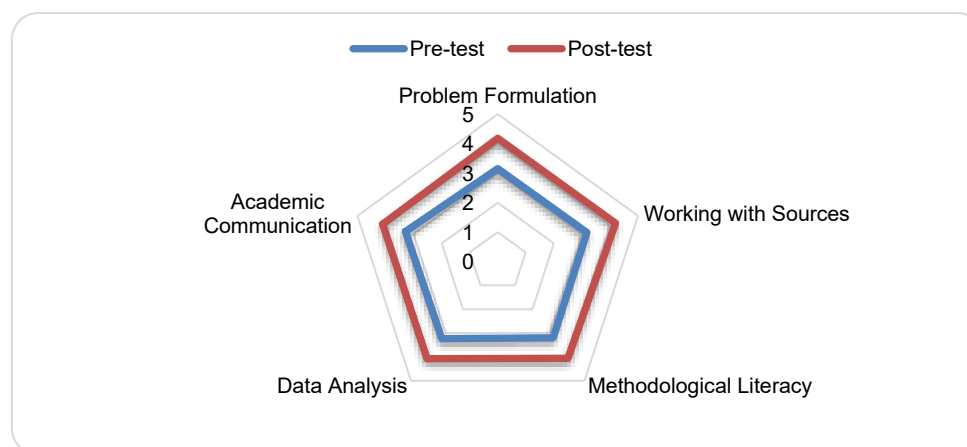


Figure 2. Development of Research Competence Components (EG)

The largest increase is observed in working with academic sources ($d = 1.31$), reflecting a very large effect size and indicating a significant transformation in students' ability to search for, evaluate, and use scholarly information. Moreover, the indicator of formulating a scientific problem also showed growth ($d = 1.25$). The components of methodological literacy, analytical skills and academic

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

communication also had large effects ($d > 1.0$). Thus, the model ensured the development of all structural components.

Discussion

The results of the quasi-experimental study indicated the effectiveness of the developed integrated model (IRSDM) for the formation of research competence of higher education students. Notably, the obtained data indicated noticeable intergroup differences after the intervention. The proposed hypotheses were confirmed. In particular, (H1) was confirmed: the use of IRSDM led to a statistically significant increase in the level of research skills compared to the traditional teaching method. The value of Cohen's d within large effects and partial $\eta^2 = .18$ indicated the practical significance of the changes.

The second hypothesis (H2) was also empirically confirmed. The experimental group received an increase in indicators between the pre-test and the post-test. This made it possible to indicate that the detected effect was a consequence of the systematic implementation of IRSDM. The effectiveness of the model can be explained by its integrative structure, which consisted of cognitive, methodological, and digital components of research activity within a single pedagogical system. Unlike isolated teaching approaches, IRSDM provided research skills development that allowed students to move from basic problem formulation to data interpretation and academic communication.

The results obtained made it possible to indicate the importance of the formation of research skills for learners based on IRSDM. High effect sizes (Cohen's $d > 0.8$) indicated that the model was not limited to a isolated improvement in individual skills. It affected the cognitive system of research competence. In addition, the most noticeable changes could be recorded in the components of problem formulation and work with academic sources. One factor explaining this result is the "digital amplification" effect. The integration of digital tools, academic databases, and reference management systems (Module 2) significantly expanded students' access to high-quality sources and improved their ability to critically evaluate information. This explains the particularly large effect size for source work ($d = 1.31$), indicating not only improved skills but also a transformation in how students interact with academic knowledge. This can be explained by the fact that IRSDM shifted the focus from reproductive task performance to cognitively active activity. In this system, the functions of forming a research question, selecting relevant information and evaluating it began to play an important role. In the traditional learning model, these processes often remain implicit.

Thus, the results indicated that a digital research system can create conditions for the transition from superficial assimilation to a conceptual understanding of research methodology. Such data can also be found in other scientists (Barragán Díaz, 2019; Enriquez et al., 2023). Specifically, studies of digital technologies and project-oriented models indicated a positive impact on the formation of critical thinking and problem-solving skills (Laura-De La Cruz et al., 2023). The obtained results confirmed these conclusions and indicated a more pronounced effect. This can be explained by the phased integration of project activities with the methodological module. Unlike classical project-based learning, which often focuses primarily on the final product, the IRSDM model includes a structured phase of methodological reflection and step-by-step calcification. This ensures that students not only complete research tasks, but also consciously develop methodological understanding, which explains higher results in methodological literacy and data

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

analysis (Lander et al., 2019). The authors also determined that it is worth focusing on the development of cognitive autonomy based on certain research questions (Nikitchenko et al., 2024; Sivarajah et al., 2019). In this study, similar mechanisms were identified in the degree of the problem formulation indicator.

Moreover, the developed model was distinguished by the structure of the sequence of stages. If previous models were implemented as an open process, then in the proposed model each stage was logically connected to the next and was associated with digital support tools. This made it possible to reduce cognitive overload. This structured sequential ordering acted as a form of cognitive scaffolding, reducing fragmentation in learning and supporting the gradual acquisition of research practices.

In addition, the theory of research-based learning, which is presented in modern literature, emphasized the importance of integrating research experience into the educational process. At the same time, the results obtained regarding performative assessment are fully consistent with this paradigm. A significant increase in the quality of mini-research projects also indicated that the practical implementation of the research cycle had a significant impact. Furthermore, the developed model expanded the research component by involving the digital component. In addition, the integration of academic search engines and visualization tools formed the effect of "digital amplification" for conducting research activities. Other studies also indicated the effectiveness of individual pedagogical tools and digital laboratories (Rodríguez et al., 2019; Tamožhska et al., 2024). In this case, the integration of such approaches into a single structured model provided a synergistic effect. It was the combination of such aspects as problematization and digital academic literacy that led to the high value of the effect (Bapanova et al., 2023; Castillo-Martínez et al., 2023). The results also indicated the importance of the constructivist learning paradigm, according to which knowledge is formed based on active activity and reflection. The developed model also indicated that research competence does not arise only because of completing coursework. This requires systemic space of formation. Thus, the study contributed to the understanding that the effectiveness of the development of research skills is determined by an integrated structure. This distinguishes the present study from previous research, which primarily focused on individual approaches rather than their systematic combination. Although earlier scientists emphasized the importance of individual methods (Edeh et al., 2021; Garay-Argandona et al., 2021). Moreover, the authors of this article suggested the importance of a systemic approach.

Despite the statistically significant results obtained, the study had several limitations that needed to be considered. First, the proposed sample was formed according to the principle of purposive selection and included students of humanitarian and socio-pedagogical majors. This approach significantly limited the possibilities for further generalization of the results. Also, the use of a quasi-experimental design with cluster distribution into groups did not provide for individual randomization, which could potentially affect the internal validity of the study. Additionally, the sample consisted primarily of students in humanities and social sciences programs. Therefore, caution should be exercised when generalizing the results to STEM or engineering disciplines, where the structure of research activities and the role of quantitative methods may differ significantly.

Conclusions

Thus, the study indicated that the implementation of IRSDM influenced the increase in the overall level of development of research skills of education seekers compared

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

to the traditional learning model. Within the framework of the quasi-experimental design, positive dynamics were recorded in the experimental group according to the post-test results. In addition, noticeable intergroup differences were recorded after the intervention, which confirms the effectiveness of the proposed model.

The greatest increase in indicators was found in the formulation of a scientific problem, work with academic sources and data interpretation. This indicated the effectiveness of the phased structure of the model and the principle of methodological support, which ensure the consistent development of research skills. At the same time, the integration of digital tools within the IRSDM made it possible to develop academic digital literacy skills and increase the level of independence of students in performing research tasks, acting as a key structural element of the model.

Additionally, it was found that students in the experimental group had a higher quality of research project implementation according to the criteria of the logic of research construction, adequacy of methodology and validity of conclusions.

The main scientific contribution of the study is the development and empirical verification of a holistic pedagogical system that integrates research-oriented learning and digital technologies into a single structured model. Unlike existing approaches that are often used fragmentarily, the proposed model overcomes the fragmentation of individual methods and ensures their interaction aimed at achieving measurable educational results.

The practical significance of the study lies in the possibility of implementing IRSDM in higher and professional pre-higher education institutions of Ukraine as an effective tool for modernizing educational programs in accordance with international standards. The use of the model can contribute to improving the quality of training of education seekers and the development of their academic autonomy. Prospects for further research are related to testing the proposed model in other educational contexts, in particular in fully digital or distance learning environments, as well as in technical and natural sciences.

Bibliographic references

- Adeoye, M. A., & Jimoh, H. A. (2023). Problem-Solving Skills Among 21st-Century Learners Toward Creativity and Innovation Ideas. *Thinking Skills and Creativity Journal*, 6(1), 52-58. <https://doi.org/10.23887/tscj.v6i1.62708>
- Alberto, M. C. L., Viviana, B. V. C., Vladimir, B. E. C., & Fernanda, P. A. P. (2024). Innovative strategies to strengthen teaching-researching skills in chemistry and biology education: a systematic literature review. *Frontiers in Education*, 9. <https://doi.org/10.3389/feduc.2024.1363132>
- Aliyeva, G. B., Honcharuk, V., Pavliuk, N., Zinchenko, V., & Sivachenko, I. (2023). Review of modern pedagogical technologies and methods in the field of philology according to European standards (literature review). *Revista on line de Política e Gestão Educacional*, 27(esp.2), e023049. <https://doi.org/10.22633/rpge.v27iesp.2.18778>
- Ampa, A. T., & Nurqalbi, N. (2021). Innovative Learning Strategies to Increase Students' Participation and Quality of English Teaching and Learning Process. *Technium Social Sciences Journal*, 26, 314-325. <https://doi.org/10.47577/tssj.v26i1.5195>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- Bapanova, G. K., Orekhova, N. V., Kadirsizova, S. B., Kasbayeva, G. S., & Sholpankulova, G. K. (2023). Research Skills as the Student Learning Achievement. *International Journal of Educational Reform*, 34(3), 543-558. <https://doi.org/10.1177/10567879231155874>
- Barragán Díaz, D. M. (2019). La experiencia estudiantil universitaria en América Latina: una revisión de literatura. *Revista Colombiana de Educación*, 1(78), 147-172. <https://doi.org/10.17227/rce.num78-6708>
- Bohomaz, O., Koreneva, I., Lihus, V., Kambalova, Y., Shevchuk, V., & Tolchieva, H. (2023). Regarding the development of educational and scientific potential in the 21st century: technological challenges. *Conhecimento & Diversidade*, 15(38), 479-495. <https://doi.org/10.18316/rcd.v15i38.11100>
- Boichenko, M., Churychkanych, I., Kulichenko, A., Shramko, R., & Rakhno, M. (2023). Mind maps to boost the learning of English as L2 at higher education institutions in Ukraine. *Amazonia Investiga*, 12(70), 229-240. <https://doi.org/10.34069/AI/2023.70.10.21>
- Campos-Ugaz, O., Campos-Ugaz, W. A., Hernández, R. M., Doig, S. G. A., Ortíz, J. B. F., Saavedra-López, M. A., & Garay-Argandoña, R. (2022). Formative Research to Strengthen Enquiry Competence in University Students. *International Journal of Learning, Teaching and Educational Research*, 21(11), 443-464. <https://doi.org/10.26803/ijlter.21.11.25>
- Castillo-Martínez, I. M., Cerros Regalado, C. P., Glasserman-Morales, L. D., & Ramírez-Montoya, M. S. (2023). Academic literacy among the university students in Mexico and Spain: A holistic perspective. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.1055954>
- Castillo-Martínez, I. M., & Ramírez-Montoya, M. S. (2021). Research Competencies to Develop Academic Reading and Writing: A Systematic Literature Review. *Frontiers in Education*, 5. <https://doi.org/10.3389/feduc.2020.576961>
- Dighliya, B. (2024). Innovative Teaching Methods for Skill Development. In *Advances in Higher Education and Professional Development* (pp. 229-250). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-3443-0.ch009>
- Edeh, N. I., Ugwoke, E. O., & Anaele, E. O. (2021). Effects of innovative pedagogies on academic achievement and development of 21st-century skills of taxation students in colleges of education. *Innovations in Education and Teaching International*, 59(5), 533-542. <https://doi.org/10.1080/14703297.2021.1919174>
- Enriquez, G., Zevallos, E., Zenteno, F., Pariona, D., & López, R. (2023). Formative research and the achievement of skills based on undergraduate theses in university higher education. *Journal of Technology and Science Education*, 13(2), 498. <https://doi.org/10.3926/jotse.1744>
- Garay-Argandona, R., Rodriguez-Vargas, M. C., Hernandez, R. M., Carranza-Esteban, R., & Turpo, J. E. (2021). Research competences in university students in virtual learning environments. *Cypriot Journal of Educational Sciences*, 16(4), 1721-1736. <https://doi.org/10.18844/cjes.v16i4.6031>
- Guzmán-Valenzuela, C., Chiappa, R., Rojas-Murphy Tagle, A., Ismail, N., & Pedraja Rejas, L. (2023). Investigating critical thinking in higher education in Latin America: Acknowledging an epistemic disjuncture. *Critical Studies in Teaching and Learning*, 11(SI), 71-99. <https://hdl.handle.net/10520/ejc-cristal-v11-nsi1-a6>
- Hryn, O., Domanova, H., Pavlenko, L., Striliuk, O., & Shara, L. (2024). Developing research competence in students through the study of socio-humanitarian subjects. *Multidisciplinary Reviews*, 8, 2024spe061. <https://doi.org/10.31893/multirev.2024spe061>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Karpliuk, S., Moyseyenko, I., Lysenko, T., Moroz, O., & Protas, O. (2024). The role of ICT in education: Comparing virtual and traditional learning methods. *Multidisciplinary Reviews*, 8, 2024spe068. <https://doi.org/10.31893/multirev.2024spe068>
- Khryk, V., Ponomarenko, S., Koval, L., Verhun, A., Morhulets, O., Nikonenko, T., & Koval, L. (2021). Digitization of education as a key characteristic of modernity. *International Journal of Computer Science and Network Security*, 21(10), 191-195. <https://doi.org/10.22937/IJCSNS.2021.21.10.26>
- Koyuncuoglu, D. (2020). An Investigation of Potential Leadership and Innovation Skills of University Students. *International Journal of Education in Mathematics, Science and Technology*, 9(1), 103-115. <https://doi.org/10.46328/ijemst.1374>
- Lander, J., Seeho, S., & Foster, K. (2019). Learning Practical Research Skills Using An Academic Paper Framework – An Innovative, Integrated Approach. *Health Professions Education*, 5(2), 136-145. <https://doi.org/10.1016/j.hpe.2018.06.002>
- Laura-De La Cruz, K. M., Pérez Yufra, D. N., Mendoza-Gómez, C. R. d. P., & Mendoza-Del Valle, L. A. (2023). Formative Research and Research Competencies in Foreign Language Students in Higher Education. *TECHNO REVIEW. International Technology, Science and Society Review /Revista Internacional de Tecnología, Ciencia y Sociedad*, 15(1), 107-117. <https://doi.org/10.37467/revtechno.v15.5078>
- Marín, J., Roman Castillo, E., Sigüeñas Fernandez, R. L., Jara Alarcón, T. J., & Dominguez Aguilar, D. (2025). Development of Research Competencies in University Students: A Systematic Review. *The International Journal of Interdisciplinary Educational Studies*, 21(1), 1-21. <https://doi.org/10.18848/2327-011x/cgp/v21i01/1-21>
- Meissner, D., & Shmatko, N. (2018). Integrating professional and academic knowledge: the link between researchers skills and innovation culture. *The Journal of Technology Transfer*, 44(4), 1273-1289. <https://doi.org/10.1007/s10961-018-9662-8>
- Mora-Pablo, I., & González, M. (2025). Centering English as a foreign language (EFL) teachers' research skills to enhance their teaching practice: An examination of a teacher education program in Mexico. *System*, 131, 103677. <https://doi.org/10.1016/j.system.2025.103677>
- Mubarak, Z. K., & Selimin, M. A. (2023). Significance of Innovative Learning Skills in the Era of Education 4.0. *International Journal of Sustainable Construction Engineering and Technology*, 14(3), 339-352. <https://doi.org/10.30880/ijscet.2023.14.03.029>
- Nikitchenko, L., Davydova, Z., Krylova, V., Samborska, O., & Arkushyna, H. (2024). Innovative Approaches to Learning and Teaching in Ukrainian Higher Education. *Cadernos de Educação, Tecnologia e Sociedade*, 17(1), 495-505. <https://doi.org/10.14571/brajets.v17.n1.495-505>
- Okolie, U. C., Igwe, P. A., Mong, I. K., Nwosu, H. E., Kanu, C., & Ojemuyide, C. C. (2021). Enhancing students' critical thinking skills through engagement with innovative pedagogical practices in Global South. *Higher Education Research & Development*, 41(4), 1184-1198. <https://doi.org/10.1080/07294360.2021.1896482>
- Ratnawati, N., & Idris, I. (2020). Improving Student Capabilities through Research-Based Learning Innovation on E-Learning System. *International Journal of Emerging Technologies in Learning (IJET)*, 15(04), 195. <https://doi.org/10.3991/ijet.v15i04.11820>
- Rodríguez, G., Pérez, N., Núñez, G., Baños, J.-E., & Carrió, M. (2019). Developing creative and research skills through an open and interprofessional inquiry-based

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- learning course. *BMC Medical Education*, 19(1), 134. <https://doi.org/10.1186/s12909-019-1563-5>
- Salinas Velastegui, V. G., Paredes Salinas, J. G., & Tufiño Aguilar, A. A. (2023). Metacognition and Higher Education. *Medwave*, 23(S1), eUTA226. <https://doi.org/10.5867/medwave.2023.s1.uta226>
- Sernaqué, M. A. C., Luis, M. C., Alarcon, M. A. C., Farías, V. A. G., Valdiviezo, O. B., & Chávez, J. J. T. (2023). Development of Research Competences in University Professors: A Bibliographic Review. *International Journal of Membrane Science and Technology*, 10(3), 1750-1755. <https://doi.org/10.15379/ijmst.v10i3.1790>
- Sivarajah, R. T., Curci, N. E., Johnson, E. M., Lam, D. L., Lee, J. T., & Richardson, M. L. (2019). A Review of Innovative Teaching Methods. *Academic Radiology*, 26(1), 101-113. <https://doi.org/10.1016/j.acra.2018.03.025>
- Sobarzo-Ruiz, R. (2023). habilidades investigativas en la formación inicial docente en Chile. *Revista Realidad Educativa*, 3(1), 163-166. <https://doi.org/10.38123/rre.v3i1.275>
- Songkram, N., Chootongchai, S., Keereerat, C., & Songkram, N. (2024). Potential of ChatGPT in academic research: exploring innovative thinking skills. *Interactive Learning Environments*, 33(2), 1689-1711. <https://doi.org/10.1080/10494820.2024.2375342>
- Spector, P. E. (2025). Promoting your research in the digital age. In *How to Conduct and Publish High-Quality Research in Industrial-Organizational Psychology* (pp. 420–428). Cheltenham, UK: Edward Elgar Publishing. <https://doi.org/10.4337/9781035307746.00039>
- Tamozhska, I., Chubuk, R., Pienov, V., Myroshnychenko, N., & Prokofyeva, L. (2024). Innovative teaching methods for developing basic skills in higher education students through real professional contexts. *Salud, Ciencia y Tecnología - Serie de Conferencias*, 3, 1214. <https://doi.org/10.56294/sctconf2024.1214>
- Tapullima-Mori, C., Pizzan Tomanguillo, S. L., Pizzan Tomanguillo, N. d. P., Vásquez Sánchez, M., & Soria Quijaite, J. J. (2025). Charting the path to excellence: A review of research competencies in university students. *Journal of Technology and Science Education*, 15(2), 364. <https://doi.org/10.3926/jotse.2729>
- Turchyn, I., Zaitseva, S., Rudenko, N., Saienko, V., Kuzemko, N., & Denefil, O. (2023). Using distance learning models as opportunities for blended learning for foreigners. *Revista Romaneasca Pentru Educatie Multidimensionala*, 15(4), 178-191. <https://doi.org/10.18662/rrem/15.4/787>
- Uribe-Tirado, A., & Machin-Mastromatteo, J. D. (2024). Past, present and future of information literacy in Latin America. *Journal of Information Literacy*, 18(2), 6-36. <https://doi.org/10.11645/18.2.632>
- Valeriano Carrasco, H. M., & James Wilfredo, H. G. (2023). Habilidades blandas en estudiantes de ingeniería de una universidad pública peruana. *Ciencia Latina Revista Científica Multidisciplinar*, 7(3), 8198-8221. https://doi.org/10.37811/cl_rcm.v7i3.6806
- Vélez Jiménez, D., Soria Pérez, Y. F., Lujano Ortega, Y., & Sebastiani Elías, Y. d. F. (2022). Estrategias didácticas y desarrollo de habilidades investigativas en el nivel universitario. *Revista Latinoamericana Ogmios*, 2(5), 436-458. <https://doi.org/10.53595/rlo.v2.i5.046>
- Vovchasta, N., Kan, O., Hlavatska, Y., Sovach, K., & Makukhina, S. (2024). Digitalisation and its role in developing hard skills among university students in Ukraine. *Multidisciplinary Reviews*, 8, 2024spe070. <https://doi.org/10.31893/multirev.2024spe070>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Desarrollo de la competencia digital de los futuros profesionales: condiciones psicológicas y pedagógicas en un panorama educativo en rápida transformación

Digital competence development of future professionals: Psychological and pedagogical conditions in a rapidly transforming educational landscape

Vitaliy Tretko¹  Lyudmila Bilan²  Valentyna Pliushch³  Andriy Tkachuk⁴  Kateryna Skyba⁵ 

Afiliación autor:

¹ Doctor of Pedagogical Sciences, Full Professor, Professor of the Department of International Communication and Political Science, Khmelnytskyi National University, Ukraine. tretko@khmnu.edu.ua

² Candidate of Pedagogical Sciences, Associate Professor of the Department of Management and Educational Technologies, National University of Life and Environmental Sciences of Ukraine, Ukraine. bilanli@ukr.net

³ Doctor of Pedagogical Sciences, Professor, Department of Natural Sciences and Methods of Their Teaching, Volodymyr Vynnychenko Central Ukrainian State Pedagogical University, Ukraine. valentynapi@ukr.net

⁴ Candidate of Technical Sciences (PhD (Technical Sciences)), Associate Professor, Dean of the Faculty of Information Technology, Mathematics and Natural Sciences, Associate Professor of the Department of Technological and Vocational Education, Volodymyr Vynnychenko Central Ukrainian State University, Ukraine. a.i.tkachuk@cuspu.edu.ua

⁵ Doctor of Pedagogical Sciences, Professor, Department of Germanic Philology and Translation Studies, Khmelnytskyi National University, Ukraine. skybakm@khmnu.edu.ua

Recibido: 10/01/26

Aceptado: 16/04/26

Cómo citar:

Tretko, V., Bilan, L., Pliushch, V., Tkachuk, A., & Skyba, K. (2026). Digital competence development of future professionals: Psychological and pedagogical conditions in a rapidly transforming educational landscape. *Revista Eduweb*, 20(2), 70-90. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.5>



Creative Commons Attribution 4.0 International (CC BY 4.0)



Resumen

El artículo examina el desarrollo de la competencia digital entre futuros especialistas en el contexto de la rápida transformación digital de la educación superior. El objetivo del estudio es fundamentar y verificar experimentalmente la efectividad de las condiciones psicológicas y pedagógicas que aseguran la formación de la competencia digital. Se aplicó un diseño de investigación de métodos mixtos, combinando enfoques cualitativos y cuantitativos. La estructura de la competencia digital se operacionalizó a través de tres componentes: motivacional, operacional y basado en valores, con sus respectivos criterios e indicadores. En la etapa de determinación, la distribución de los niveles de competencia fue la siguiente: alto – 11,2%, promedio – 56,7%, bajo – 32,1%, lo que indica un nivel de desarrollo fragmentado e insuficiente. Los resultados demostraron mejoras estadísticamente significativas en el EG en comparación con el CG. La proporción de estudiantes con un nivel alto aumentó al 41,1% (motivacional), 38,9% (operacional) y 38,4% (valor), mientras que la proporción de indicadores de nivel bajo disminuyó al 11,9%, 5,1% y 9,5%, respectivamente. En contraste, el grupo de control mostró cambios mínimos. Los resultados demuestran que la implementación de las condiciones psicológicas y pedagógicas propuestas mejora significativamente la competencia digital de los estudiantes, especialmente en lo que respecta al comportamiento digital ético, el procesamiento de la información y las habilidades técnicas. El estudio contribuye a la mejora de los modelos de formación digital en la educación superior y tiene implicaciones prácticas para el diseño de entornos de aprendizaje enriquecidos digitalmente.

Palabras clave: condiciones psicológicas y pedagógicas, competencia digital, futuros especialistas, cultura digital, seguridad digital.

Abstract

The article examines the development of digital competence among future specialists under conditions of rapid digital transformation of higher education. The purpose of the study is to substantiate and experimentally verify the effectiveness of psychological and pedagogical conditions that ensure the formation of digital competence. A mixed-methods research design was applied, combining qualitative and quantitative approaches. The structure of digital competence was operationalized through three components: motivational, operational, and value-based, with corresponding criteria and indicators. At the ascertaining stage, the distribution of competence levels was as follows: high – 11.2%, average – 56.7%, low – 32.1%, indicating a fragmented and insufficient level of development. The results demonstrated statistically significant improvements in the EG compared to the CG. The proportion of students with a high level increased to 41.1% (motivational), 38.9% (operational), and 38.4%

(value), while the share of low-level indicators decreased to 11.9%, 5.1%, and 9.5%, respectively. In contrast, the CG showed only minor changes. The findings prove that the implementation of the proposed psychological and pedagogical conditions significantly enhances students' digital competence, particularly in terms of ethical digital behavior, information processing, and technical skills. The study contributes to improving digital training models in higher education and has practical implications for designing digitally enriched learning environments.

Keywords: psychological and pedagogical conditions, digital competence, future specialists, digital culture, digital security.

Introduction

The rapid digital transformation of higher education has intensified the need for developing digital competence among future specialists as a key component of their professional readiness. Contemporary frameworks emphasize that digital competence includes not only technical skills but also cognitive, ethical, and communicative dimensions required for effective functioning in a digital society. However, despite the widespread integration of digital technologies into educational environments, the outcomes of such integration remain inconsistent and often insufficient (Caena & Redecker, 2019).

Existing research primarily focuses on the conceptualization of digital competence or the implementation of isolated digital tools, while less attention is paid to the systematic design and empirical validation of comprehensive psychological and pedagogical conditions that ensure its holistic development. Moreover, current studies rarely provide statistically grounded evidence demonstrating how these conditions influence different structural components of digital competence in real educational settings (Cronin, 2017).

Thus, there is a clear research gap between the recognized importance of digital competence in higher education and the lack of empirically validated, systematically implemented psychological and pedagogical conditions that ensure its effective development across motivational, operational, and value-based dimensions.

This gap highlights the need for experimental research that not only substantiates such conditions but also verifies their effectiveness through quantitative and qualitative analysis.

Literature Review

The issue of developing digital competence in higher education has been widely explored in contemporary research, particularly in the context of global digital transformation. However, the existing body of literature demonstrates conceptual diversity and methodological fragmentation, which necessitates a more systematic and empirically grounded approach.

A significant number of studies emphasize the role of digital technologies in enhancing the quality of professional training. For instance, research on digital and blended learning environments highlights their potential to improve accessibility, flexibility, and student engagement (Cronin, 2017; Fullan, 2018). Similarly, Do (2024) underlines the importance of integrating digital tools into professional education, particularly in globally interconnected fields. While these studies convincingly demonstrate the transformative impact of digitalization, they primarily

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

focus on technological integration rather than on the pedagogical mechanisms that ensure the development of digital competence as a holistic construct.

Another group of studies conceptualizes digital competence as a multidimensional phenomenon. Caena & Redecker (2019), as well as Vuorikari et al. (2022), define it as a complex combination of knowledge, skills, and attitudes, structured within European competence frameworks (DigComp, DigCompEdu). These approaches provide a solid theoretical foundation; however, they remain largely normative and do not sufficiently address the practical implementation of competence development in specific educational contexts. In particular, the operationalization of competence components and their measurable indicators is often underdeveloped.

Empirical studies focusing on the development of digital competence offer valuable insights but also reveal important limitations. For example, Mendoza Muñoz & Párraga Muñoz (2022) identify a strong relationship between information literacy and pedagogical management, yet their findings point to insufficient development of critical information-processing skills among educators. Similarly, Galarce-Miranda et al. (2023) demonstrate the effectiveness of structured online training programs in enhancing digital and pedagogical competence; however, their research is limited to professional development contexts and does not fully address the formation of competence at the undergraduate level.

Recent studies also highlight the importance of ethical and reflective dimensions of digital competence. Berríos-Barra & Calderón-López (2025) note progress in digital ethics and citizenship among teacher educators but identify a lack of reflective pedagogical practices and insufficient integration of digital technologies into teaching. This indicates that value-based aspects of digital competence remain underdeveloped in practice. At the same time, Brochero Sarabia & Hidalgo Colón (2022) emphasize the communicative dimension of digital competence, particularly in the context of pedagogical interaction, yet their work does not consider the broader integration of technical and motivational components.

Furthermore, studies on digital transformation in education (Tondeur et al., 2023; Zasiiekina et al., 2025) stress the need for continuous professional development and adaptive learning environments. While these approaches contribute to understanding the dynamic nature of digital competence, they often lack empirical validation through controlled experimental designs and do not provide clear evidence of causal relationships between pedagogical conditions and competence development.

Thus, the analysis of the literature reveals several key gaps: insufficient integration of different components of digital competence into a unified model; limited attention to the motivational and value-based dimensions alongside technical skills; lack of empirically validated psychological and pedagogical conditions implemented within real educational settings; insufficient number of experimental studies using statistical methods to confirm the effectiveness of the proposed approaches.

In response to these limitations, the present study proposes a holistic model of digital competence that integrates motivational, operational, and value-based components into a unified structure. Unlike previous research, this model is not only theoretically grounded in existing competence frameworks but also operationalized through clearly defined criteria and indicators.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Moreover, the study establishes a direct connection between theory and practice by embedding the model within a system of psychological and pedagogical conditions and verifying its effectiveness through a quasi-experimental design with statistical validation (Student's t-test). This approach allows not only to address the identified research gaps but also to provide empirical evidence of how structured pedagogical interventions contribute to the comprehensive development of digital competence among future specialists.

The purpose of the article is to theoretically substantiate the psychological and pedagogical conditions for the development of digital competence among future specialists, but also to empirically verify their effectiveness through a quasi-experimental research design.

Methodology

Research Design

This study employed a mixed-methods research design integrating quantitative and qualitative approaches to ensure a comprehensive analysis of the development of digital competence among future specialists. The research was conducted as a quasi-experimental study with a control group (CG) and an experimental group (EG), allowing for the assessment of causal relationships between pedagogical intervention and learning outcomes.

The study was implemented in three consecutive stages: ascertaining (diagnostic), formative (intervention), and control (evaluation).

This design enabled the identification of baseline levels of digital competence, the implementation of psychological and pedagogical conditions, and the evaluation of their effectiveness through comparative analysis.

Participants

The study involved 94 undergraduate students (years 1–3) enrolled in higher education institutions during the period 2023–2025. Participants were divided into two groups:

- Experimental group (EG): students exposed to the author's model incorporating psychological and pedagogical conditions.
- Control group (CG): students receiving traditional instruction without targeted intervention.

The groups were comparable in terms of curriculum, academic workload, and learning conditions, ensuring internal validity. Participation was voluntary, and ethical standards (informed consent, confidentiality) were strictly followed.

Variables and Operationalization

Independent Variable

The independent variable was the implementation of a set of psychological and pedagogical conditions, including:

- Integration of digital tools into professional disciplines.
- Use of interactive teaching methods (projects, simulations, case studies).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Application of digital platforms (e.g., LMS, collaborative tools).
- Modeling of professional situations in a digital environment.
- Fostering reflective and ethical digital practices.

Operationalization:

0 = absence of intervention (CG)

1 = implementation of intervention (EG).

Dependent Variable

The dependent variable was the level of digital competence.

Digital competence was conceptualized as a multidimensional construct consisting of three components:

- Motivational,
- Operational,
- Value-based.

Operationalization:

An integrated index was calculated as the aggregate score across all components. Competence levels were classified as:

- Low (0–33%),
- Average (34–66%),
- High (67–100%).

Latent Variables

Each component was operationalized as a latent variable:

- Motivational index – readiness and engagement in digital activities.
- Operational index – knowledge and skills in using digital technologies.
- Value-based index – ethical attitudes and responsible digital behavior.

Each index was calculated as the mean score of its indicators.

Instruments and Data Collection

Data collection was carried out using a combination of complementary methods:

Diagnostic tools

- Standardized questionnaires (Likert scale 1–5).
- Surveys assessing motivation and attitudes.
- Structured interviews.

Behavioral tools

- Systematic observation using predefined checklists.
- Monitoring of student activity in digital environments.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Performance-based assessment

- Evaluation of digital projects using analytic rubrics.
- Case-based practical tasks.
- Student e-portfolios.

The triangulation of methods ensured the reliability and validity of the collected data.

Criteria and Indicators

The assessment of digital competence was based on a system of criteria and indicators corresponding to each component:

Motivational component

Criterion: readiness to use digital technologies
Indicators: initiative, frequency of use, collaboration in digital environments.

Operational component

Criterion: level of digital knowledge and skills
Indicators: information processing, critical analysis, content creation.

Value-based component

Criterion: digital culture and ethics
Indicators: academic integrity, cybersecurity awareness, ethical behavior.

Intervention Procedure

During the formative stage, the experimental group was exposed to the developed psychological and pedagogical conditions, while the control group continued traditional learning.

The intervention included:

- Integration of digital tools across disciplines.
- Implementation of interactive and practice-oriented tasks.
- Use of digital platforms for collaboration and communication.
- Modeling real professional scenarios in digital environments.

The equivalence of learning conditions (content, workload, duration) across both groups ensured experimental validity.

Data Analysis

Quantitative data were analyzed using methods of mathematical statistics: descriptive statistics (means, percentages); comparative analysis between groups.

Student's t-test for independent samples.

The level of statistical significance was set at $p \leq 0.05$.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The obtained value ($t = 3.12$) exceeded the critical value ($t \approx 1.99$) at $df = 92$, indicating statistically significant differences between the experimental and control groups.

Qualitative data (interviews, observations) were analyzed using content analysis to interpret changes in students' motivation, behavior, and attitudes.

Validity and Reliability

The validity of the study was ensured through:

- The use of a structured competence model with clearly defined criteria.
- Triangulation of data collection methods.
- Comparison between control and experimental groups.

Reliability was supported by:

- Consistent application of diagnostic instruments.
- Repeated measurements at different stages.
- Internal consistency of scales (cronbach's alpha ≥ 0.7).

Results and Discussion

The content, components, and essence of digital competence of future specialists. The importance of creating an innovative, rich digital educational environment.

Digital competence encompasses five main components, according to the definitions set out in the European digital competence framework, DigComp 2.2: collaboration and communication, information literacy, security, creation of digital content, and problem-solving in the digital environment (Vuorikari et al., 2022). Therefore, we consider digital competence to be the ability to create content innovatively, critically evaluate information, adhere to legal and ethical norms, ensure cybersecurity, and interact effectively in the digital space, rather than merely using technical devices.

The digital transformation of the educational space of higher education involves the transition to active use, rather than passive consumption, of digital tools as means of communication, educational interaction, reflection, and assessment. In this context, it is important to create an innovative, rich digital educational environment that clearly provides access to learning management systems (LMS), innovative digital platforms, cloud technologies, collaborative editing tools, interactive multimedia tools, and feedback tools (Hualpá Zúñiga, 2023).

The digital competence of future specialists is formed in an innovative digital educational environment through interdisciplinary integration across all areas of digital technology training, not only during the study of individual disciplines in the informatics cycle. The use of digital tools is effective across professional disciplines and allows higher education students to immediately apply professional knowledge in digital formats, not just acquire it. Therefore, it is important for future professionals to consistently use distance and blended learning platforms to create interactive educational materials, facilitate online interactions, and maintain digital portfolios (Araújo da Silva & Alejandra Behar, 2023).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The ability of a higher education institution to create an innovative, favorable digital educational environment largely depends on the effectiveness of developing digital competence in future specialists, which encompasses didactic, organizational, technical, and methodological components. Special attention when creating an innovative, favorable digital educational environment requires developing a system to monitor the level of digital competence among higher education applicants, enabling the identification of problem areas, the objective assessment of educational outcomes, and the adjustment of the educational process. For this purpose, it is advisable to use electronic portfolios, digital standardized tests, expert assessment of projects, self-assessment, and feedback during the educational process. Involving students in the creation of educational digital products is also important for learning with social significance (e.g., online courses, video instructions, digital reference books, educational chatbots) (Knysh et al., 2026).

The use of adaptive learning in the formation of digital competence of future specialists. Key types of digital competence.

The use of adaptive learning is a promising area of digital competence formation, based on personalized trajectories and educational data analytics. Particularly effective in the distance format are platforms that identify weaknesses in specialist training, adapt the material to applicants' knowledge levels within the field, and provide individualized recommendations. A deeper assimilation of the material is facilitated by tools that foster self-assessment and reflection, thereby increasing the effectiveness of self-study. At the same time, addressing issues of digital equality requires the introduction of innovative digital technologies, compliance with ethical norms, and the protection of personal data. Digital inclusion, in this context, is of particular importance and aims to ensure equal access to digital resources for all categories of higher education applicants, particularly people with health problems, residents of rural areas, and people with low incomes (Tondeur et al., 2023).

Digital competence requires adaptation to new conditions, constant expansion and updating, and is not a stable characteristic, underscoring the need for continuous professional development for teachers, students, and specialists. An innovative and effective approach in this direction is massive open online courses (MOOCs), whose purpose is to enable rapid acquisition of new knowledge, exchange of experience, and expansion of digital tools. Participation in online conferences, digital training, and hackathons contributes to improving a person's digital literacy and to developing intercultural communication, professional mobility, and social skills (Zasiekina et al., 2025).

There are three main types of digital competence, each of which is directly important for higher education: communicative competence, information and media competence, and technical competence. Information and media competence enable the student to effectively select, search, create, and analyze digital content, which is the basis for the professional preparation of modern methodological materials. Communicative competence in the context of blended and distance learning involves possessing modern tools for online interaction, which, in the educational process, become an integral part of quality education. Technical competence includes the ability to use software complexes, work with digital devices to create multimedia instructions, simulate professional production processes, and automate the control of student knowledge (Mytnyk et al., 2024).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The experimental research.

As part of the study, an experimental study was conducted to develop the digital competence of future specialists amid the transformation of the modern education system and society, and to verify the effectiveness of the psychological and pedagogical conditions developed and implemented. In total, 94 students of the 1st–3rd years participated in the experimental study (2023–2025). All participants in the experiment were previously informed about the study's content, purpose, and forms of participation for ethical reasons.

Respondents were divided into two groups to ensure scientific objectivity:

- Experimental group – training took place according to the author's model (psychological and pedagogical conditions, projects, interactive methods, simulations, cases; use of Google Workspace, Microsoft Teams, etc.).
- Control group – training took place without any innovative interventions, following the traditional program.

The combination of practice-oriented, educational, and cognitive activities of students was an important condition of the experiment, which allowed integrating the development of digital competence into professional disciplines and bringing all the proposed tasks closer to the real conditions of professional activity.

Special attention in the EG was paid to the use of digital platforms, in particular, the coordination of approaches to digitalization (Google, Workspace, Microsoft Teams, etc.), the formation of a single strategy for supporting the motivation of EG students, the development of common criteria for assessing students' knowledge when performing tasks, as well as the responsible attitude of respondents to work in a digital environment.

The phased structure of the experiment provided an opportunity to assess the effectiveness of psychological and pedagogical conditions objectively, track positive changes in the EG, and not merely diagnose respondents' initial digital competence.

Stating stage. The first step in the study's implementation was the starting phase, which aimed to conduct a comprehensive diagnosis of the experimental and control groups and their initial levels of digital competence. The results of this stage served as the basis for further comparisons and helped us identify the aspects requiring the greatest pedagogical support.

The data collected at the start of the study allowed us to identify the strengths of the respondents' digital preparation (basic knowledge and ability to use standard digital services) as well as problem areas (low readiness for digital activity, insufficient critical thinking, and fragmented cognitive knowledge). The starting point for further analysis was the study's results, which provided a basis for testing the effectiveness of the psychological and pedagogical conditions in shaping respondents' digital competence.

System of evaluation criteria. The study, conducted to validate the assessment of the level of formation of the specified competence, enabled us to use the three-component author's structure (motivational, operational, and value components) and their criteria and indicators.

A separate dimension of the competency approach reflects each component:

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The motivational component includes, in its content criteria, the ability to apply digital tools for professional and educational tasks, taking into account the readiness for cooperation and the manifestation of initiative in the digital environment, and indicators – creating and editing content in digital environments, practical actions; organizing online team and individual work; integration into everyday operational processes of digital tools.

The operational component includes, in its content, criteria – the ability and level of knowledge for the conscious use of digital technologies and indicators – orientation in information flows, knowledge of digital procedures and concepts; data evaluation and critical analysis based on digital evidence; reasoned decision-making.

The value component includes, as content criteria, an attitude toward digital technologies, consideration of the culture of communication, the space for responsible and ethical activity, and indicators such as compliance with digital ethics, academic integrity, security rules, and readiness for mutual support and self-development.

The formative stage. The formative stage was the second stage of the experiment. It involved the direct implementation of psychological and pedagogical conditions to develop digital competence in the practice of teaching respondents in the experimental group. The purpose of this stage is to verify the effectiveness of the methodological approaches and the developed system of tasks in a real educational environment, ensuring a combination of practical and theoretical components of the higher education process.

During the formative stage, the control group studied in the usual mode, using traditional learning methods and educational approaches that met the requirements of the professional education standard. At the same time, the EG followed the proposed methodology. Therefore, the purity of the experiment was ensured, and the objectivity of the assessment of the impact of the proposed psychological and pedagogical conditions on the formation of digital competence of EG students was ensured.

Thus, the formative stage performed two key functions:

- Provided testing of the developed author's psychological and pedagogical conditions for the formation of digital competence.
- Created methodological and organizational conditions for tracking the ways of formation of digital competence and the dynamics of changes in levels (high, average, low).

The central part of the experiment was the formative stage, in which the psychological and pedagogical conditions were theoretically substantiated, tested in practice, and the changes obtained were correlated with the initial data of the ascertaining section.

At this stage, we were able to conclude the impact of the developed psychological and pedagogical conditions on respondents' digital competence. When comparing the control group's intermediate results with the experimental group's indicators, particular attention was paid to ensuring that conditions were equivalent across both groups. This meant that students in both groups mastered the same topics, studied the same educational and professional program, had the same number of hours of extracurricular and classroom work, and worked with comparable types of tasks. The only difference was the presence, in the experimental group, of developed

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

author's psychological and pedagogical conditions and methodological approaches that constituted the essence of pedagogical influence. The purity of the experiment was ensured by maintaining structural equivalence, since the changes in digital competence levels could be objectively linked to the implemented psychological and pedagogical conditions.

A comparison of the experimental and control groups' results revealed a statistically significant difference in the dynamics of digital competence development. The increase in indicators in the control group remained within the natural course of learning, that is, it was low. Moreover, in the experimental group, we observe positive, significant growth, as confirmed by both qualitative observations and quantitative measurements. This process confirmed the effectiveness of the developed psychological and pedagogical conditions and enabled us to identify the most effective pedagogical tools for developing digital competence.

Qualitative and quantitative analysis at the ascertaining stage of the study of the formation of students' digital competence.

The involvement of a significant number of students allowed not only to determine the initial level of digital competence formation by its key components (motivational, operational, and value) but also to identify educational, age, and experience differences in the ways of using digital tools. The results of the ascertainment stage showed that students' digital competence is non-systemic and fragmentary:

- A significant number of respondents had difficulties (working with cloud storage, structuring files, using corporate email) in organizing their digital work environment.
- Insufficient development of work skills with educational platforms (Google Workspace, Microsoft Teams).
- A linear strategy prevails in information search skills (entering the first few results without critically analyzing the query).

In addition, students have a poor understanding of academic integrity and digital security principles in the digital space. This confirms the need to develop skills for working in an online educational environment and to implement psychological and pedagogical conditions for the formation of digital competence.

To identify general trends and generalize the results on the formation of digital competence across different stages of professional training, respondents were grouped by digital competence level according to the specified criteria and indicators.

The results of quantitative diagnostics are presented in Table 1 and Figure 1 to clearly trace the distribution of respondents at the ascertaining stage by digital competence level.

Table 1.
Distribution of levels of formation of digital competence of respondents (assertive stage) – summarized data for all components

Levels	(%)
High	11,2
Average	56,7
Low	32,1

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

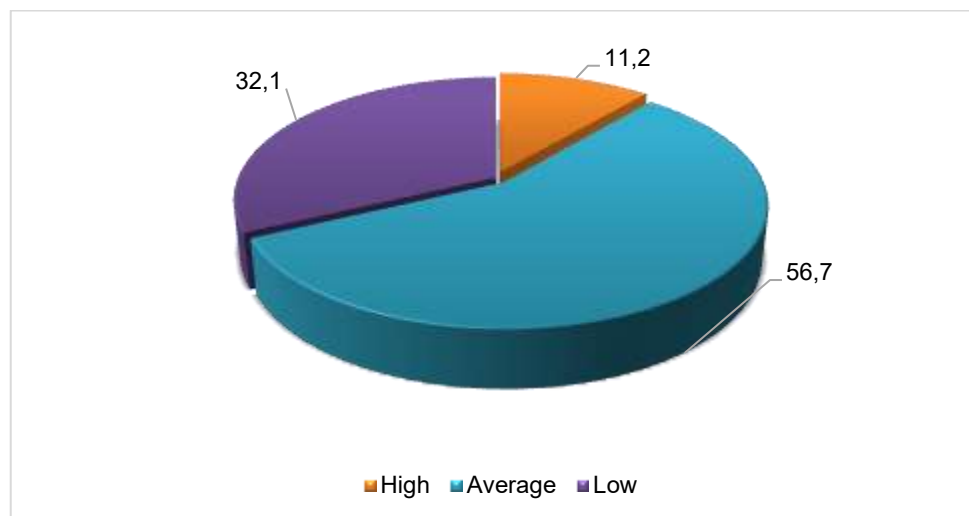


Figure 1. Distribution of levels of formation of digital competence of respondents (assertive stage) – summarized data for all components.

Analysis of the dynamics of the formation of digital competence of respondents.

In our study, we define digital competence as the ability to make critical, appropriate, and safe choices in professional practice; to create and modify digital resources; to protect and distribute them; to manage them; and to apply them in student learning. We, for EG, have proposed a structure for the formation of digital competence of future specialists, consisting of three interconnected components:

- **Online communicative competence** – the ability of students to carry out educational communication and professional interaction in a digital environment.
- **Information search competence** – students' critical assessment of digital information, the ability to analyze and search for it, transforming it into high-quality production or educational content.
- **Security competence** – the ability of an individual to work safely with software, digital technologies, and information resources.

It is this model of forming the digital competence of future specialists that can be effectively adapted to the needs of higher education institutions, because it involves the ability to work with information, the development of higher education students to communicate in a digital environment, as well as the ability to ensure information security in future professional activities.

The analysis of the results of the formative stage of the experimental study aimed to determine the development of digital competence and changes in the dynamics of respondents' levels after the introduction of the author's psychological and pedagogical conditions.

During one semester, assessment was carried out using a blended learning format, which allowed tracing the influence of pedagogical tools on digital distance interaction and in the traditional classroom environment.

The comparative approach was used to increase the reliability of the results: the study involved an experimental group (EG), in which psychological and pedagogical conditions for developing digital competence were implemented, and a control group

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

(CG), in which the educational process was implemented according to the traditional model. The assessment was carried out according to three structural components of the outlined competence: motivational, operational, and value, which provide a multidimensional and comprehensive analysis of the dynamics of its development.

Analysis of the dynamics of the motivational component. We are talking about a significant increase in motivational readiness among respondents in the experimental group regarding digital activity, as confirmed by the results of the control section.

Table 2.

Comparison of the levels of the motivational component in the CG and EG during the control section

Levels	Control Group (CG)	Experimental Group (EG)
Low	30,2%	11,9%
Average	57,4%	47,0%
High	12,4%	41,1%

Source: Summarized by the author.

In contrast to the control group, most respondents at the average level retained their indicators. In contrast, in the experimental group, we observe a significant shift towards a high level of the motivational profile (41,1%). We note that the proportion of respondents with low motivation has almost halved, indicating a significant positive effect of the proposed author's psychological and pedagogical conditions on the formation of digital competence.

Fundamentally significant in the EG is the increase in the motivational component, because the basic driver of the formation of the outlined competence is precisely motivational readiness, which determines the depth of immersion in digital practices, the sustainability of further changes, and the level of students' involvement in working with technologies.

Analysis of the dynamics of the operational component. We are talking about a significant increase in the development of the operational component of digital competence (conducting in-depth analysis of digital information, the effective use of digital tools, and creating and editing their own digital products), as confirmed by the results of the control section.

Table 3.

Comparison of operational component levels in CG and EG during the control section (in %)

Levels	Control Group (CG)	Experimental Group (EG)
Low	18,9%	5,1%
Average	67,7%	56,0%
High	13,4%	38,9%

Source: Summarized by the author

The data in Table 3 show that the results in the control group remained almost unchanged: the average level dominates, and only 13,4% of respondents reached the high level. The stability of the indicators confirms this ratio under the conditions of the traditional learning model, in which digital activity is fragmented.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

In the experimental group, there was a significant redistribution of levels, indicating the effectiveness of the author's psychological and pedagogical conditions in shaping digital competence. The share of respondents with a high level of the operational component, according to the results of the control section, almost tripled, while the share with low indicators significantly decreased. Changes in the EG confirm the influence of the system of interactive tasks, an activity approach, and regular work with educational digital platforms.

Analysis of the dynamics of the value component. The formation of academic integrity, ethical attitudes, compliance with norms of responsible use of digital information, and readiness in the digital environment for tolerant and constructive communication constitute the value component of digital competence. This component received special attention within the experiment because it assesses behavioral and ideological readiness rather than technical readiness. Situational-value, reflective tasks were used for their development.

The results of the control section of the value component in the CG and EG are presented in Table 4.

Table 4.

Comparison of the levels of the value component in the CG and EG during the control section (in %)

Levels	Control Group (CG)	Experimental Group (EG)
Low	26,1%	9,5%
Average	61,6%	52,1%
High	12,3%	38,4%

Source: Summarized by the autor.

In the control group, according to the results of the control section, the majority of respondents at the average level maintained their indicators (61,6%). In comparison, the share of respondents at the low level was 26,1%.

In the experimental group, a different trend is observed: 38,4% of respondents reached a high level, more than three times the CG's comparable indicator, while the share of respondents with a low level decreased to 9,5%.

The results obtained at the control stage indicate that implementing the author's psychological and pedagogical conditions in the development of digital competence significantly influenced the development of an ethical and responsible style of digital behavior among respondents.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

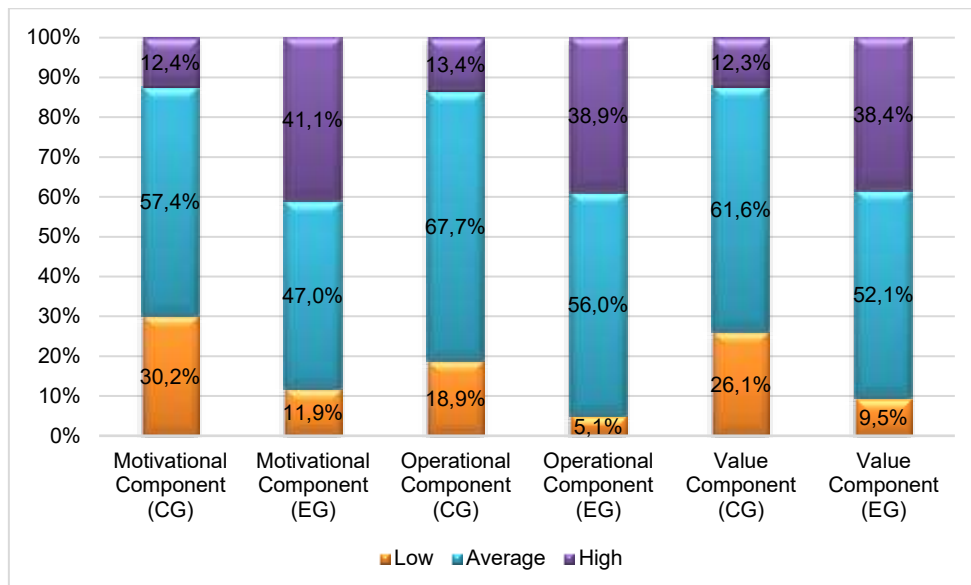


Figure 2. Comparison of motivational, operational, and value component levels in CG and EG during the control section.

We used the Student's t-test – one of the methods for testing statistical hypotheses. To verify the reliability of the results, a statistical analysis of the data obtained during the experiment was conducted to assess differences between the experimental and control groups.

We compare the obtained coefficient $t = 3.12$ with the theoretical (tabular) value of the Student's t-distribution.

We take into account the degree of freedom calculated by the formula $df = N_1 + N_2 - 2 = 92$ at $p = 5\%$ (significance level $= 0.05$, which corresponds to 95% confidence), and $t = 1.98$ is the theoretical value of the Student's t-distribution.

The obtained coefficient $t = 3.12$ significantly exceeds the tabular value, indicating that the proposed author's psychological and pedagogical conditions for the formation of digital competence in higher education institutions are effective.

The growth of indicators for all components confirms that the author's psychological and pedagogical conditions contribute to compliance with digital security standards, the formation of ethics and digital culture, and to ensuring that students master technical skills that determine the professional readiness of a future specialist to work in the digital environment.

Descriptive Statistics of Digital Competence

At the ascertaining stage, the initial level of digital competence in both groups was relatively homogeneous and characterized by predominantly average and low levels, indicating insufficient and fragmented development.

To ensure a more robust quantitative analysis, descriptive statistics (mean and standard deviation) were calculated for each component of digital competence (Table 5).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Table 5.
Descriptive statistics of digital competence (pre-test)

Component	Group	Mean (M)	SD
Motivational	EG	2.68	0.54
	CG	2.71	0.51
Operational	EG	2.59	0.57
	CG	2.62	0.55
Value-based	EG	2.64	0.52
	CG	2.66	0.50

The results indicate no statistically significant differences between the groups at the initial stage ($p > 0.05$), confirming their equivalence prior to the intervention.

Post-test Results and Dynamics of Change

Following the implementation of the psychological and pedagogical conditions, significant positive changes were observed in the experimental group across all components of digital competence, while the control group demonstrated only minor improvements.

Table 6.
Descriptive statistics of digital competence (post-test)

Component	Group	Mean (M)	SD
Motivational	EG	3.89	0.48
	CG	2.94	0.52
Operational	EG	3.76	0.51
	CG	2.85	0.56
Value-based	EG	3.81	0.47
	CG	2.91	0.50

The experimental group showed a substantial increase in mean scores across all components, while the control group exhibited only slight natural growth associated with traditional learning.

Pre-test vs Post-test Comparison

To better illustrate the dynamics, a comparative analysis of pre-test and post-test results was conducted (Table 7).

Table 7.
Pre-test vs post-test comparison (EG vs CG)

Component	Group	Pre-test M	Post-test M	Δ (Change)
Motivational	EG	2.68	3.89	+1.21
	CG	2.71	2.94	+0.23
Operational	EG	2.59	3.76	+1.17
	CG	2.62	2.85	+0.23
Value-based	EG	2.64	3.81	+1.17
	CG	2.66	2.91	+0.25

The data demonstrate that the increase in the experimental group is approximately 4–5 times higher than in the control group, confirming the effectiveness of the implemented pedagogical conditions.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Distribution of Competence Levels

The distribution of students across competence levels further supports these findings.

At the initial stage:

- High level – 11.2%
- Average level – 56.7%
- Low level – 32.1%

After the intervention, the experimental group showed a significant shift toward higher levels:

- High level increased up to ~38–41%
- Low level decreased below 12%

In contrast, the control group showed only minimal changes.

Inferential Statistics

To verify the statistical significance of the observed differences, an independent samples Student's t-test was conducted.

- $t = 3.12$
- $df = 92$
- $p \leq 0.05$

The obtained t-value exceeds the critical value ($t \approx 1.99$), indicating statistically significant differences between the experimental and control groups.

Interpretation of Results

The results confirm that the implementation of psychological and pedagogical conditions had a strong positive effect on the development of digital competence.

The most substantial improvements were observed in:

- Motivational readiness (increased engagement and initiative).
- Operational skills (information processing and digital content creation).
- Value-based attitudes (ethical and responsible digital behavior).

The consistency of improvements across all components indicates the systemic impact of the intervention rather than isolated effects.

Comparison with Previous Research

The findings are consistent with the conceptual framework of digital competence proposed by Caena & Redecker (2019), who emphasize its integrative structure combining knowledge, skills, and attitudes. In this study, such integration was not only theoretically substantiated but also empirically verified through a quasi-experimental design, thus extending prior research that has largely remained at a theoretical level.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Similarly, the results align with the conclusions of Cronin (2017), who highlights the transformative potential of digital learning environments. However, while Cronin focuses primarily on openness and digital practices, the present study demonstrates that systematically designed pedagogical conditions – rather than mere access to technologies – are the key factor influencing competence development.

The significant growth observed in the operational component corroborates findings by Mendoza Muñoz & Párraga Muñoz (2022), who underline the importance of information literacy and critical thinking. At the same time, the current study advances this perspective by showing that these skills develop more effectively when embedded in practice-oriented and interactive learning formats, such as projects and simulations.

Particular attention should be paid to the value-based component. The results support the observations of Berríos-Barra & Calderón-López (2025), who point to the insufficient development of digital ethics in educational practice. In contrast, the present study demonstrates that targeted pedagogical interventions can significantly enhance students' ethical awareness, academic integrity, and responsible digital behavior.

Theoretical Implications

This study contributes to the theoretical understanding of digital competence in several ways:

- It validates a three-component structural model (motivational, operational, value-based) as an empirically measurable construct.
- It provides a clear operationalization of digital competence, addressing a gap identified in previous studies.
- It establishes a causal link between pedagogical conditions and competence development, which is rarely demonstrated in existing literature.

Thus, the findings bridge the gap between theoretical frameworks (e.g., DigComp) and their practical implementation in higher education.

Practical Implications

From a practical perspective, the study demonstrates that the development of digital competence requires:

- Systematic integration of digital tools into professional training.
- The use of interactive and practice-oriented teaching methods.
- The creation of a supportive digital learning environment.
- The inclusion of ethical and reflective components in digital education.

These results may be useful for curriculum designers, educators, and policymakers aiming to modernize higher education in the context of digital transformation.

Critical Reflection

Despite the positive outcomes, it is important to note that the development of digital competence is a dynamic and context-dependent process. The effectiveness of pedagogical conditions may vary depending on institutional resources, students' prior experience, and the level of digital infrastructure.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Moreover, while the experimental group showed significant improvements, the persistence of average-level indicators suggests that long-term and continuous interventions are necessary to achieve sustainable results.

Conclusions

The content, components, and essence of the digital competence of future specialists are revealed. The importance of creating an innovative, rich digital educational environment is proven. The role of adaptive learning in developing the digital competence of future specialists is demonstrated. The key types of digital competence are analyzed.

As part of the study, an experimental study was conducted to develop the digital competence of future specialists amid the transformation of the modern education system and society, and to verify the effectiveness of the psychological and pedagogical conditions developed and implemented.

The combination of students' practice-oriented, educational, and cognitive activities was an important condition of the experiment, enabling the integration of digital competence development into professional disciplines and bringing the proposed tasks closer to the real conditions of professional activity.

Particular attention in the EG was paid to the use of digital platforms, in particular, the coordination of approaches to digitalization (Google, Workspace, Microsoft Teams, etc.), the formation of a single strategy to support the motivation of EG students, the development of common criteria for assessing students' knowledge when performing tasks, as well as the responsible attitude of respondents to work in a digital environment.

The experiment on the formation of digital competence of future specialists was organized into three interconnected stages: ascertaining, formative, and control.

The experiment's phased structure provided an opportunity to objectively assess the effectiveness of psychological and pedagogical conditions, track positive changes in the EG, and diagnose respondents' initial level of digital competence.

The study, conducted to assess the validity of the assessment of the level of formation of the specified competence, used a three-component author's structure (motivational, operational, and value components) with their criteria and indicators. The results of the ascertaining stage showed that students' digital competence is unsystematic and fragmented.

The results obtained at the control stage indicate that implementing the author's psychological and pedagogical conditions in the development of digital competence significantly influenced the development of an ethical and responsible style of digital behavior among respondents.

We used the Student's t-test – one of the methods for testing statistical hypotheses.

To verify the reliability of the results, a statistical analysis of the data obtained during the experiment was conducted to determine whether there was a difference between the experimental and control groups. The obtained coefficient $t = 3.12$ significantly exceeds the tabular value, indicating that the proposed author's psychological and

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

pedagogical conditions for the formation of digital competence in higher education institutions are effective.

The growth of indicators for all components confirms that the author's psychological and pedagogical conditions contribute to compliance with digital security standards, the formation of ethics and digital culture, and to ensuring that students master technical skills that determine the professional readiness of a future specialist to work in the digital environment.

Despite its contributions, the study has several limitations: the sample size ($n = 94$), while sufficient for statistical analysis, limits the generalizability of the results; the study was conducted within a specific educational context, which may influence the applicability of findings to other institutions or countries; the duration of the intervention was relatively short, preventing the assessment of long-term effects; the reliance on self-reported data (questionnaires) may introduce subjective bias.

Future research should focus on: expanding the sample size and including multiple institutions to enhance generalizability; conducting longitudinal studies to assess the sustainability of digital competence development; exploring the impact of specific digital tools and technologies (e.g., AI-based learning systems); investigating the role of teachers' digital competence as a mediating factor; refining measurement instruments and developing standardized tools for assessing digital competence.

Bibliographic references

- Araújo da Silva, K. K., & Alejandra Behar, P. (2023). Modelos pedagógicos basados en competencias digitales transversales en educación a distancia: parámetros para la construcción. *RIED-Revista Iberoamericana de Educación a Distancia*, 26(1), 101–119. <https://doi.org/10.5944/ried.26.1.34006>
- Berrios-Barra, L., & Calderón-López, M. (2025). Análisis de la competencia didáctico-digital en formadores de futuros docentes: Prácticas y percepciones. *Revista Latinoamericana de Tecnología Educativa (RELATEC)*, 24(1), 29–47. <https://doi.org/10.17398/1695-288X.24.1.29>
- Brochero Sarabia, A. E., & Hidalgo Colón, R. E. (2022). Teacher's digital competence: A communicative vision from the pedagogical praxis. *Dialogica*, 19(2), 50–66. <https://revistas.upel.edu.ve/index.php/dialogica/article/view/2157>
- Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (DigCompEdu). *European Journal of Education*, 54(3), 356–369. <https://doi.org/10.1111/ejed.12345>
- Cronin, C. (2017). Openness and praxis: Exploring the use of open educational practices in higher education. *The International Review of Research in Open and Distributed Learning*, 18(5), 15–34. <https://doi.org/10.19173/irrodl.v18i5.3096>
- Do, T. (2024). Technological competence for graduate employability: Pedagogical and professional perspectives from cross-national translation working contexts. In L. H. Phan, D. Bao, & J. Windle (Eds.), *Vietnamese language, education and change in and outside Vietnam: Global Vietnam: Across time, space and community*. Singapore: Springer. https://doi.org/10.1007/978-981-99-9093-1_11
- Fullan, M. (2018). *Nuance: Why some leaders succeed and others fail*. Corwin.
- Galarce-Miranda, C., Gormaz-Lobos, D., & Köhler, T. (2023). Improving the digital and pedagogical competence in engineering educational context. In M. E. Auer, W. Pachatz, & T. Rützmann (Eds.), *Learning in the age of digital and green transition (ICL 2022) (Lecture Notes in Networks and Systems, Vol. 634)*. Cham: Springer. https://doi.org/10.1007/978-3-031-26190-9_40

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Huallpa Zúñiga, R. (2023). Uso pedagógico de la tableta y la competencia digital docente en Educación Básica Regular Primaria de instituciones rurales del Perú. *Revista de Climatología*, 23(SI), 1663–1671. <https://doi.org/10.59427/rcli/2023/v23cs.1663-1671>
- Knysh, I., Chovriy, S., Vaculenko, S., Koycheva, T., Lytvynov, A., & Kuchai, O. (2026). Artificial Intelligence: a tool for quality training of future specialists in socio-economic specialties. *Revista Conrado*, 22(108), e4682. <https://conrado.ucf.edu.cu/index.php/conrado/article/view/4682>
- Mendoza Muñoz, G. K., & Párraga Muñoz, S. M. (2022). Alfabetización informacional y competencia digital en la gestión pedagógica docente. *Revista San Gregorio*, 51, 126-138. <https://doi.org/10.36097/rsan.v0i51.2169>
- Mytnyk, A., Uninets, I., Ivashkevych, E., Rashkovska, I., Ivashkevych, E., & Kuchai, O. (2024). Formation of professional competence in future psychologists using innovative technologies. *Revista Conrado*, 20(100), 293–304. <https://conrado.ucf.edu.cu/index.php/conrado/article/view/3963>
- Tondeur, J., Howard, S., Van Zanten, M., Gorissen, P., Van der Neut, I., Uerz, D., & Kral, M. (2023). The HeDiCom framework: Higher education teachers' digital competencies for the future. *Educational Technology Research and Development*, 71, 33-53. <https://doi.org/10.1007/s11423-023-10193-5>
- Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens – With new examples of knowledge, skills and attitudes*. Luxembourg: Publications Office of the European Union. <https://publications.jrc.ec.europa.eu/repository/handle/JRC128415>
- Zasiekina, T., Desiatnyk, K., Makaruk, O., Dvorska, A., Kostolovych, M., & Kuchai, O. (2025). Formation of leadership qualities for successful professional activity of specialists. *Revista Conrado*, 21(S1), e4355. <https://conrado.ucf.edu.cu/index.php/conrado/article/view/4355>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Herramientas digitales en la enseñanza de lenguas extranjeras: oportunidades y desafíos

Digital tools in foreign language teaching: opportunities and challenges

Dmytro Marieiev¹  Liubov Terletska²  Anna Boiko³  Olha Hvozdyak⁴  Lidiia Aizikova⁵ 

Afiliación autor:

¹ Candidate of Philological Sciences, Associate Professor, Head of the Chair of Foreign Languages and Teaching Methods, Academic and Research Institute of Philology and History, Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Hlukhiv, Ukraine. mareiev.dmitriy2@gmail.com

² Senior Lecturer, Foreign Languages and Methodology Department, Faculty of Pedagogical Education, Borys Grinchenko Kyiv Metropolitan University, Kyiv, Ukraine. terletskalm@ukr.net

³ PhD in Pedagogy, Senior Researcher, Department of Out-of-School Education, Institute of Problems on Education of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine. boikoanna@gmail.com

⁴ Candidate of Pedagogical Sciences, Professor, Professor of the Department of German Philology, Faculty of Foreign Philology, Uzhhorod National University, Uzhhorod, Ukraine. olha.hvozdyak@uzhnu.edu.ua

⁵ Lecturer of the Department of Germanic Philology, Philological Faculty, Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine. laizikova@gmail.com

Recibido: 13/03/26
Aceptado: 01/05/26

Cómo citar:

Marieiev, D., Terletska, L., Boiko, A., Hvozdyak, O., & Aizikova, L. (2026). Digital tools in foreign language teaching: opportunities and challenges. *Revista Eduweb*, 20(2), 91-103. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.6>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Resumen

El propósito del artículo propuesto fue analizar el impacto del uso sistemático de herramientas digitales en los resultados del aprendizaje de una lengua extranjera. El estudio se realizó con un diseño cuasiexperimental, utilizando pretest y posttest para los grupos control y experimental. Participaron 200 estudiantes que cursaban una lengua extranjera como parte de un curso obligatorio. Se utilizaron estadísticas descriptivas, análisis de correlación, ANCOVA y regresión lineal múltiple para analizar los datos. Los resultados del estudio mostraron un impacto positivo de las herramientas digitales en el nivel de preparación de los estudiantes en lenguas extranjeras tras controlar el nivel inicial de conocimientos. Se encontró que la intensidad del uso de herramientas digitales y el nivel de autorregulación del aprendizaje se convirtieron en factores clave para el aumento de los resultados de aprendizaje. La motivación desempeñó un papel de apoyo. Los resultados obtenidos mostraron que la eficacia de las herramientas digitales estuvo determinada por el diseño pedagógico del aprendizaje y la interacción activa de los estudiantes con el entorno digital. Las conclusiones enfatizan la justificación de la viabilidad del uso sistemático y metódicamente equilibrado de las herramientas digitales en la enseñanza de lenguas extranjeras.

Palabras clave: autorregulación del aprendizaje, cuasi-experimento, enseñanza de lenguas extranjeras, herramientas digitales, resultados del aprendizaje.

Abstract

The purpose of the proposed article was to analyze the impact of the systematic use of digital tools on the results of learning a foreign language. The study was conducted in a quasi-experimental design using pretest–posttest for the control and experimental groups. 200 students who studied a foreign language as part of a mandatory course participated in the experiment. Descriptive statistics, correlation analysis, ANCOVA, and multiple linear regression were used to analyze the data. The results of the study showed a positive impact of digital tools on the level of foreign language preparation of students after controlling for the initial level of knowledge. It was found that the intensity of use of digital tools and the level of self-regulation of learning became key factors for increasing learning outcomes. Motivation played a supporting role. The results obtained showed that the effectiveness of digital tools was determined by the pedagogical design of learning and the active interaction of students with the digital environment. The conclusions emphasize the justification of the feasibility of the systematic and methodically balanced use of digital tools in teaching foreign languages.

Keywords: digital tools, foreign language teaching, learning outcomes, quasi-experiment, self-regulation of learning.

Introduction

The rapid digitalization of education, which has significantly accelerated due to the COVID-19 pandemic, Russian aggression against Ukraine, and global changes in labor markets, has caused fundamental changes in the teaching of foreign languages. The latest digital tools (such as online platforms, learning management systems, mobile applications, artificial intelligence (AI), virtual and augmented reality) have been successfully integrated into the educational process. Thanks to their use, new models of interaction between teachers, students, and educational content have been formed. For the understanding of modern education, such technologies have opened up significant opportunities for personalizing learning, developing student autonomy, authentic language practice, and building intercultural competence.

Modern researchers have shown that digital tools usually have a positive impact on the formation of motivation in higher education students, the formation of better speech activity, and the development of the necessary reading, writing, listening, and speaking skills (Torres Martín et al., 2021; Zou et al., 2020). Digital capabilities are also relevant for the development of academic mobility and readiness for lifelong learning (Kern et al., 2022). At the same time, the empirical results obtained were quite heterogeneous. In particular, along with the declared advantages, problems were recorded (Kulichenko et al., 2018; Okoye et al., 2022). For example, a significant challenge was the superficial use of technologies, overload with digital resources, the growth of cognitive fatigue, unequal access to digital infrastructure, etc (Graeske & Sjöberg, 2021). Finally, the lack of methodological recommendations (since digital technologies developed extremely dynamically) also made itself felt. In the context of the crisis of digital transformation, the ability of learners to self-regulate has become particularly important. The transition to autonomous and technologically mediated forms of learning required learners to independently manage their learning activities, including planning, monitoring, and evaluating their own results. It is self-regulation that has made it possible to reduce the negative effects of cognitive overload, support motivation, and ensure effective learning in a digital environment.

Despite the significant increase in the number of scientific publications, modern researchers focused on the description of individual digital tools, a certain generalization of positive practices (Hossain, 2024). However, the lack of a systematic analysis of pedagogical, organizational and psychological-didactic limitations of the use of modern technologies was a research gap. Despite the significant increase in the number of scientific publications, modern research has mainly focused on the issues of individual digital tools or the generalization of positive practices in their use. Such fragmentation did not allow for the full consideration of the interaction of pedagogical, organizational and psychological factors that determined the effectiveness of digital learning. In this context, a systemic approach was more productive, as it allowed considering digital tools as elements of a holistic didactic system where technologies, participants in the educational process and educational content interact.

The purpose of the proposed article was a comprehensive analysis of the opportunities and problems of using digital tools in teaching foreign languages in higher education institutions. The study was aimed at identifying the pedagogical potential of digital technologies, finding key barriers that did not allow for the effective integration of such opportunities into the educational process.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The scientific novelty of the article consisted in the systematization of digital tools taking into account their didactic functions, as well as in the identification of problem areas that affect the quality of foreign language learning in the university environment.

Literature Review

In recent years, digital tools have become an important component of foreign language teaching in higher education institutions, especially in distance and blended learning environments. In the scientific literature, digital tools are usually understood to include the use of online platforms, mobile applications, video communication services, digital resources for students' independent work, as well as online assessment and feedback tools. Researchers emphasize that the integration of such tools changes the organization of the educational process, the forms of interaction between the teacher and students, and the nature of work with educational material (Alexander et al., 2023; Castañeda-Trujillo & Jaime Osorio, 2021).

In most modern studies, scientists have emphasized the positive impact of digital tools on language teaching (Crompton et al., 2024). Such tools have significantly expanded access to authentic language resources, contributed to the formation of regular language practice, and made it possible to study outside the classroom (Boichenko et al., 2023). Special attention was paid to mobile applications that supported the development of vocabulary, grammar and reading skills in a format convenient for students (Karataş et al., 2024). The researchers also noted that digital tools were able to increase the motivation and engagement of students (Kukulska-Hulme, 2021). This was especially true when these tools were combined with the use of gamification elements and self-monitoring of learning progress.

The researchers also concluded that the positive effect of digital tools was not automatic. Many studies emphasized the fact that the mere fact of using technology did not guarantee an increase in the quality of foreign language learning (Law, 2024; Aliyeva et al., 2023). Often, digital tools were used fragmentarily or only performed an auxiliary function, that is, they were not integrated into a holistic methodological system (Turchyn et al., 2023). In such circumstances, they could not change the pedagogical logic of learning, but recreated traditional approaches in electronic format.

Such problems are particularly evident in research conducted in Mexico, Spanish-speaking Latin American countries, and the Philippines (Ancheta, 2025; Castaño-Roldán & Correa, 2021). In these contexts, the effectiveness of using digital tools is significantly limited by a combination of structural and pedagogical factors. First, limited access to stable internet connections and digital devices has created quite unequal learning conditions and limited students' participation in online activities. Second, insufficient training of teachers in digital pedagogy has led to superficial use of technologies without integrating them into a holistic didactic design. Third, insufficient institutional support has led to the lack of agreed standards for the implementation of digital learning. As a result, digital tools have often reproduced traditional learning models in an electronic format, without providing qualitative pedagogical changes. This demonstrated the dependence of the effectiveness of digitalization on both the availability of technologies and the broader educational environment in which they were applied. These studies concluded that foreign language teaching was based on a rapid adaptation to online formats (Dooley, 2023). The main challenges were the organization of speech interaction, the control of learning activities and the support of student motivation.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

In addition to technical and organizational barriers, researchers also analyzed the problems of overloading students with digital resources (Godwin-Jones, 2021; González & Ferreiro, 2024). In particular, an excessive number of platforms, tasks and online activities could lead to fatigue, decreased concentration and superficial assimilation of the material. This was especially relevant for the development of productive language skills (speaking and writing), which required high-quality feedback and thoughtful pedagogical support.

The analysis of the scientific literature also showed that most researchers focused on describing the experience of using digital tools or on studying the attitudes of students and teachers towards technology (Bohomaz et al., 2023; Slamet, 2024). In contrast, significantly fewer works were devoted to the real impact of digital tools on learning outcomes or combined quantitative and qualitative data. In addition, in many publications the concept of "digital tools" is used quite generally, without a clear distinction between their didactic functions (Rintaningrum, 2023; Selfa-Sastre et al., 2022).

Therefore, despite a significant number of studies, a number of gaps in previous research have been identified. The conditions under which digital tools really contribute to the development of foreign language competence have not been sufficiently studied, the role of pedagogical design, digital competence of teachers and institutional support has been established. This has led to the need for further research aimed at a comprehensive analysis of the opportunities and problems of using digital tools in teaching foreign languages.

Methodology

Design and general logic

The study was conducted in a quasi-experimental format using a pretest–posttest design in the control and experimental groups. The aim was to assess the impact of the targeted use of digital tools on the results of foreign language learning and related psychological and pedagogical indicators (engagement, motivation, self-regulation).

Participants

The study involved 200 students studying a foreign language as part of a compulsory education course. All participants had approximately the same initial level of foreign language proficiency, which was checked using an entrance language test (pretest) before the start of the experiment. The sample was formed according to the cluster principle based on established academic groups, which determined the quasi-experimental nature of the study. According to the organization of the educational process, the students were divided into an experimental (EG, n = 100) and a control group (CG, n = 100). This division provided grounds for further correlation and regression analyses.

Therefore, the sample included students who regularly attended classes and participated in all stages of the study. Indicators of participants with incomplete data or with a low level of involvement (attendance of less than 75% of classes) were excluded from the final analysis. All participants provided informed consent to participate in the study. Accordingly, data collection and processing were carried out in compliance with the ethical principles of anonymity and confidentiality. All participants had the right to refuse to participate in the experiments at any time. To

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

reduce the influence of possible extraneous factors, the previous level of educational training, as well as the basic educational characteristics of the participants, were taken into account in the statistical analysis. In order to ensure group equivalence, a preliminary analysis of the pretest results was conducted, which revealed no statistically significant differences between the experimental and control groups. This made it possible to correctly compare the results of the experimental and control groups, increasing the internal validity of the study.

Educational intervention (digital tools)

The intervention lasted 10 weeks and was integrated into the standard curriculum without increasing the classroom load. In the experimental group, the training focused on the use of a “digital package”, which combined the use of LMS platforms (posting materials, deadlines, assessment rubrics, organizing independent work), mobile/web tools for vocabulary and repetition (spaced practice), formative assessment services (short online tests, instant feedback), tools for oral/written production (short mini-answers, peer feedback, finalizing drafts). In the control group, the mastery of similar educational material took place with the same amount of hours, using educational and methodological materials. However, the work took place primarily in the traditional model (auditorium exercises and basic homework), without the systematic and mandatory use of a digital package.

Measurement tools and procedure

Data collection was carried out twice: before the intervention (pretest) and after completion (posttest). First of all, to determine the learning outcomes in a foreign language (the main outcome), a standardized or unified test (with parallel forms) was used - to determine the key components of foreign language competence. The main indicator was the increase in the result (posttest - pretest) or the posttest score with the pretest control in the statistical model.

A standardized test, modeled after international TOEFL/IELTS exams and adapted for the study, was used to determine the level of foreign language proficiency. The test consisted of reading, writing, listening, and speaking tasks and was validated by a group of experts in the field of foreign language teaching.

Psychological and pedagogical variables (secondary outcomes) were then used. As a result, learning motivation, involvement, and self-regulation of learning were assessed using short validated scales (Likert format). The reliability of the scales was checked by Cronbach's α coefficients. Digital tool usage indicators (EG only) were measured by recording log data (frequency of entries, tasks completed, number of test attempts, volume of activities), which were then used as quantitative predictors in correlation and regression analyses.

At the first stage, all participants filled out an informed consent and took a pretest (language test and questionnaires). Then, for 10 weeks, the intervention was applied: EG worked with a digital package, CG – in a standard format. At the final stage, all participants took a posttest using a similar procedure (See Table 1).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 1.

Comparison of learning activities in experimental and control groups

Component	Experimental group (EG)	Control group (CG)
Learning materials	LMS-based digital content, structured modules	Printed/manual materials
Vocabulary practice	Mobile/web tools (spaced repetition)	Traditional exercises (textbook)
Assessment	Online quizzes with instant feedback	Written tests with delayed feedback
Speaking/writing	Digital tools, peer feedback, mini-tasks	Classroom-based activities
Feedback	Continuous, automated + peer	Teacher-based, periodic
Learning format	Blended/digital-supported	Traditional face-to-face

Data analysis

The analysis took place in several consecutive steps. First, descriptive statistics (M, SD) were calculated and the internal consistency of the scales (α) was checked. To assess the effect of the intervention, ANCOVA was used, where the posttest result (or gain) was compared between EG and CG with control for pretest and additional covariates (if necessary).

To explain the mechanisms of influence, a correlation analysis between log data, motivation/engagement/self-regulation and performance gains was used. Then, multiple linear regression (hierarchical approach) was applied. In particular, the pretest and baseline characteristics were sequentially entered into the model, followed by group membership (EG/CG), and then the intensity of digital tool use and psychological and pedagogical variables. Statistical significance was assessed at $p < 0.05$ (it was additionally interpreted as effect sizes and confidence intervals).

Results and Discussion

Results

At the initial stage, descriptive statistics of the main variables were analyzed. The mean values of the input language test (pretest) in the experimental and control groups did not demonstrate significant statistical differences ($p > 0.05$). Such circumstances indicated a completely comparable initial level of foreign language training of the participants. Also, the internal consistency check of the psychological and pedagogical scales showed a completely acceptable level of reliability. In particular, the Cronbach's α indicators for the motivation, involvement and self-regulation scales were within 0.78–0.86. Such indicators fully corresponded to the recommendations for conducting educational research.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 2.
Descriptive statistics of main study variables

Variable	Group	N	Mean (M)	SD
Language proficiency (Pre-test)	EG	100	58.42	8.61
	CG	100	57.96	8.47
Language proficiency (Post-test)	EG	100	71.85	7.94
	CG	100	66.12	8.21
Gain score (Post-Pre)	EG	100	13.43	5.62
	CG	100	8.16	5.44
Motivation	EG	100	3.89	0.61
	CG	100	3.52	0.65
Learning engagement	EG	100	3.95	0.58
	CG	100	3.47	0.63
Self-regulated learning	EG	100	3.82	0.59
	CG	100	3.41	0.62
Digital tool usage index	EG	100	4.21	0.73
	CG	100	2.14	0.69

Note. Language proficiency scores are reported on a 0–100 scale. Motivation, engagement, self-regulated learning, and digital tool usage were measured on a 5-point Likert scale (1 = low, 5 = high).

To assess the effect of using digital tools, an ANCOVA was conducted, where the dependent variable was the posttest result in a foreign language, and the covariate was the pretest (See Table 3).

Therefore, the results of the analysis demonstrated the existence of a statistically significant effect for the experimental group on educational outcomes after controlling for the initial level:

$F(1, 197) = 18.42, p < 0.001, \text{partial } \eta^2 = 0.09.$

Table 3.
ANCOVA and hierarchical regression predicting language learning outcomes

Source	df	F	p	Partial η^2
Pre-test (covariate)	1	52.17	< .001	.21
Group (EG vs CG)	1	18.42	< .001	.09
Error	197			

Note. Dependent variable: post-test language proficiency score.

The adjusted mean values demonstrated that students in the experimental group had higher educational outcomes than participants in the control group. This indicated a positive impact of the systematic use of digital tools on the level of foreign language training.

The next stage was to perform an analysis of the relationships between the intensive use of digital tools, psychological and pedagogical indicators and the increase in language outcomes (in the experimental group).

Such a correlation analysis (Pearson) made it possible to identify several important phenomena. First of all, a moderate positive relationship was characterized between the intensity and use of digital tools, the increase in language outcomes ($r = 0.41, p < 0.001$). Another result was a significant relationship between self-regulation of learning and the increase in results ($r = .46, p < 0.001$). Positive correlations were found between student engagement and indicators of activity in the digital environment ($r = 0.38, p < 0.01$).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Therefore, the data obtained showed that the fact of using digital tools in combination with the nature and regularity of interaction with them played an important role in achieving learning outcomes.

To identify the factors that most predicted the increase in foreign language competence, a hierarchical multiple regression analysis was carried out. Model 1 consisted of including not only the pretest, explaining 21% of the variance in the results ($R^2 = 0.21$). At the same time, Model 2 with the addition of the variable of group affiliation (EG/CG) demonstrated a statistically significant increase in the explained variance ($\Delta R^2 = 0.07$, $p < 0.01$). Model 3, which additionally included the intensity of use of digital tools, motivation and self-regulation, explained up to 39% of the total variance in the increase in language results ($R^2 = 0.39$).

In the final model, the following factors were significant predictors: self-regulation of learning ($\beta = 0.32$, $p < 0.001$), intensity of use of digital tools ($\beta = 0.27$, $p < 0.01$) and belonging to the experimental group ($\beta = 0.21$, $p < 0.05$) (See Table 4).

Table 4.
Hierarchical multiple regression predicting gain score

Predictor	β	t	p
Model 1			
Pre-test proficiency	-.46	-7.82	< .001
$R^2 = .21$			
Model 2			
Pre-test proficiency	-.39	-6.41	< .001
Group (EG = 1, CG = 0)	.27	4.36	< .001
$\Delta R^2 = .07$			
Model 3			
Pre-test proficiency	-.31	-5.12	< .001
Group (EG = 1, CG = 0)	.21	3.18	.002
Digital tool usage	.27	3.94	< .001
Self-regulated learning	.32	4.71	< .001
Motivation	.14	1.98	.049
$R^2 = .39$			

Motivation demonstrated a positive, but less pronounced predictive power after the inclusion of other variables in the model. The results confirmed that the use of digital tools in teaching foreign languages had a statistically significant and pedagogically relevant effect. However, this effect was not uniform for all participants. The greatest learning achievements were observed in students with the highest level of self-regulation, more active interaction with digital learning environments. Therefore, the results in general showed that the effectiveness of digital tools was determined not only by their availability, but also by the pedagogical design of learning and the individual characteristics of students.

Discussion

The aim of this study was to analyze the impact of the systematic use of digital tools on the results of foreign language learning, as well as to identify factors that mediated or enhanced this impact. The results obtained indicated that the integration of digital tools into the educational process could have a positive effect on the level of foreign language preparation of education seekers. However, such an effect was not uniform and depended on several pedagogical and individual factors.

First, the results obtained indicated that the systematic use of digital tools contributed to increasing the level of foreign language training of education seekers.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

This was fully consistent with the previous conclusions of modern researchers, who emphasized that digital tools could increase the effectiveness of foreign language learning, if they were purposefully and methodically justified in their integration (Cordeiro, 2022). It is important that within the framework of the proposed study, digital tools were not used in isolation (García Botero et al., 2022). They were integrated into the logic of the course as a means of supporting practice, feedback, and independent work.

Importantly, the intensity of interaction with digital tools played a key role in achieving learning outcomes. This indicated the presence of the so-called “dose–response effect”. That is, the fact of using technologies and regular interaction with the digital environment had an important (if not decisive) significance for the success of students’ learning. This result supported the position of the researchers, who emphasized that digital tools played the role of a catalyst in learning (Kasneci et al., 2023; Müller-Hartmann & Hauck, 2022). However, this situation developed only when these capabilities were involved in systematic activities and were used not only in episodic or formal tasks.

Also, regression analysis showed that self-regulation of learning became one of the strongest signs of the increase in foreign language competence. This made it possible to interpret digital tools not as a self-sufficient factor of success, but as an environment in which the already existing or formed skills of planning, control and reflection of educational activities are strengthened. Thus, the results supported the approach in the scientific literature (Gagić et al., 2023), according to which the effectiveness of digital technologies depended mostly on the promotion of the development of autonomy and responsibility among learners (Panagiotidis et al., 2023; Puebla et al., 2021).

The results obtained made it possible to identify some heterogeneity in previous findings recorded in older studies. The literature often outlined contradictory data on the impact of digital tools on educational achievements (Alves et al., 2019; Boreland et al., 2023). This was partly due to differences in pedagogical design and the level of support for learners (Bećirović et al., 2021). The results obtained in this study showed that digital tools were effective when they were combined with a clear task structure, regular formative assessment and opportunities for reflection. At the same time, the tools were not used only as a technical addition to traditional learning.

The proposed results also indicated that motivation was related to educational outcomes. However, this type of motivation became a weaker predictor in the final regression model, especially when combined with self-regulation and actual use of digital tools. This could indicate that motivation alone did not guarantee better results without appropriate learning strategies and active participation in the educational process. This conclusion significantly supplemented the current discussions on the need to move from motivation-oriented approaches to models that focused on learning strategies and behavioral indicators (Masterson, 2020; Pilege et al., 2021).

In general, it is worth noting that the proposed research results confirmed the idea of digital tools as a factor in significantly increasing the effectiveness of foreign language teaching. However, such an impact is possible only if they are used pedagogically appropriate (Lenkaitis & Loranc-Paszyk, 2019; Lira-Gonzales & Grégoire, 2021). Therefore, the practical contribution of the study was to demonstrate that the increase in learning outcomes is not so much due to access to digital resources, but rather due to the interaction between the intensity of their use, the individual characteristics of students and the general organization of the educational process. Such results highlighted the need for a comprehensive

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

approach to the digitalization of foreign language education, which was focused on the technology itself and the quality of the learning experience.

Further interpretation of the results will require consideration of the limitations of the methodology used. First, the use of a quasi-experimental design with clustering significantly limited the possibility of complete randomization, which could have affected internal validity. Although the use of a pretest and ANCOVA allowed us to control for initial differences between groups, the results could have been influenced by uncontrolled individual and contextual factors. There was also a need to take into account a significant part of the psychological and pedagogical variables (motivation, engagement, self-regulation), which were measured using self-assessment questionnaires. Although the scales used demonstrated adequate reliability, such data could be sensitive to socially desirable responses. At the same time, the use of self-report questionnaires created the risk of social desirability effects. In particular, participants may have overestimated their own motivation, engagement, or self-regulation, considering such responses more desirable. This could partly explain the relatively high mean values of psychological indicators and influence the strength of the identified relationships. In addition, the subjective nature of such data limited the ability to accurately measure actual learning behavior. In subsequent studies, self-reports were combined with objective indicators (e.g., behavioral logs or observations), which allowed to increase the validity of the obtained results.

Conclusions

The proposed study analyzed the systematic application of digital tools on the results of learning a foreign language. As a result of a quasi-experiment with the participation of 200 students, it was determined that the purposeful integration of digital tools into the educational process had a significant impact on the development of foreign language competence (when compared to the traditional learning model).

The data obtained demonstrated that the effectiveness of digital tools depends not only on their use. First of all, another aspect is the intensity and quality of interaction with the digital learning environment, as well as the individual characteristics of students. In particular, self-regulation of learning and active participation in digital activities became important prerequisites for achieving academic success. At the same time, motivation became an auxiliary factor that did not play a decisive role.

In the practical sphere, the results of the study had important implications for teachers and developers of educational programs. In particular, it has been proven that digital tools should be implemented as part of a holistic pedagogical scenario with clearly defined learning objectives and formative feedback. Equally important, attention should be paid to the development of learners' self-regulation skills, including planning, reflection and responsibility for their own learning.

Prospects for further research were related to a more detailed analysis of the impact of new digital technologies on the process of learning foreign languages. In particular, the study of the potential of generative artificial intelligence as a tool for personalized learning, automated feedback, and the development of productive speaking skills will be relevant. In addition, a separate direction may be the study of the use of virtual and augmented reality technologies to create an authentic language environment and develop communicative competence.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Bibliographic references

- Alexander, K., Savvidou, C., & Alexander, C. (2023). Who wrote this essay? Detecting ai-generated writing in second language education in higher education. *The Journal of Teaching English with Technology*, 2023(2). <https://doi.org/10.56297/buka4060/xhld5365>
- Aliyeva, G. B., Honcharuk, V., Pavliuk, N., Zinchenko, V., & Sivachenko, I. (2023). Review of modern pedagogical technologies and methods in the field of philology according to European standards: A literature review. *Revista on line de Política e Gestão Educacional*, 27(esp.2), e023049. <https://doi.org/10.22633/rpge.v27iesp.2.18778>
- Alves, P., Miranda, L., & Morais, C. (2019). The Importance of Virtual Learning Environments in Higher Education. In *Computer-Assisted Language Learning* (pp. 109–131). IGI Global. <https://doi.org/10.4018/978-1-5225-7663-1.ch005>
- Ancheta, J. R. (2025). Computer-Mediated Communication in Language Teaching: Challenges and Responses of Filipino ESL Teachers in the Philippines. *Jurnal Komunikasi: Malaysian Journal of Communication*, 41(1), 351–367. <https://doi.org/10.17576/jkmjc-2025-4101-20>
- Bećirović, S., Brdarević-Čeljo, A., & Deliđ, H. (2021). The use of digital technology in foreign language learning. *SN Social Sciences*, 1(10). <https://doi.org/10.1007/s43545-021-00254-y>
- Bohomaz, O., Koreneva, I., Lihus, V., Kambalova, Y., Shevchuk, V., & Tolchieva, H. (2023). Regarding the development of educational and scientific potential in the 21st century: Technological challenges. *Conhecimento & Diversidade*, 15(38), 479–495. <https://doi.org/10.18316/rcd.v15i38.11100>
- Boichenko, M., Churychkanich, I., Kulichenko, A., Shramko, R., & Rakhno, M. (2023). Mind maps to boost the learning of English as L2 at higher education institutions in Ukraine. *Amazonia Investiga*, 12(70), 229–240. <https://doi.org/10.34069/AI/2023.70.10.21>
- Boreland, T., Lotherington, H., Tomin, B., & Thumlert, K. (2023). The use of digital tools in French as a Second Language teacher education in Ontario. *TESL Canada Journal*, 39(2). <https://doi.org/10.18806/tesl.v39.i2/1375>
- Castañeda-Trujillo, J. E., & Jaime Osorio, M. F. (2021). Pedagogical Strategies Used by English Teacher Educators to Overcome the Challenges Posed by Emergency Remote Teaching During the COVID-19 Pandemic. *Íkala*, 26(3), 697–713. <https://doi.org/10.17533/udea.ikala/v26n3a12>
- Castaño-Roldán, J. D., & Correa, D. (2021). Critical Reading With Undergraduate EFL Students in Colombia: Gains and Challenges. *Profile: Issues in Teachers' Professional Development*, 23(2), 35–50. <https://doi.org/10.15446/profile.v23n2.89034>
- Cordeiro, J. (2022). Emergency Remote Teaching and Learning. In *Impact of Digital Transformation in Teacher Training Models* (pp. 140–159). IGI Global. <https://doi.org/10.4018/978-1-7998-9538-1.ch008>
- Crompton, H., Edmett, A., Ichaporia, N., & Burke, D. (2024). AI and English language teaching: Affordances and challenges. *British Journal of Educational Technology*, 55(6), 2503–2529. <https://doi.org/10.1111/bjet.13460>
- Dooly, M. (2023). Language Teaching, Language Learning, and Virtual Exchange in an Age of Complexity. *International Journal of Computer-Assisted Language Learning and Teaching*, 12(3), 1–18. <https://doi.org/10.4018/ijcallt.316459>
- Gagić, A., Gajić, T., Gavranović, V., Maenza, N., & Veljković Michos, M. (2023). Digital Tools for Language Learning: Exploring Teachers' Innovative and Engaging Practices. In *Sinteza 2023 – International Scientific Conference on Information Technology and Data Related Research*. Belgrade, Serbia: Singidunum University. <https://doi.org/10.15308/sinteza-2023-281-287>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- García Botero, G., Nguyet, D. A., García Botero, J., Zhu, C., & Questier, F. (2022). Acceptance and Use of Mobile-Assisted Language Learning by Higher Education Language Teachers. *Lenguaje*, 50(1), 66–92. <https://doi.org/10.25100/lenguaje.v50i1.11006>
- Godwin-Jones, R. (2021). Big data and language learning: Opportunities and challenges. *Language Learning & Technology*, 25(1), 4–19. <https://doi.org/10.64152/10125/44747>
- González, M. d. L. Á. G., & Ferreiro, A. L. (2024). Web-assisted instruction for teaching and learning EFL phonetics to Spanish learners: Effectiveness, perceptions and challenges. *Computers and Education Open*, 7, 100214. <https://doi.org/10.1016/j.caeo.2024.100214>
- Graeske, C., & Sjöberg, S. A. (2021). VR-Technology in Teaching: Opportunities and Challenges. *International Education Studies*, 14(8), 76. <https://doi.org/10.5539/ies.v14n8p76>
- Hossain, K. I. (2024). Reviewing the role of culture in English language learning: Challenges and opportunities for educators. *Social Sciences & Humanities Open*, 9, 100781. <https://doi.org/10.1016/j.ssaho.2023.100781>
- Karataş, F., Abedi, F. Y., Ozek Gunyel, F., Karadeniz, D., & Kuzgun, Y. (2024). Incorporating AI in foreign language education: An investigation into ChatGPT's effect on foreign language learners. *Education and Information Technologies*, 29, 19343–19366. <https://doi.org/10.1007/s10639-024-12574-6>
- Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., . . . & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, 103, 102274. <https://doi.org/10.1016/j.lindif.2023.102274>
- Kern, R., Liddicoat, A. J., & Zarate, G. (2022). Research perspectives on virtual intercultural exchange in language education. In *Virtual Exchange for Intercultural Language Learning and Teaching* (pp. 1–20). New York, NY, USA: Routledge. <https://doi.org/10.4324/9781003024620-1>
- Kukulska-Hulme, A. (2021). Reflections on research questions in mobile assisted language learning. *Journal of China Computer-Assisted Language Learning*, 1(1), 28–46. <https://doi.org/10.1515/jccall-2021-2002>
- Kulichenko, A. K., Sotnik, T. V., & Stadnychenko, K. V. (2018). Electronic portfolio as a technique of developing creativity of a foreign language teacher. *Information Technologies and Learning Tools*, 66(4), 286–304. <https://doi.org/10.33407/itlt.v66i4.2178>
- Law, L. (2024). Application of Generative Artificial Intelligence (GenAI) in Language Teaching and Learning: A Scoping Literature Review. *Computers and Education Open*, 6, 100174. <https://doi.org/10.1016/j.caeo.2024.100174>
- Lenkaitis, C. A., & Loranc-Paszyk, B. (2019). Facilitating global citizenship development in lingua franca virtual exchanges. *Language Teaching Research*, 25(5), 136216881987737. <https://doi.org/10.1177/1362168819877371>
- Lira-Gonzales, M.-L., & Grégoire, P. (2021). Technologies in second-language classes. In *Foreign Language Learning in the Digital Age* (pp. 189–206). New York, NY, USA: Routledge. <https://doi.org/10.4324/9781003032083-16>
- Masterson, M. (2020). An Exploration of the Potential Role of Digital Technologies for Promoting Learning in Foreign Language Classrooms: Lessons for a Pandemic. *International Journal of Emerging Technologies in Learning (iJET)*, 15(14), 83. <https://doi.org/10.3991/ijet.v15i14.13297>
- Müller-Hartmann, A., & Hauck, M. (2022). Chapter 7. Fostering (Critical) digital teaching competence through virtual exchange. In *Language Learning &*

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Language Teaching* (pp. 135–156). John Benjamins Publishing Company. <https://doi.org/10.1075/llt.57.07mul>
- Okoye, K., Hussein, H., Arrona-Palacios, A., Quintero, H. N., Ortega, L. O. P., Sanchez, A. L., Ortiz, E. A., Escamilla, J., & Hosseini, S. (2022). Impact of digital technologies upon teaching and learning in higher education in Latin America: an outlook on the reach, barriers, and bottlenecks. *Education and Information Technologies*, 28, 2291–2360. <https://doi.org/10.1007/s10639-022-11214-1>
- Panagiotidis, P., Krystalli, P., & Arvanitis, P. (2023). Technology as a Motivational Factor in Foreign Language Learning. *European Journal of Education*, 6(1), 69–84. <https://eric.ed.gov/?id=EJ1417303>
- Pilege, E., Plota, S., Pilegis, G., & Zivitere, M. (2021). ACT Digital: The Strategic Role of Analytics, Creativity and Technologies for Cultural and Creative Sector and Education. *Digital Presentation and Preservation of Cultural and Scientific Heritage*, 11, 135–150. <https://doi.org/10.55630/dipp.2021.11.12>
- Puebla, C., Fievet, T., Tsopanidi, M., & Clahsen, H. (2021). Mobile-assisted language learning in older adults: Chances and challenges. *ReCALL*, 34(2), 169–184. <https://doi.org/10.1017/s0958344021000276>
- Rintaningrum, R. (2023). Technology integration in English language teaching and learning: Benefits and challenges. *Cogent Education*, 10(1). <https://doi.org/10.1080/2331186x.2022.2164690>
- Selfa-Sastre, M., Pifarré, M., Cujba, A., Cutillas, L., & Falguera, E. (2022). The Role of Digital Technologies to Promote Collaborative Creativity in Language Education. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.828981>
- Slamet, J. (2024). Potential of ChatGPT as a digital language learning assistant: EFL teachers' and students' perceptions. *Discover Artificial Intelligence*, 4(1). <https://doi.org/10.1007/s44163-024-00143-2>
- Torres Martín, C., Acal, C., El Homrani, M., & Mingorance Estrada, Á. (2021). Impact on the Virtual Learning Environment Due to COVID-19. *Sustainability*, 13(2), 582. <https://doi.org/10.3390/su13020582>
- Turchyn, I., Zaitseva, S., Rudenko, N., Saienko, V., Kuzemko, N., & Denefil, O. (2023). Using distance learning models as opportunities for blended learning for foreigners. *Revista Românească pentru Educație Multidimensională*, 15(4), 178–191. <https://doi.org/10.18662/rrem/15.4/787>
- Zou, B., Liviero, S., Hao, M., & Wei, C. (2020). Artificial Intelligence Technology for EAP Speaking Skills: Student Perceptions of Opportunities and Challenges. In *Technology and the Psychology of Second Language Learners and Users* (pp. 433–463). Springer International Publishing. https://doi.org/10.1007/978-3-030-34212-8_17

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Aprendizaje combinado y competencia profesional en la educación superior

Blended learning and professional competence in higher education

Tetiana Hrebenyk¹  Oksana Shkvyr²  Yuliia Kulimova³  Svitlana Vyhovska⁴  Zoia Turianytsia⁵ 

Afiliación autor:

¹ Candidate of Pedagogical Sciences, Associate Professor, Head of College, Sumy State University, Ukraine.

up.grebenik@gmail.com

² Doctor of Pedagogical Sciences, Professor, Professor of the Department of Pedagogics and Social Work, Khmelnytskyi Humanitarian-Pedagogical Academy, Ukraine. shkvyr@ukr.net

³ PhD in Pedagogical Sciences, Associate Professor of the Department of Primary Education, Poltava V.G. Korolenko National Pedagogical University, Ukraine. stepurochka@gmail.com

⁴ Candidate of Pedagogical Sciences, Associate Professor of the Department of Pedagogy, National University of Life and Environmental Sciences of Ukraine, Ukraine. vygovsika@ukr.net

⁵ Candidate of Pedagogical Sciences (PhD in Pedagogy), Senior Lecturer at the Department of Vocational Education and Agricultural Production Technology, Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Ukraine. tzytum@ukr.net

Recibido: 26/01/26

Aceptado: 16/04/26

Cómo citar:

Hrebenyk, T., Shkvyr, O., Kulimova, Y., Vyhovska, S., & Turianytsia, Z. (2026). Blended learning and professional competence in higher education. *Revista Eduweb*, 20(2), 104-118. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.7>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

El estudio investiga la efectividad del aprendizaje semipresencial en la formación profesional de futuros docentes en instituciones de educación superior. El objetivo es verificar empíricamente el impacto de un entorno educativo integrado basado en el aprendizaje semipresencial en la formación de competencias profesionales. Se empleó un diseño de investigación de métodos mixtos, que combinó análisis teórico, recopilación de datos empíricos y validación estadística. La competencia profesional se evaluó según criterios motivacionales, de contenido y de actividad, con niveles clasificados como alto, medio y bajo. Tras la implementación del entorno educativo integrado basado en el aprendizaje semipresencial, se observaron mejoras sustanciales en el grupo experimental. En la etapa formativa, la proporción de estudiantes con un alto nivel de competencia aumentó al 49,9 % en el grupo experimental en comparación con el 19,8 % en el grupo de control, mientras que el nivel bajo disminuyó al 11,3 % en el grupo experimental frente al 23,6 % en el grupo de control. El nivel medio en el grupo experimental disminuyó al 38,8 %, lo que indica un cambio hacia niveles de competencia más altos. Los hallazgos demuestran que la implementación de un entorno educativo integrado basado en el aprendizaje semipresencial mejora significativamente la competencia profesional de los futuros docentes. El estudio aporta evidencia empírica que respalda la integración de formatos de aprendizaje digitales y tradicionales como medio para mejorar la calidad de la educación superior.

Palabras clave: aprendizaje semipresencial, formación profesional, futuros educadores, entorno educativo de la educación superior, tecnologías de aprendizaje móvil.

Abstract

The study investigates the effectiveness of blended learning in the professional training of future educators within higher education institutions. The aim is to empirically verify the impact of an integrated educational environment based on blended learning on the formation of professional competencies. A mixed-methods research design was employed, combining theoretical analysis, empirical data collection, and statistical validation. Professional competence was assessed across motivational, content, and activity criteria, with levels classified as high, average, and low. Following the implementation of the blended learning-based integrated educational environment, substantial improvements were observed in the experimental group. At the formative stage, the proportion of students with a high level of competence increased to 49.9% in EG compared to 19.8% in CG, while the low level decreased to 11.3% in EG versus 23.6% in CG. The average level in EG decreased to 38.8%, indicating a shift toward higher competence levels. The findings demonstrate that the implementation of a blended learning-based integrated educational environment significantly enhances the professional competence of future educators. The

study provides empirical evidence supporting the integration of digital and traditional learning formats as a means of improving higher education quality.

Keywords: blended learning, professional training, future educators, educational environment of higher education, mobile learning technologies.

Introduction

The rapid digital transformation of society and the growing demands of the labor market have significantly reshaped the requirements for the professional training of future educators. Modern higher education institutions are expected to ensure not only the acquisition of theoretical knowledge but also the development of digital competencies, practical skills, and the ability for lifelong learning. In this context, blended learning has emerged as a promising educational approach that integrates traditional face-to-face instruction with digital and online learning environments.

Despite the increasing adoption of blended learning in higher education, existing research predominantly focuses on its technological implementation, general pedagogical advantages, and descriptive models. Previous studies highlight its potential for enhancing flexibility, personalization, and student engagement; however, they often lack empirical evidence regarding its direct impact on the formation of professional competencies, particularly in the training of future educators. Moreover, insufficient attention has been paid to the role of an integrated educational environment as a systemic factor that ensures the effectiveness of blended learning.

A critical analysis of the literature also reveals several research gaps. First, there is a lack of comprehensive models that combine pedagogical conditions, digital tools, and organizational components into a unified system of professional training based on blended learning. Second, empirical studies rarely provide statistically validated results demonstrating the effectiveness of such systems in improving specific components of professional competence (motivational, content, and activity). Third, the issue of aligning blended learning technologies with the real needs of future educators and their readiness for professional tasks remains underexplored.

These gaps lead to a clear research problem: how to design and implement an integrated educational environment based on blended learning that effectively enhances the professional competence of future educators and produces statistically significant improvements in their training outcomes.

The necessity of this study is due to the need to bridge the gap between the theoretical potential of blended learning and its practical effectiveness in the professional training of future specialists. Addressing this issue is essential for improving the quality of higher education, ensuring the alignment of educational outcomes with labor market demands, and developing evidence-based pedagogical solutions.

Literature Review

Blended learning has been widely explored in contemporary educational research as an approach that integrates traditional face-to-face instruction with digital and online learning environments. A significant body of literature conceptualizes blended learning primarily as a combination of instructional modalities. For instance, Saboowala & Manghirmalani Mishra (2021) define it as an integrated educational

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

process that combines classroom and online interaction to enhance learning effectiveness.

While these studies provide a solid theoretical foundation, their focus remains largely descriptive and organizational. They tend to generalize the benefits of blended learning without offering sufficiently detailed empirical validation of its impact on measurable educational outcomes, particularly professional competence. This limits their applicability in designing evidence-based training systems for future educators. Another group of studies addresses the readiness of educators and students for blended learning. Çemçem et al. (2024) examine readiness through multidimensional constructs, including pedagogical, technological, and organizational components. These works contribute to understanding the conditions necessary for successful implementation; however, they predominantly assess readiness as a precondition rather than as a dynamic outcome influenced by targeted pedagogical interventions. Consequently, they do not fully explain how blended learning environments can actively shape and improve professional competencies.

Research focusing on specific instructional strategies within blended learning – such as flipped classrooms, mobile learning, and interactive technologies – highlights their potential to increase student engagement and autonomy (Beltrán del Río, 2021; García-Ponce & Mora-Pablo, 2020). These studies demonstrate the effectiveness of particular tools or methods but often lack a holistic perspective. They analyze isolated elements rather than considering blended learning as a systemic phenomenon embedded within an integrated educational environment. As a result, the interconnections between pedagogical conditions, technological infrastructure, and competency development remain insufficiently explored.

Furthermore, recent studies (e.g., Cabezas et al., 2023; Cespedes-Panduro et al., 2023) emphasize the importance of teachers' perceptions, digital competencies, and instructional quality in blended environments. Although these works contribute to understanding contextual factors, they rely heavily on qualitative or perceptual data, which may introduce subjectivity and limit the generalizability of findings. There is a notable lack of studies employing rigorous statistical methods to confirm the effectiveness of blended learning interventions.

Thus, the critical analysis of the literature reveals several key limitations:

1. Fragmentation of research focus – most studies examine individual aspects of blended learning (technologies, models, or readiness) rather than integrated systems.
2. Insufficient empirical validation – a lack of statistically grounded evidence demonstrating the impact of blended learning on clearly defined components of professional competence.
3. Limited systemic perspective – inadequate consideration of the integrated educational environment as a complex factor combining pedagogical conditions, digital resources, and organizational mechanisms.
4. Weak linkage to professional training outcomes – many studies do not directly connect blended learning with measurable improvements in future educators' readiness for professional activity.

In contrast to the existing literature, the present study offers a systemic and empirically validated approach to blended learning in higher education. Its unique contribution lies in: the development and implementation of an integrated

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

educational environment that combines pedagogical, technological, and organizational components into a unified system of professional training; the operationalization of professional competence through clearly defined criteria (motivational, content, and activity), enabling precise measurement of learning outcomes; the use of a controlled pedagogical experiment with experimental and control groups to ensure comparability of results; the application of statistical validation (Fisher's exact test, $\phi = 4.8$), which provides reliable evidence of the effectiveness of the proposed approach; the demonstration of quantitative improvements in competence levels, thus bridging the gap between theoretical assumptions and empirical confirmation.

Therefore, this study not only extends the theoretical understanding of blended learning but also addresses the identified gaps by providing a comprehensive, evidence-based model for enhancing the professional competence of future educators within higher education.

The aim of this study is to theoretically substantiate and empirically verify the effectiveness of an integrated educational environment based on blended learning in the professional training of future educators, as well as to assess its impact on the formation of key components of professional competence (motivational, content, and activity) through a controlled pedagogical experiment and statistical validation of the obtained results.

Methodology

The study employed a mixed-methods research design integrating theoretical, empirical, and statistical approaches to ensure a comprehensive and valid evaluation of the effectiveness of blended learning in the professional training of future educators.

Research Design and Procedure

The research was conducted in three sequential stages: ascertaining, exploratory, and formative.

At the ascertaining stage, baseline data were collected to determine the initial levels of professional competence and students' readiness for professional activity. The exploratory stage involved the design of an integrated educational environment based on blended learning and the identification of pedagogical conditions for its implementation.

At the formative stage, a pedagogical experiment was conducted to verify the effectiveness of the proposed system through a controlled comparison between groups.

Participants

The study involved 85 students of higher education institutions, including an experimental group (EG, $n = 41$) and a control group (CG, $n = 44$). All participants were senior students who had completed pedagogical practice, ensuring a comparable baseline of professional experience.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Instruments and Data Collection

To enhance the validity and reliability of the findings, multiple data collection instruments were used:

- Structured questionnaire consisting of closed and semi-closed items aimed at diagnosing motivational attitudes, self-assessment of professional readiness, and engagement with digital technologies. The questionnaire included Likert-scale items (1–5) to quantify responses.
- Semi-structured interviews to clarify qualitative aspects of students' experiences, difficulties, and perceptions of blended learning.
- Pedagogical observation protocols, which recorded students' activity, interaction, and application of professional skills in both online and offline learning contexts.
- Diagnostic assessment tasks, designed to evaluate practical skills and the ability to apply knowledge in simulated professional situations.

Triangulation of these instruments ensured consistency and reduced subjective bias in data interpretation.

Criteria and Indicators of Assessment

Professional competence was operationalized through three interrelated criteria:

1. Motivational criterion

Indicators: intrinsic motivation for professional development, readiness for self-directed learning, interest in using digital technologies in professional activity.

2. Content criterion

Indicators: level of theoretical and digital knowledge, understanding of blended learning tools, and awareness of professional standards.

3. Activity criterion

Indicators: practical skills, ability to apply knowledge in professional contexts, problem-solving skills, and use of digital tools in pedagogical practice.

Each criterion was assessed using a three-level scale:

- High level – systematic and independent application of knowledge and skills.
- Average level – partial application with occasional support.
- Low level – fragmented knowledge and limited ability to apply it in practice.

Quantitative thresholds for level classification were based on the percentage of successfully completed diagnostic tasks:

- High: $\geq 80\%$
- Average: 50–79%
- Low: $< 50\%$

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Intervention Description

The experimental group was exposed to a specially designed system of professional training based on an integrated educational environment. This system included:

- Integration of online (LMS platforms, digital tools) and offline instruction.
- Implementation of blended learning models (flipped classroom, rotation model).
- Development of digital educational resources (multimedia materials, online courses).
- Enhancement of methodological and technical support.
- Organization of synchronous and asynchronous interaction.

The control group continued learning under traditional instructional conditions.

Data Analysis and Statistical Procedures

Quantitative data were processed using methods of mathematical statistics to ensure objective evaluation of the results.

To determine the statistical significance of differences between the experimental and control groups, the Fisher's angular transformation (φ^*) criterion was applied. This method was selected due to its suitability for:

- Comparing proportions (percentages) between two independent samples.
- Analyzing categorical data (distribution across high, average, and low levels).
- Relatively small sample sizes ($n < 100$), where parametric tests may be less reliable.

The procedure involved the following steps:

1. Conversion of percentage values into angular (φ) values using Fisher's transformation formula.
2. Calculation of the empirical difference between the two groups (φ_{emp}).
3. Comparison of the obtained value with critical values to determine statistical significance.

The empirical value obtained in the study ($\varphi = 4.8$) exceeds the critical threshold ($p < 0.05$), indicating statistically significant differences between the groups.

Thus, the null hypothesis (H_0), which assumed no difference between the experimental and control groups, was rejected, while the alternative hypothesis (H_1) was accepted, confirming that the implemented blended learning system had a significant positive effect on the formation of professional competence.

Validity and Reliability

The reliability of the study was ensured through:

- The use of multiple data collection methods (triangulation).
- Consistency in measurement procedures across stages.
- Statistical validation of results.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Internal validity was supported by the experimental design with control and experimental groups, while external validity is associated with the representativeness of participants as senior students in higher education.

Ethical Considerations

Participation in the study was voluntary, and respondents were informed about the purpose of the research. Data confidentiality and anonymity were ensured throughout all stages of the study.

Results and Discussion

Content, advantages, features, and main models of blended learning. Ways of implementing blended learning in the educational process of higher education. Economic competition, rapid changes in production, and global digitalization contribute to the search (in the direction of modernization of educational activities) for effective ways to ensure the training of a new generation of specialists who will be able to compete in the modern labor market and will be able to adapt to today's conditions and act in non-standard situations. Therefore, a high responsibility lies with higher education institutions that train future educators. Thanks to the spread of innovations and their implementation in education, an educational system for creative, individualized, flexible, open, continuous, and lifelong education of a person is being formed. This system includes the following components: new methods, modern educational technologies, teaching and learning methods, new means of interaction, and pedagogical innovations in the educational process, i.e., digital technologies (Huilcapi-Collantes et al., 2020).

One advantage of blended learning over traditional learning is the active use of interactive technologies and access to learning materials. Technology becomes a full-fledged tool in the educational process, not just an auxiliary one. Blended learning involves a combination of different approaches and methods and offers variability in the presentation of new material. Thus, one part of the educational content can be designed for independent study, and the second can be devoted to group work, aimed at completing the task jointly (Garcez et al., 2022).

Flexibility is an important feature of blended learning – it can take place remotely, through online platforms and electronic resources, and in a traditional classroom. Blended learning expands students' opportunities to engage with educational material actively. It promotes a personalized approach to education, which positively impacts the development of skills and knowledge among future specialists. Blended learning provides a new role for educators as facilitators of the educational process (Ota et al., 2020).

Also, in the training of future specialists, the advantages of blended learning include: individualization of learning, because blended learning technologies allow future specialists to choose the pace that meets their needs and the method and sequence of studying the material; and diversity of learning methods. Combining online resources with traditional teaching methods, which allows future specialists to receive diversity in learning, to improve understanding of the material; stimulating self-discipline and independence; formation of key professional competencies: critical thinking, independence, communication and cooperation, ability to solve problems; familiarization with digital technologies that are widely used in professional activities to prepare students to work in a digital environment and

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

increase their competitiveness in the labor market (García-Ponce & Mora-Pablo, 2020).

Scientists distinguish several main models of blended learning used in higher education. The **Supplemental Model** complements traditional classroom instruction with electronic resources, while the **Replacement Model** transfers a significant part of learning to digital formats with educator support and consultation. The **Buffet Model** allows students to combine online and face-to-face learning according to their needs, whereas the **Emporium Model** focuses on mastering course content in computer laboratories and online platforms (Sandoval-Cruz et al., 2022).

Another widely used approach is the **Rotation Model** (including station rotation, individual rotation, and the flipped classroom), which alternates between classroom and online activities. The **Flex Model** emphasizes remote learning with opportunities for individual consultation with educators. The **A La Carte Model** enables students to select additional online courses alongside their core program, while the **Enriched Virtual Model** combines initial face-to-face instruction with subsequent remote learning and independent study (Cabezas et al., 2023).

Key characteristics of blended learning. Mobile learning technologies to support contextual learning. Effective tools of student-centered blended learning technology. The integrated educational environment at the university is based on the principles of blended learning.

Mobile learning technologies in higher education support contextual learning in educator training within blended learning environments. At the same time, students' personal qualities and the alignment of training content with stable technologies play a crucial role in ensuring high-quality professional preparation. Among the effective models of blended learning, the flipped classroom has proven particularly valuable, especially during the transition to online educator training, where both students and educators often prefer it to traditional teaching approaches. The effectiveness of professional preparation largely depends on the appropriate selection of teaching forms, methods, tools, and methodology that enhance students' academic success and support active, structured learning (Beltrán del Río, 2021).

Blended learning contributes to the development of creativity, critical thinking, professional skills, and learning motivation among future educators. Student-centered learning technologies are widely used in this process, supported by digital platforms and tools such as Zoom, Moodle, Google applications, Whiteboard, and Telegram, as well as educational resources including Wolfram Alpha, Khan Academy, and Coursera. To support distance and blended learning, various digital materials are implemented, including instructional mind maps, video lessons, electronic manuals, presentations, test tasks, and methodological guidelines.

Blended learning combines traditional educational forms – such as classroom discussions, reports, and essays – with e-learning technologies that provide access to digital resources and enable interaction through telecommunications networks. The effectiveness of this approach depends on the development of a strong didactic and methodological base for each course, which allows students with different levels of preparation to learn at an individual pace and develop professional competencies. Innovative technologies widely used in blended learning include distance learning tools, interactive methods, project-based learning, simulation technologies, case methods, video training, collaborative learning, computer modeling, and differentiated learning approaches (Marín-Zapata et al., 2022; Cespedes-Panduro et al., 2023; Vielma Puente & Ruano, 2021).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Experimental research

The effectiveness of the proposed system of professional training based on an integrated educational environment within blended learning was verified through a pedagogical experiment conducted in three stages: ascertaining, exploratory, and formative. The study involved 85 students, including 41 students in the experimental group (EG) and 44 students in the control group (CG), which ensured the comparability of the samples and the reliability of the obtained results.

Professional competence was assessed according to three criteria: motivational, content, and activity, which together reflect students' motivation for professional development, their theoretical and digital knowledge, and their ability to apply professional skills in practical situations. Each criterion was evaluated according to three levels of competence formation: high, average, and low.

Baseline (ascertaining stage) results

The results of the ascertaining stage demonstrated that the initial levels of professional competence formation in both groups were nearly identical, which confirms the methodological validity of further comparison between the groups.

In the control group, the distribution of competence levels was as follows:

- High level – 10.3%.
- Average level – 57.1%.
- Low level – 32.6%.

In the experimental group, the indicators were similar:

- High level – 11.4%.
- Average level – 56.5%.
- Low level – 32.1%.

The obtained results indicate that the majority of students in both groups demonstrated average or low levels of professional competence, which reflects insufficient development of practical skills and digital competencies necessary for modern professional activity. The similarity of indicators between the groups confirms that both samples were statistically comparable at the beginning of the experiment.

In addition, the results of questionnaires and interviews revealed that many students experienced difficulties in mastering digital tools and applying professional knowledge in practice. These findings indicate the need to improve the system of professional training through the integration of innovative educational technologies and digital learning environments.

The survey was conducted to assess students' motivation for practical training; determine the level of possession of digital knowledge necessary for professional activity, the presence of stable motives for mastering professional skills and abilities, and to reflect the results of training, appropriate measuring procedures, or episodic superficial interest, or real professional interest in the conditions of practical training for studying the material.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The results of the ascertaining stage of the experiment showed that the development of all components in both the experimental and control groups was insignificant, with most components at average or low levels.

Table 1.

Results of the baseline assessment of professional competence levels among future educators in higher education

Groups	Levels		
	High	Average	Low
Control	10,3%	57,1%	32,6%
Experimental	11,4%	56,5%	32,1%

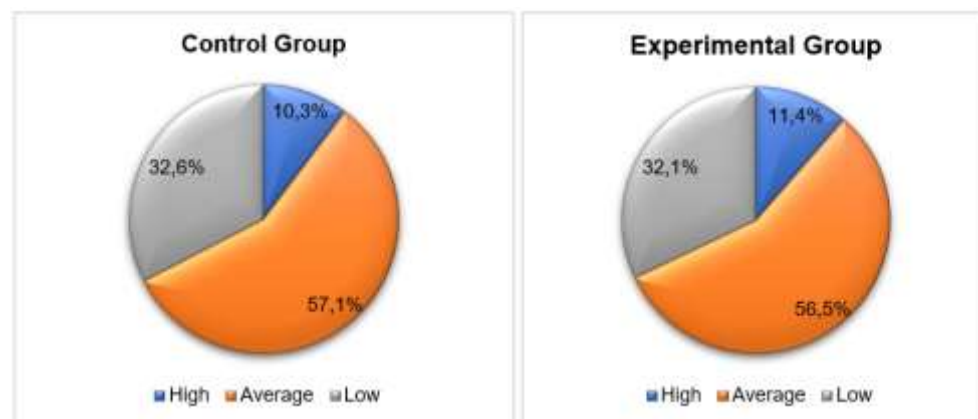


Figure 1. Results of the baseline assessment of professional competence levels among future educators in higher education.

So, using methods such as interviews and questionnaires, the experiment's ascertaining stage was conducted, and the level of professional competence of future educators during professional training was determined. Senior students who had completed pedagogical practice participated in the survey.

The survey results revealed that the majority of students have an average-to-low level of professional competence. The majority of respondents independently mastered the digital knowledge necessary for professional activity. It noted difficulties during this learning process, indicating the need to improve the professional training system for future specialists in blended learning by developing and implementing an integrated educational environment based on blended learning in higher education.

It was found that, in a blended-learning context, an important aspect of the functioning of the integrated educational environment system is the organization of interaction between students and educators. In the professional training of future educators, pedagogical interaction in blended learning conditions was conducted using a synchronous system (text conferences, video communication tools, videos, webinars) and an asynchronous system (e-mail, forums, wiki sites, etc.).

As a result of testing the integrated educational environment system based on blended learning implemented in a higher school, in the EG, the formative stage of the experiment showed a significant change in the level of formation across all components in the experimental group. Moreover, in the control group, we observe

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

a slight increase in the phenomenon under study; that is, the results have changed, but only slightly.

Table 2.

Results of the formative stage of the experiment assessing the levels of professional competence formation among future educators in higher education

Groups	Levels		
	High	Average	Low
Control	19,8%	56,6%	23,6%
Experimental	49,9%	38,8%	11,3%

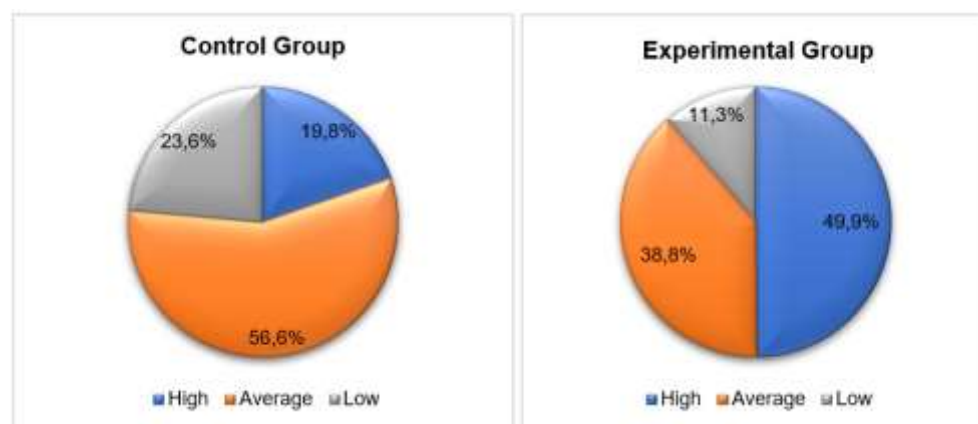


Figure 2. Results of the formative stage of the experiment assessing the levels of professional competence formation among future educators in higher education.

Using Fisher's exact test, the reliability of the results was calculated. Two hypotheses were proposed: working and alternative.

H_0 (working): the proportion of students in the experimental group is not greater than the proportion of students in the control group who scored above 80% or at the same level.

H_1 (alternative): the proportion of students in the experimental group is greater than the proportion of students in the control group who scored above 80% or at the same level.

We used Fisher's exact test to assess the statistical significance of the difference between the percentages of the two samples. The Fisher angular transformation, measured in radians, converts the central angle to percentages. A larger angle corresponds to a larger percentage, and a smaller angle corresponds to a smaller percentage. Therefore, the values of φ^* were determined for both groups using the Fisher angular transformation method.

$$\varphi^* = (\varphi_1 - \varphi_2) \cdot \sqrt{\frac{n_1 n_2}{n_1 + n_2}} = (1.563 - 0.996) \cdot \sqrt{\frac{141 \cdot 153}{141 + 153}} = 0.555 \cdot 8.5 = 4.8$$

φ_1 — for the experimental group

φ_2 — for the control group

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

For different percentages, the table of angle values was used to determine which level of significance this value belongs to.

The empirical value of 4.8 falls within the significance zone; accordingly, we reject H_0 and accept H_1 : the proportion of students in the experimental group who received scores above 80% is greater than that in the control group.

We can conclude from the results obtained after the formative stage of the experiment that the proportion of students in the experimental group is greater than in the control group at both high and average levels of professional competency formation. It can be argued that the system we proposed contributes to increasing professional competencies and is effective through blended learning, which is an important aspect of the functioning of an integrated educational environment in higher education.

To determine the statistical significance of the obtained differences between the experimental and control groups, Fisher's angular transformation (ϕ)* was applied. This method is appropriate for comparing proportions between two independent samples and allows reliable analysis of categorical data distributions.

The empirical value obtained during the analysis ($\phi = 4.8$) exceeded the critical value at the $p < 0.05$ significance level, which indicates statistically significant differences between the experimental and control groups.

Therefore, the null hypothesis stating that there is no difference between the groups was rejected, while the alternative hypothesis was accepted. This confirms that the implementation of the integrated educational environment based on blended learning had a statistically significant positive effect on the formation of professional competence among future educators.

Overall, the results of the pedagogical experiment demonstrate that the integration of digital learning technologies with traditional forms of instruction creates favorable conditions for improving students' professional competence. The significant increase in the proportion of students with high competence levels and the simultaneous decrease in the number of students with low competence levels confirm the effectiveness of the proposed educational model.

Thus, the obtained empirical data provide reliable evidence that the implementation of a blended learning-based integrated educational environment contributes to improving the quality of professional training of future educators in higher education. The results of this study generally confirm the conclusions presented in previous research on the effectiveness of blended learning in higher education. In particular, the findings support the arguments of Sandoval-Cruz et al. (2022), who emphasize that blended learning models contribute to increasing students' engagement and flexibility in the educational process. Similar to their conclusions, the present study demonstrates that the integration of digital technologies with traditional instruction creates favorable conditions for the development of professional competencies among future educators.

At the same time, the obtained results extend the findings of Marín-Zapata et al. (2022), who primarily focused on the organizational and technological aspects of implementing blended learning. While their research highlights the importance of digital platforms and online learning tools, the results of the current study indicate that the effectiveness of blended learning depends not only on technological infrastructure but also on pedagogical conditions,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

methodological support, and the active involvement of students in the learning process.

Furthermore, the results are consistent with the conclusions of Cespedes-Panduro et al. (2023) and Vielma Puente and Ruano (2021), who emphasize the importance of interactive and practice-oriented learning technologies in professional training. However, unlike these studies, which mainly analyze theoretical or methodological aspects of blended learning, the present research provides empirical evidence of statistically significant improvements in students' competence levels after the implementation of a blended learning environment.

Nevertheless, some differences with earlier studies can also be observed. While several researchers highlight the dominant role of digital learning environments in improving educational outcomes, the findings of this study suggest that the most effective results are achieved through a balanced integration of traditional and digital learning formats. Thus, the effectiveness of blended learning should be viewed not only as a technological innovation but also as a comprehensive pedagogical system that integrates methodological, organizational, and technological components of the educational process.

Conclusions

The study investigated the effectiveness of implementing a blended learning environment in the professional training of future educators in higher education institutions. The results of the pedagogical experiment demonstrated that the integration of traditional teaching methods with digital learning technologies contributes to a significant improvement in the level of students' professional competence. In particular, the experimental group showed a noticeable increase in the proportion of students with a high level of competence and a decrease in the number of students with a low level of competence compared with the control group. These results confirm the effectiveness of the integrated educational environment based on blended learning and highlight its potential for improving the quality of professional training in higher education.

The findings also demonstrate that the effectiveness of blended learning depends not only on the use of digital tools but also on the pedagogical organization of the educational process, the application of interactive learning methods, and the development of methodological support for students' independent and collaborative learning activities. The integration of digital platforms, multimedia resources, and practice-oriented tasks creates favorable conditions for the development of critical thinking, creativity, and professional skills among future educators.

Despite the positive results obtained, the study has several limitations: the research was conducted within a limited sample of students from one higher education institution, which may restrict the generalizability of the findings to other educational contexts; the study focused primarily on the assessment of professional competence levels and did not examine in detail other potential outcomes of blended learning, such as long-term learning retention, students' digital literacy, or psychological factors influencing learning motivation. In addition, the duration of the experiment was limited, which makes it difficult to evaluate the long-term sustainability of the observed improvements.

The practical implications of this study are related to the possibility of using blended learning as an effective pedagogical approach in the professional training of future

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

educators. The proposed model of an integrated educational environment can be applied in higher education institutions to improve the organization of the educational process, enhance student engagement, and support the development of professional competencies required in the modern educational environment. The results of the study may also be useful for educators, curriculum developers, and university administrators when designing innovative educational programs and integrating digital learning technologies into teacher education.

Future research should focus on expanding the empirical base of the study by involving a larger and more diverse sample of participants from different higher education institutions and countries. It would also be useful to investigate the long-term impact of blended learning on students' professional development and career readiness. Further studies may explore the effectiveness of specific digital tools, adaptive learning technologies, and artificial intelligence in blended learning environments, as well as analyze the relationship between students' motivation, digital competence, and academic performance in the context of blended education.

Bibliographic references

- Beltrán del Río, N. (2021). A useful framework for teacher professional development for online and blended learning to use as guidance in times of crisis. *Educational Technology Research and Development*, 69, 7–9. <https://doi.org/10.1007/s11423-021-09953-y>
- Cabezas, V., Pereira, S., Figueroa, C., & Straub, C. (2023). Teachers' perceptions about the delivery and methodology of a blended learning mentor training course: A case from Chile. *International Journal of Mentoring and Coaching in Education*, 12(2), 177–193. <https://doi.org/10.1108/IJMCE-05-2022-0032>
- Çemçem, G.D., Korkmaz, Ö., & Kukul, V. (2024). Readiness of teachers for blended learning: A scale development study. *Education and Information Technologies*, 29, 23631–23655. <https://doi.org/10.1007/s10639-024-12777-x>
- Céspedes-Panduro, B., Ticona-Arapa, H.C., Zela-Payí, N.O., Chambi-Condori, N., Sucari-León, A., Chipana-Loayza, P., Sardon-Quispe, W.W., Callupe-Cueva, P.C., Torres-Chuco, M.S., Aguilar-Pichón, F.M., & Tilwani, S.A. (2023). Important teacher qualities for integrating blended learning in higher education. *Information Sciences Letters*, 12(5), 2189–2201. <https://doi.org/10.18576/isl/120553>
- García-Ponce, E., & Mora-Pablo, I. (2020). Challenges of using a blended learning approach: A flipped classroom in an English teacher education program in Mexico. *Higher Learning Research Communications*, 10(2). <https://doi.org/10.18870/hlrc.v10i2.1209>
- Garcez, A., Silva, R., & Franco, M. (2022). The hard skills bases in digital academic entrepreneurship in relation to digital transformation. *Social Sciences*, 11(5), 192. <https://doi.org/10.3390/socsci11050192>
- Huilecapi-Collantes, C., Hernández Martín, A., & Hernández-Ramos, J.P. (2020). The effect of a blended learning course of visual literacy for in-service teachers. *Journal of Information Technology Education: Research*, 19, 131–166. <https://doi.org/10.28945/4533>
- Marín-Zapata, S.I., Román-Calderón, J.P., Robledo-Ardila, C., & Jaramillo-Serna, M.A. (2022). Soft skills: Do we know what we are talking about? *Review of Managerial Science*, 16, 969–1000. <https://doi.org/10.1007/s11846-021-00474-9>
- Ota, M. A., Nagata, A.C., & Ferreira, T.C. (2020). Blended teacher training program: Rethinking learning spaces and evaluating active learning in basic education schools. In *Handbook of research on determining the reliability of online*

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- assessment and distance learning* (pp. 337–357). IGI Global.
<https://doi.org/10.4018/978-1-7998-4769-4.ch014>
- Saboowala, R., & Manghirmalani Mishra, P. (2021). Readiness of in-service teachers toward a blended learning approach as a learning pedagogy in the post-COVID-19 era. *Journal of Educational Technology Systems*, 50(1), 9–23.
<https://doi.org/10.1177/00472395211015232>
- Sandoval-Cruz, R.I., Navarro Rangel, Y., González Calleros, J.M., & Perales-Escudero, M.D. (2022). Pre-service EFL teachers' conceptions of learning about SLA through online discussion forums and WhatsApp in blended learning. *RELC Journal*, 53(1), 165–179.
<https://doi.org/10.1177/0033688220917221>
- Vielma Puente, J.E., & Ruano, M.A. (2021). Análisis de la utilidad del programa básico de formación docente en modalidad semipresencial. *Estudios Pedagógicos*, 47(2), 289–298. <https://doi.org/10.4067/S0718-07052021000200289>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Eficacia de los entornos de aprendizaje basados en la nube en la formación de futuros especialistas: Un estudio cuasiexperimental

Effectiveness of cloud-based learning environments in the training of future specialists: A quasi-experimental study

Sofiya Chovriy¹  Liubov Prokopiv²  Mariana Dereniuk³  Iryna Kuchera⁴  Denys Diahel⁵ 

Afiliación autor:

¹ Candidate of Pedagogical Sciences, Associate Professor, Associate Professor at the Department of Pedagogy, Psychology, Primary, Pre-School Education and Management of Educational Institutions, Ferenc Rakoczi II Transcarpathian Hungarian University, Ukraine.

csoori.zsofia@gmail.com

² Candidate of Pedagogical Sciences, Professor, Head of the Department of the Bohdan Stuparyk Department of Pedagogy and Educational Management, Vasyl Stefanyk Carpathian National University, Ukraine.

liubov.prokopiv@cnu.edu.ua

³ Doctor of Philosophy (PhD), Assistant of the Bohdan Stuparyk Department of Pedagogy and Educational Management, Vasyl Stefanyk Carpathian National University, Ukraine.

mariana.dereniuk@cnu.edu.ua

⁴ Candidate of Historical Sciences, Associate Professor, Associate Professor of the Department of Philosophy, Sociology and Religious Studies, Vasyl Stefanyk Carpathian National University, Ukraine.

iryna.kuchera@cnu.edu.ua

⁵ PhD in State Border Security, Associate Professor of the Border Security Department, Faculty of Professional Education and Leadership, Bohdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine, Ukraine. denysda1982@icloud.com

Recibido: 10/01/26

Aceptado: 16/05/26

Cómo citar:

Chovriy, S., Prokopiv, L., Dereniuk, M., Kuchera, I., & Diahel, D. (2026). Effectiveness of cloud-based learning environments in the training of future specialists: A quasi-experimental study. *Revista Eduweb*, 20(2), 119-136. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.8>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

Este estudio tiene como objetivo evaluar la efectividad de un entorno de aprendizaje basado en la nube para la formación de futuros especialistas y su impacto en el desarrollo de sus competencias profesionales. Se empleó un enfoque de métodos mixtos, combinando análisis teórico, métodos empíricos y procesamiento estadístico de datos. El análisis estadístico se realizó mediante ANOVA y la prueba t de Student con un nivel de significancia de $\alpha = 0,05$. Los resultados demostraron una mejora significativa en el grupo experimental en comparación con el grupo de control. En particular, la proporción de estudiantes con un alto nivel de preparación para el uso de tecnologías en la nube aumentó un 20 % en el grupo experimental, mientras que el nivel bajo disminuyó un 34 %. Se observaron dinámicas positivas similares en los criterios de preparación para el sistema, la interacción y la satisfacción. El análisis estadístico confirmó diferencias significativas entre los grupos ($F = 32,17$; $p < 0,001$), lo que indica la efectividad de la metodología implementada. Se concluye que la integración de un entorno de aprendizaje basado en la nube, respaldado por condiciones pedagógicas específicas y una metodología propia, mejora significativamente la formación profesional de futuros especialistas. Los resultados resaltan el potencial de las tecnologías en la nube, incluidas las herramientas de realidad virtual y aumentada, para mejorar los resultados educativos en la educación superior.

Palabras clave: aprendizaje en la nube, formación, futuros especialistas, tecnologías en la nube, tecnologías de realidad virtual aumentada y mixta, educación superior.

Abstract

This study aims to evaluate the effectiveness of a cloud-based learning environment in the training of future specialists and its impact on the development of their professional competencies. A mixed-methods approach was employed, combining theoretical analysis, empirical methods, and statistical data processing. Statistical analysis was performed using ANOVA and Student's t-test at a significance level of $\alpha = 0.05$. The results demonstrated a significant improvement in the experimental group compared to the control group. In particular, the proportion of students with a high level of readiness to use cloud technologies increased by 20% in the EG, while the low level decreased by 34%. Similar positive dynamics were observed across system, interaction readiness, and satisfaction criteria. The statistical analysis confirmed significant differences between the groups ($F = 32.17$; $p < 0.001$), indicating the effectiveness of the implemented methodology. It is concluded that the integration of a cloud-based learning

environment, supported by targeted pedagogical conditions and an author's methodology, significantly enhances the professional training of future specialists. The findings highlight the potential of cloud technologies, including virtual and augmented reality tools, to improve educational outcomes in higher education.

Keywords: cloud-based learning, training, future specialists, cloud technologies, virtual augmented mixed reality technologies, higher education.

Introduction

The digital transformation of higher education, driven by globalization and the integration of European educational standards, has intensified the need for innovative approaches to the professional training of future specialists. In this context, cloud-based learning environments (CBLEs) are increasingly recognized as a powerful technological and pedagogical solution that ensures flexibility, accessibility, and scalability of the educational process. These environments facilitate real-time collaboration, provide access to distributed educational resources, and enable the integration of advanced digital tools, including virtual, augmented, and mixed reality technologies (Rivera et al., 2017).

A growing body of research highlights the potential of cloud technologies in education. Previous studies have explored cloud-based infrastructures for distance learning, adaptive cloud systems, and the application of open science services in higher education. These works demonstrate improvements in accessibility, usability, and student engagement. However, most of these studies focus primarily on technological implementation or isolated instructional tools rather than on the comprehensive pedagogical integration of cloud-based environments into the training process of future specialists.

Despite these contributions, several important research gaps remain: there is a lack of studies that examine cloud-based learning environments as holistic pedagogical systems that integrate technological, methodological, and organizational components in higher education; insufficient attention has been paid to the development and experimental validation of specific pedagogical conditions that ensure the effective use of cloud-based environments in the formation of professional competencies; existing research rarely employs rigorous quasi-experimental designs with control and experimental groups to provide statistically significant evidence of the effectiveness of cloud-based learning environments; there is limited empirical evidence on how cloud-based environments influence key dimensions of professional training, such as students' readiness for interaction, system-level engagement, and satisfaction with the learning process.

Therefore, the research problem of this study lies in the absence of a theoretically grounded and empirically validated approach to the integration of cloud-based learning environments into the system of professional training of future specialists.

The study is based on the hypothesis that the systematic implementation of a cloud-based learning environment, including cloud laboratories, a dedicated course on cloud technologies, and enhanced collaborative practices, leads to statistically significant improvements in students' readiness to use cloud technologies, their level of interaction, and overall satisfaction with the learning process.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

This research contributes to the field by providing empirical evidence from a quasi-experimental study, proposing a validated set of pedagogical conditions for the effective use of cloud-based learning environments, and expanding the understanding of their role in the development of professional competencies in higher education.

Literature Review

The integration of cloud-based technologies into higher education has become a prominent research direction, reflecting the broader shift toward digital and open educational ecosystems. Existing studies provide valuable insights into the technological, pedagogical, and organizational dimensions of cloud-based learning environments (CBLEs). However, their findings remain fragmented, necessitating a more integrative and critical analysis.

A significant body of research focuses on the technological dimension of cloud-based learning. For instance, Larcher et al. (2021) propose a Fog-Cloud architecture that enhances the efficiency of distance learning systems, particularly in conditions of limited connectivity. Similarly, Nascimento et al. (2019) develop a reinforcement learning-based approach to optimize cloud-based scientific workflows, demonstrating the adaptability of cloud infrastructures. These studies confirm the scalability and flexibility of cloud technologies; however, they primarily treat education as a technical application domain, with limited attention to pedagogical integration.

Another group of studies emphasizes the pedagogical applications of cloud technologies. Vargas & Virtanen (2023) demonstrate that adaptive cloud-based learning tasks can significantly improve student performance and engagement, particularly when grounded in constructivist approaches. Likewise, Ramírez-Donoso et al. (2017) highlight the role of cloud-based platforms in supporting collaboration and group learning in higher education. While these findings underline the pedagogical potential of CBLEs, they often focus on specific tools or instructional strategies rather than offering a comprehensive model of their implementation.

A growing research stream addresses the integration of cloud technologies with open science and digital education paradigms. Ignat & Ayris (2020) emphasize the importance of embedding open science practices into university systems, highlighting the role of cloud-based tools in ensuring accessibility and knowledge sharing. Similarly, Tenorio-Sepúlveda et al. (2021) focus on the development of cloud-related competencies among educators within the Education 4.0 framework. These studies contribute to understanding the broader ecosystem of cloud-based education but provide limited empirical evidence regarding their direct impact on students' professional competencies.

Empirical research has also examined the usability and cognitive impact of cloud-based systems. Carreón (2025) demonstrates that cloud-based platforms significantly improve usability and reduce cognitive load compared to traditional systems. Additionally, Gamboa-Cruzado et al. (2025) provide a comprehensive systematic review confirming the positive impact of cloud computing on higher education institutions. However, these studies primarily focus on user experience and system efficiency, without sufficiently linking these factors to competency-based educational outcomes.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Other researchers, such as Kalogiannakis et al. (2021) and Kim & Lim (2019), explore the design and sustainability of digital and cloud-based educational systems. Their findings emphasize the importance of system architecture and digital infrastructure. At the same time, Shuliak et al. (2022) underline the role of cloud computing in organizing educational space and improving professional training. Nevertheless, these studies do not provide a sufficiently structured pedagogical framework supported by experimental validation.

A critical synthesis of the reviewed literature reveals several key limitations: the majority of studies adopt a fragmented approach, focusing either on technological infrastructure or isolated pedagogical practices, without integrating these dimensions into a unified system; there is a lack of rigorous experimental research designs, as only a limited number of studies employ control and experimental groups to verify effectiveness statistically; the development of professional competencies in cloud-based environments is insufficiently explored, particularly in terms of multidimensional assessment (e.g., readiness, interaction, satisfaction); there is a lack of clearly defined pedagogical conditions and methodologies that would ensure the effective implementation of CBLEs in higher education.

Thus, despite the growing body of research, there remains a need for integrative studies that combine technological capabilities with pedagogical design and provide robust empirical evidence of effectiveness.

In this context, the present study contributes to the literature by proposing and experimentally validating a comprehensive pedagogical approach to the use of cloud-based learning environments in the training of future specialists. Unlike previous studies, it integrates technological, methodological, and organizational components within a unified framework and applies a quasi-experimental design to assess their impact on the development of professional competencies. This approach not only confirms the effectiveness of CBLEs but also explains the mechanisms through which they influence learning outcomes.

The aim of the study is to evaluate the effectiveness of a cloud-based learning environment in the training of future specialists and to determine its impact on the development of their professional competencies under specially designed pedagogical conditions.

Methodology

Research Design

The study employed a mixed-methods approach combining theoretical, empirical, and statistical methods to evaluate the effectiveness of a cloud-based learning environment (CBLE) in the training of future specialists. A quasi-experimental design with control (CG) and experimental (EG) groups was implemented. The research was conducted between 2021 and 2025 and included four stages: preparatory, ascertaining, formative, and final.

Participants

The sample consisted of 120 undergraduate students enrolled in pedagogical specialties. Among them, 35% were future primary school teachers and 65% were subject teachers for secondary education; 75% were female and 25% male.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Participants were divided into CG and EG with comparable initial levels of digital competence and academic performance.

Operationalization of Variables

The independent variable of the study was the implementation of a cloud-based learning environment under defined pedagogical conditions (cloud laboratories, a specialized course, and collaborative learning practices).

The dependent variable was the level of professional competence in the context of cloud technologies, operationalized through three criteria:

- System criterion: openness, integration, interactivity, and collaboration within the CBLE.
- Readiness for interaction: motivational, cognitive, and activity-based components.
- Level of satisfaction: perceived usability, organization of the learning process, and overall experience.

Each criterion was measured across three levels (high, medium, low), which were quantified using composite indices derived from survey responses and observational data.

Data Collection Instruments

Data were collected using a combination of quantitative and qualitative instruments:

1. Structured questionnaire

The questionnaire included 24 items grouped according to the three criteria. A 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) was used to measure students' perceptions, readiness, and satisfaction. The questionnaire was administered at both the ascertaining and final stages.

2. Observation protocol

A structured observation checklist was used to assess students' actual engagement with the cloud-based environment, including frequency of interaction, participation in collaborative tasks, and use of cloud tools.

3. Pedagogical experiment

The experimental group was exposed to the developed methodology, while the control group followed traditional instruction. Pre- and post-test measurements were conducted to assess changes in the dependent variables.

Validity and Reliability of Instruments

To ensure content validity, the questionnaire and observation protocol were developed based on established theoretical frameworks of digital competence and cloud-based learning and were reviewed by three experts in educational technology and pedagogy.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Construct validity was examined through exploratory factor analysis (EFA), confirming the alignment of questionnaire items with the three predefined criteria (factor loadings > 0.70).

The reliability of the questionnaire was assessed using Cronbach's alpha coefficient:

- System criterion: $\alpha = 0.82$
- Readiness for interaction: $\alpha = 0.85$
- Satisfaction level: $\alpha = 0.88$

These values indicate high internal consistency of the measurement instrument.

Additionally, a pilot study ($n = 30$) was conducted to refine the questionnaire items and ensure clarity and consistency.

Experimental Procedure

At the ascertaining stage, baseline measurements of students' readiness to use cloud technologies were obtained. The results indicated predominantly low and medium levels in both groups.

During the formative stage, the experimental group was exposed to the following pedagogical conditions:

- Implementation of cloud laboratories.
- Integration of a cloud-based learning environment.
- Introduction of a specialized course ("Application of Cloud Technologies in the Educational Process").
- Enhancement of collaborative and research-based learning activities.

The control group continued traditional instruction without these interventions. At the final stage, post-test data were collected and compared with baseline results.

Data Analysis

Statistical analysis was performed using RStudio and SPSS. Normality of data distribution was verified using the Lilliefors and Kolmogorov–Smirnov tests.

Given the normal distribution, parametric methods were applied:

- Analysis of variance (ANOVA) for repeated measures to assess changes over time.
- Student's t-test (independent and dependent samples) to compare CG and EG.

The significance level was set at $\alpha = 0.05$.

Ethical Considerations

Participation in the study was voluntary and anonymous. All participants were informed about the purpose of the research and provided consent. Data confidentiality and ethical standards of academic research were strictly maintained.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Results and Discussion

The content of the main concepts of the study and the main conditions for improving the quality of specialist training. Methods of using a cloud-based learning environment in the training of future specialists.

Components of an innovative cloud-based learning environment. Higher education for specialists, within the framework of the common concept of openness, is an environment where open education and open science can interact, as they are connected through subjects such as teachers at higher education institutions, practitioners at schools, and students involved in the research process. The key components of openness in open science relate to educational and research activities and are closely tied to open education. At the same time, openness concerns the tool's availability, compatibility, and cost relative to other services. Software and tools in the educational environment are called open-source services, which are modifiable, and accessible, and free. Therefore, open-source research tools for teaching and learning are available and easy to use, and this approach to education is of high quality because it facilitates access to research sources and data for students and professionals (Heck et al., 2020).

The didactic capacity of the open learning environment is significantly enriched by the set of cloud-based tools, which today plays a significant role in the development of the open cloud-based learning environment, its information content in higher education institutions, the expansion of its service properties, and information and communication.

Let us describe the main methods of using the cloud-based environment of the educational space of higher education in the training of future specialists:

The project method provides a process of project-based joint activity of students who learn to work together on a problem, distribute responsibilities, draw up an action plan, present the final product created – tools for working on joint projects, automated systems, selected cloud-based tools, compilers, focused on project-based joint activity, where students in any role can try themselves, which is provided for by the software development project, joint activity on a scientific project (Kotsev et al., 2020).

The research method enables the use of virtual and remote laboratories, webinars, and video conferences within an integrated cloud services environment, which, in an innovative cloud-based learning environment, contribute to the development of students' research skills. This method, in an innovative cloud-based environment for higher education, is convenient when conducting student conferences and is also necessary within the problem group during remote communication to consider discussion issues that may arise for students when writing qualified papers.

Explanatory and illustrative methods provide the opportunity to upload video files to the data storage for students' further viewing, and, using the Udemy platform, students receive training based on video materials from leading scientists worldwide (Gamboa-Cruzado et al., 2025).

The Makhmutov method is used via cloud services to work on a joint project, contributing to the collective solution to the problem of creating the proposed problem situation.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The heuristic method allows the teacher to offer students the opportunity to complete a joint project in cloud-based learning environments not typically used for educational activities, and to present a non-typical, innovative task within selected web-oriented systems (Ramírez-Donoso et al., 2017).

These should be cloud services hosted on a single platform, free to use, publicly available, and containing open content for other users (Tenorio-Sepúlveda et al., 2021).

Nowadays, there is a need to expand the services and infrastructure of cloud-based systems in modern society, creating conditions to meet the growing needs of students and teachers for scientific research data. Therefore, the use of cloud-based systems in a cloud-based learning environment is promising for conducting classes or new research projects (Li et al., 2020).

Requirements for professional training of future specialists in the cloud-based environment of higher education institutions. Main directions of application of cloud-based open science services in the cloud-based environment of higher education institutions.

The process of teaching and learning in higher education institutions highlights several key requirements for the effective professional training of future specialists in a cloud-based environment (Carvalho et al., 2024). These include access to modern IT infrastructure and digital tools enabling flexible, location-independent learning; availability of online courses and educational resources for continuous professional development; and qualified organizational, technical, and methodological support (Tenorio-Sepúlveda et al., 2021).

Additionally, the effective implementation of cloud-based environments requires the integration of digital technologies into the educational process, access to open educational resources and research outputs, active collaboration among educators, and institutional support in terms of infrastructure and resource provision.

In the process of learning in a cloud-based educational environment, there is an opportunity to use cloud-based educational systems and to improve scientific and educational cooperation by organizing shared access to electronic resources (open information systems and scientific and educational networks) (Gamboa-Cruzado et al., 2025).

Digital tools such as Grapher (macOS), Desmos, GeoGebra, or online graphing calculators allow you to model processes, build graphs, visualize functions, and explore their properties. For example, using GeoGebra, a teacher can dynamically vary function parameters and observe their effects on the graph to promote a deeper understanding of relationships among higher-education students. This enables the assimilation of complex material and increases student interest by moving from static images to interactive research (Ariza et al., 2021).

The pedagogical experiment.

The study of the advantages, effectiveness, and necessity of creating a cloud-based learning environment in the training of future specialists and the possibility of their work in such an environment was carried out during 2021-2025 and covered the following stages of scientific and pedagogical search: preparatory stage, ascertaining stage, formative stage, and final stage of the study.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

To verify the influence of pedagogical conditions for organizing a cloud-based learning environment and the author's methodology for applying and shaping the cloud-based environment in the educational space of higher education on the formation of professional competencies of future specialists, a pedagogical experiment was conducted.

During the ascertaining experiment, the readiness of future specialists to work in a cloud-based environment and students' study of the basics of cloud technologies were assessed.

The respondents were first-year undergraduate students. The sample size was 120 people. The questionnaire was anonymous.

The quantitative composition of the respondents by pedagogical specialties was as follows: future elementary school specialists – 35% of students; future subject specialists in secondary and high schools – 65% of students. Regarding gender distribution, 75% of the respondents were women, and 25% were men.

The questionnaire asked about students' use of public cloud services. It turned out that higher education students use cloud services in order to obtain ubiquitous access and data processing. About 90% of students, the vast majority, store data on a smartphone or computer. Despite this, about 56% of respondents said they use Google Drive, and 10% use OneDrive.

The vast majority of students use messengers, not cloud storage, to transfer files, indicating that the speed of a given operation is an important criterion for them.

95% of students use a computer (laptop, tablet) to process documents. More than half of students reported that they can use a mobile device to complete tasks, and only 10% do so systematically.

Regarding students' use of open education services, we note that fewer than a third of respondents have heard of massive open online courses. Moreover, only 10% have worked on these platforms. The number of successful completions of open online courses is generally less than 3%.

We see the relevance and necessity of our research in the training of future specialists.

In the process of the ascertaining experiment, the diagnostic levels of study by EG and CG students of the basics of cloud technologies and the readiness of future specialists to work in a cloud-based environment were clarified (Figure 1):

- 16% of respondents and EG had a high level of readiness of future specialists to work in a cloud-based environment.
- 31% of EG students had an average level of readiness of future specialists to work in a cloud-based environment.
- 53% of EG respondents reported low readiness among future specialists to work in a cloud-based environment.

Similar results were obtained in CG:

- 13% of CG respondents had a high level of readiness of future specialists to work in a cloud-based environment.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- 33% of CG students had an average level of readiness of future specialists to work in a cloud-based environment.
- 54% of the CG respondents reported low readiness among future specialists to work in a cloud-based environment.

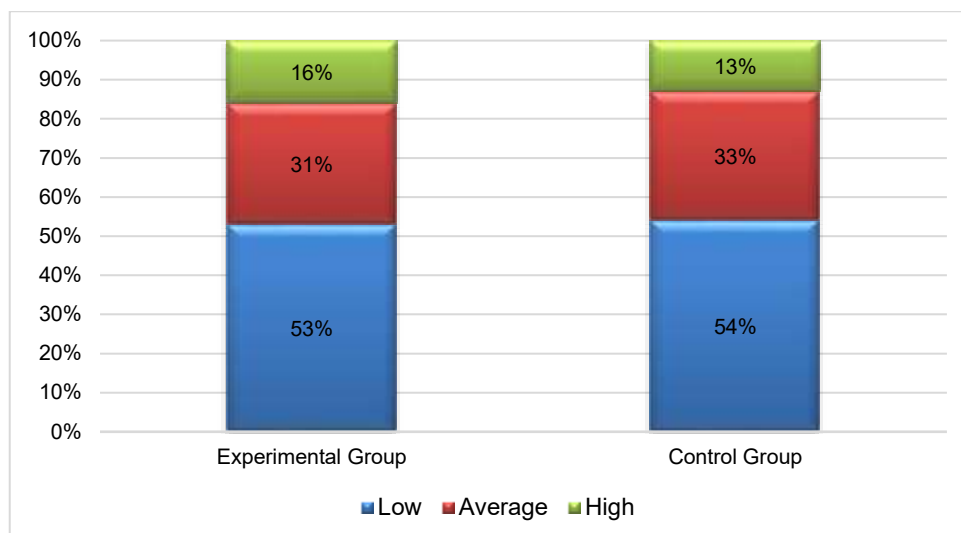


Figure 1. Levels of students' readiness to use cloud-based technologies in EG and CG (ascertaining stage)

Diagnostics of the levels of formation of future specialists' readiness to work in a cloud-based environment at the stage of ascertaining the cut-off showed insufficient effectiveness of this process.

The experiment proved that it is possible to treat modern applicants' readiness to master cloud technologies as an object of study. It showed that it is necessary to develop and implement pedagogical conditions for organizing a cloud-based learning environment and an author's methodology for applying cloud technologies in higher education to develop the professional competencies of future specialists. The results of the ascertaining experiment. determined the course of the formative experiment. The quantitative composition of the respondents remained unchanged. The formative experiment was conducted to test the developed pedagogical conditions, special course, and methodology.

System criterion. CG (formative stage of the study)

- The high level of students' mastery of the basics of cloud technologies and the readiness of future specialists to work in a cloud-based environment increased by 3%.
- The average level of students' mastery of the basics of cloud technologies and the readiness of future specialists to work in a cloud-based environment increased by 9%.
- The low level of students' mastery of the basics of cloud technologies and the readiness of future specialists to work in a cloud-based environment decreased by 12%.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

System criterion. EG (formative stage of the study)

- The high level of students' mastery of the basics of cloud technologies and the readiness of future specialists to work in a cloud-based environment increased by 20%.
- The average level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment increased by 14%.
- The low level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment decreased by 34%.

Table 1.*Changes in the System Criterion (Formative Stage)*

Level	CG Change (%)	EG Change (%)
High	+3	+20
Average	+9	+14
Low	–12	–34

Let us describe the generalized data of the formative stage of the study regarding the levels of assimilation of the basics of cloud technologies by EG and CG students and the readiness of future specialists to work in a cloud-based environment in the control and experimental groups (Fig. 2):

Criterion of readiness for interaction in a cloud-based environment of higher education students. CG (formative stage of the study)

- The high level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment increased by 3%.
- The average level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment increased by 7%.
- The low level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment decreased by 10%.

Criterion of readiness for interaction in a cloud-based environment of higher education students. EG (formative stage of the study)

- The high level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment increased by 18%.
- The average level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment increased by 15%.
- The low level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment decreased by 33%.

Criterion of the level of student satisfaction with the functioning of the cloud-based environment. CG (formative stage of the study)

- The high level of students' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment increased by 1%.
- The average level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment increased by 9%.
- The low level of respondents' mastery of the basics of cloud technologies and their readiness to work in a cloud-based environment decreased by 10%.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The criterion of the level of satisfaction of students with the functioning of the cloud-based environment. EG (formative stage of the study)

- The high level of mastery by future specialists of the basics of cloud technologies and their readiness to work in a cloud-based environment increased by 20%.
- The average level of mastery by future specialists of the basics of cloud technologies and their readiness to work in a cloud-based environment increased by 11%.
- The low level of mastery by future specialists of the basics of cloud technologies and their readiness to work in a cloud-based environment decreased by 31%.

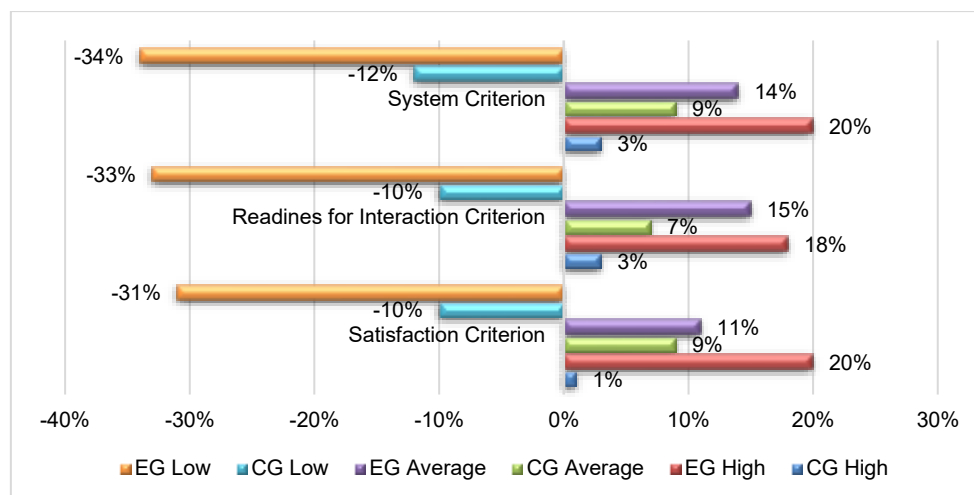


Figure 2. Distributional changes in students' readiness and cloud technology mastery in experimental and control groups (formative stage)

Thus, the results of the research and experimental work at the formative stage of the study showed that the number of EG students who reached a high level, the mastery by future specialists of the basics of cloud technologies, and their readiness to work in a cloud-based environment increased significantly in accordance with the established levels. In the CG, we see a non-significant increase.

In RStudio, statistical analysis of experimental data was performed. We assessed the scores' compliance with a normal distribution at each stage of the study to select the data processing method. The Lilliefors normality criterion was used for this.

All distributions can be considered normal. The samples should be considered dependent because the study was conducted in compliance with the above requirements and in the same groups of respondents. The method for statistical processing. In this case, in order to identify differences between the samples,

Analysis of variance for repeated measurements is used.

Let us formulate the null hypothesis (H_0) for the selected statistical method and the alternative (H_1) hypothesis:

- H_0 – there are no differences at each stage of the experiment in the average values of the respondents' scores.
- H_1 – There is a significant difference in the average values of the estimates.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

An alternative hypothesis about the homogeneity of the groups at the ascertaining stage of the study should be accepted, taking into account the p-values obtained.

We tested the sample size for the following input parameters of the experiment:

- Effect size (f) – the difference ($f = 0.5$ was taken) between the mean values of the scores in the groups.
- Significance level α – the value $\alpha = 0.05$ was taken – this is the probability of a (statistical) error of the first kind.
- Power (p) – this is the probability ($p = 0.80$ was used) of a statistical error of the first kind.

The value $n = 14$ obtained from the experiment is less than the number of applicants. Using the summary function, the following statistical significance values were obtained for the number of degrees of freedom, $df = 2$:

- $\text{SumSq} = 2924$ – the total variation between the total mean value and the group means of the obtained scores (sum of squares).
- $F = 32.17$ – F-test – test statistics.
- $1.2 \times 10^{-11} = p\text{-value}$ – this is the p-value for the F-statistic, which indicates how likely the calculated F-value is under the null hypothesis, which assumes no difference among the mean square values.

Therefore, we conclude that we can talk about reliable statistical differences between the estimates, that is, accept the alternative hypothesis, for applicants at the formative and ascertaining stages of the study.

Cloud laboratory, pedagogical conditions, and special courses are factors that caused these differences and implement the main provisions of the cloud-based learning environment.

Based on the obtained p-values, we conclude that, for the components, the alternative hypothesis should be accepted and the null hypothesis rejected.

Two-sided asymptotic significance for CG and EG. We found, using the Kolmogorov-Smirnov criterion, that the estimates are distributed according to the normal law. Student's t-test was used for independent samples, provided that the following assumptions were met, and given the small sample size, to verify statistical differences between groups.

The groups had approximately normal distributions, were independent, and had approximately equal variances. Statistical testing of equality of variances was performed in SPSS, confirming the appropriateness of the chosen statistical method. It can be stated that after the ascertaining cut, the respondents in the control and experimental groups did not show statistically significant differences in their educational achievements. The content of training at the ascertaining stage was the same for both groups, and the same teacher conducted the educational process.

Subsequently, the students in the experimental group studied a special course on organizing a cloud-based learning environment and on readiness to work in such an environment under the established pedagogical conditions. Students in the control group continued to follow the usual educational process, as in the previous case. In the experimental group, the author's methodology was implemented. After that, a second Kolmogorov-Smirnov test was conducted, and a Student's t-test was used

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

for dependent samples. The differences in test scores were compared separately for the control and experimental groups.

It can be stated, taking into account the ($\alpha < 0.05$) level of significance, that there are statistical differences between the scores obtained by respondents for completing the first and second EG test. However, such a conclusion cannot be made regarding the CG respondents. Therefore, we state the effectiveness of the developed and implemented in EG pedagogical conditions for organizing a cloud-based learning environment and the author's methodology, the application and impact of the cloud-based environment of the educational space of higher education on the formation of professional competencies of future specialists applied in the experimental group at the second stage of the study. Comparing the results of the experiment – the formative stage and the ascertaining stage of the experiment- we determined that the developed innovations implemented in EG are sufficiently effective in higher education.

The effectiveness of the cloud-based learning environment (CBLE) was evaluated by comparing the results of the control group (CG) and experimental group (EG) across three criteria: system criterion, readiness for interaction, and level of satisfaction.

Table 2.
Changes in students' readiness levels in EG (formative vs. ascertaining stage)

Level	Ascertaining Stage (%)	Formative Stage (%)	Change (%)
High	16	36	+20
Average	31	45	+14
Low	53	19	-34

The results demonstrate a substantial increase in the proportion of students with a high level of readiness (+20%) and a significant decrease in the low level (-34%) in the experimental group.

Table 3.
Comparative changes in CG and EG across criteria

Criterion	Group	High (%) Change	Average (%) Change	Low (%) Change
System criterion	CG	+3	+9	-12
	EG	+20	+14	-34
Readiness for interaction	CG	+3	+7	-10
	EG	+18	+15	-33
Satisfaction level	CG	+1	+9	-10
	EG	+20	+11	-31

The experimental group consistently outperformed the control group across all criteria, indicating the effectiveness of the implemented pedagogical conditions and methodology.

Statistical analysis confirmed these findings. The ANOVA results ($F = 32.17$; $p < 0.001$) indicate statistically significant differences between the groups. The null hypothesis (H_0) was rejected, and the alternative hypothesis (H_1) was accepted, confirming the effectiveness of the CBLE implementation.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The results of the study provide strong empirical evidence that the integration of a cloud-based learning environment, supported by targeted pedagogical conditions, significantly enhances the professional training of future specialists.

The observed improvements in the experimental group can be explained by several factors. First, the systematic integration of cloud technologies created a flexible and interactive learning environment that facilitated active student engagement and collaboration. Second, the introduction of a specialized course and cloud laboratories contributed to the development of both theoretical knowledge and practical skills. Third, the use of digital tools, including virtual and augmented reality technologies, supported deeper understanding and increased motivation.

Importantly, the multidimensional assessment (system criterion, interaction readiness, and satisfaction) confirms that the impact of CBLEs extends beyond technical skills to include behavioral and motivational aspects of learning. This supports the view that cloud-based environments should be considered not only as technological tools but as comprehensive pedagogical systems.

Comparison with Previous Studies

The findings of this study are consistent with previous research emphasizing the positive impact of cloud technologies on learning outcomes. For example, Carreón (2025) reported improved usability and reduced cognitive load in cloud-based systems, which aligns with the increased satisfaction levels observed in this study. Similarly, Vargas & Virtanen (2023) demonstrated that structured cloud-based tasks enhance student performance, supporting the improvements in interaction readiness identified in the experimental group.

At the same time, the results extend the findings of Larcher et al. (2021) and Nascimento et al. (2019), which focused primarily on technological efficiency, by demonstrating the pedagogical effectiveness of cloud environments in real educational settings.

Unlike previous studies, which often examined isolated aspects of cloud technologies, this research provides a comprehensive evaluation of CBLEs as integrated systems. In particular, it confirms the importance of pedagogical conditions, as suggested by Tenorio-Sepúlveda et al. (2021), but goes further by offering experimental validation of their impact.

However, some discrepancies with existing literature should be noted. While earlier studies often reported moderate improvements, the significant effect sizes observed in this study may be attributed to the комплексна інтеграція cloud technologies with structured pedagogical interventions, rather than their isolated use.

Critical Interpretation

Despite the positive results, several limitations should be considered. The study was conducted within a specific educational context (pedagogical specialties), which may limit the generalizability of the findings. Additionally, the duration of the experiment, although sufficient to detect significant changes, may not fully capture long-term effects.

Nevertheless, the study provides robust evidence that the effectiveness of cloud-based learning environments depends not only on technological infrastructure but also on the presence of clearly defined pedagogical conditions and methodologies.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Conclusions

This study provides empirical evidence of the effectiveness of a cloud-based learning environment (CBLE) in the professional training of future specialists under specifically designed pedagogical conditions.

The results demonstrate that the systematic integration of cloud technologies, including cloud laboratories, a specialized course, and collaborative learning practices, leads to statistically significant improvements in students' professional readiness. The experimental group showed substantial positive dynamics across all criteria (system, interaction readiness, and satisfaction), particularly in the increase of high-level indicators and reduction of low-level ones. Statistical analysis (ANOVA, $F = 32.17$; $p < 0.001$) confirmed the reliability of these differences.

The study makes several important contributions to the field: provides a comprehensive, experimentally validated model of a cloud-based learning environment as an integrated pedagogical system; identifies and substantiates specific pedagogical conditions that ensure the effectiveness of CBLE implementation; expands the understanding of multidimensional assessment of professional competencies, incorporating cognitive, behavioral, and motivational components; offers quasi-experimental evidence addressing a gap in previous research, which often lacked rigorous empirical validation.

The findings have direct implications for higher education practice: CBLEs can be effectively implemented to enhance the quality of professional training; the integration of cloud laboratories and specialized courses supports the development of both theoretical knowledge and practical skills; the use of interactive and immersive technologies (e.g., VR/AR) increases student engagement and learning motivation; the proposed pedagogical conditions can serve as a framework for curriculum design and digital transformation strategies in universities.

Despite its contributions, the study has several limitations: the sample was limited to students of pedagogical specialties, which may restrict generalizability to other disciplines; the quasi-experimental design, although robust, does not fully eliminate the influence of external variables; the duration of the study did not allow for the assessment of long-term effects of CBLE implementation.

Further research should focus on: testing the proposed model in different academic disciplines and institutional contexts; conducting longitudinal studies to evaluate the sustainability of learning outcomes; exploring the role of individual learner characteristics (e.g., digital competence, motivation); investigating the integration of CBLEs with emerging technologies such as artificial intelligence and learning analytics.

Bibliographic references

- Ariza, J., Jimeno, M., Villanueva-Polanco, R., & Capacho, J. (2021). Provisioning computational resources for cloud-based e-learning platforms using deep learning techniques. *IEEE Access*, 9, 89798–89811. <https://doi.org/10.1109/ACCESS.2021.3090366>
- Carreón, G. G. (2025). Evaluating usability and cognitive load: A comparative study of cloud-based and local database systems in higher education. *Journal of Information Technology Education: Innovations in Practice*, 24, 3. <https://doi.org/10.28945/5435>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Carvalho, D. S., Castro, P. A. de, & Fernandes Sobrinho, M. (2024). Cloud tools in higher education: Literature review. *Cadernos de Educação, Tecnologia e Sociedade*, 17(2), 663–674. <https://doi.org/10.14571/brajets.v17.n2.663-674>
- Gamboa-Cruzado, J., Espinoza-Garate, A., Julca-Zeña, J., Nuñez Meza, A., Durán Carhuamaca, A., & Amayo-Gamboa, F. (2025). Impact of cloud computing on higher education institutions: A comprehensive systematic review. *International Journal of Online and Biomedical Engineering (iJOE)*, 21(12), 154–181. <https://doi.org/10.3991/ijoe.v21i12.56811>
- Heck, T., Peters, I., Mazarakis, A., Scherp, A., & Blümel, I. (2020). Open science practices in higher education: Discussion of survey results from research and teaching staff in Germany. *Education for Information*, 36(3), 301–323. <https://doi.org/10.3233/EFI-190272>
- Ignat, T., & Ayris, P. (2020). Built to last! Embedding open science principles and practice into European universities. *Insights*, 33(1), 9. <https://doi.org/10.1629/uksg.501>
- Kalogiannakis, M., Papadakis, S., & Zourmpakis, A.-I. (2021). Gamification in science education: A systematic review of the literature. *Education Sciences*, 11(1), 22. <https://doi.org/10.3390/educsci11010022>
- Kim, T., & Lim, J. (2019). Designing an efficient cloud management architecture for sustainable online lifelong education. *Sustainability*, 11(6), 1523. <https://doi.org/10.3390/su11061523>
- Kotsev, A., Minghini, M., Tomas, R., Cetl, V., & Lutz, M. (2020). From spatial data infrastructures to data spaces: A technological perspective on the evolution of European SDIs. *ISPRS International Journal of Geo-Information*, 9(3), 176. <https://doi.org/10.3390/ijgi9030176>
- Larcher, L., Ströele, V., & Dantas, M. (2021). A cloud based system for distance learning supported by Fog Cloud cooperation. *International Journal of Grid and Utility Computing*, 12(5/6), 618–634. <https://doi.org/10.1504/IJGUC.2021.120113>
- Li, Y., Wang, K., Xiao, Y., & Froyd, J. E. (2020). Research and trends in STEM education: A systematic review of journal publications. *International Journal of STEM Education*, 7, 11. <https://doi.org/10.1186/s40594-020-00207-6>
- Nascimento, A., Olimpio, V., Silva, V., Paes, A., & de Oliveira, D. (2019). A reinforcement learning scheduling strategy for parallel cloud-based workflows. In *Proceedings of the 2019 IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW)* (pp. 817–824). <https://doi.org/10.1109/IPDPSW.2019.00134>
- Ramírez-Donoso, L., Rojas-Riethmuller, J. S., Pérez-Sanagustín, M., Neyem, A., & Alario-Hoyos, C. (2017). MyMOOCspace: A cloud-based mobile system to support effective collaboration in higher education online courses. *Computers Applications in Engineering Education*, 25(5), 910–926. <https://doi.org/10.1002/cae.21843>
- Rivera, L. F. Z., Larrondo-Petrie, M. M., & Da Silva, L. R. (2017). Implementation of cloud based smart adaptive remote laboratories for education. In *2017 IEEE Frontiers in Education Conference (FIE)* (pp. 1–5). <https://doi.org/10.1109/FIE.2017.8190473>
- Shuliak, A., Hedzyk, A., Tverezovska, N., Fenchak, L., Lalak, N., Ratsul, A., & Kuchai, O. (2022). Organization of Educational Space Using Cloud Computing in the Professional Training of Specialists. *International Journal of Computer Science and Network Security*, 22(9), 447-454. <https://doi.org/10.22937/IJCSNS.2022.22.9.58>
- Tenorio-Sepúlveda, G. C., Muñoz-Ortiz, K. d. P., Nova-Nova, C. A., & Ramírez-Montoya, M. S. (2021). Diagnostic instrument of the level of competencies in cloud computing for teachers in Education 4.0. In L. M. Camarinha Matos, X. Boucher, & H. Afsarmanesh (Eds.), *Smart and*

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

sustainable collaborative networks 4.0. PRO VE 2021 (IFIP Advances in Information and Communication Technology, Vol. 629, pp. 724–736). Springer, Cham. https://doi.org/10.1007/978-3-030-85969-5_62

Vargas, B. C., & Virtanen, S. (2023). A cloud-based systematic cyber security teaching and learning framework for high school students. *International Journal of Knowledge and Learning*, 16(3), 316–339. <https://doi.org/10.1504/IJKL.2023.132163>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

El entretenimiento educativo como herramienta para desarrollar la competencia profesional en estudiantes de educación superior

Edutainment as a tool for developing professional competence in higher education students

Pavlo Smoliak¹ Kseniia Korotkevych² Vasyl Tiahur³ Iryna Mozul⁴ Hanna Dutka⁵

Afiliación autor:

¹ PhD, Senior Lecturer at the Pedagogy Department, National University of Life and Environmental Sciences of Ukraine, Ukraine. smoliakpavlo@gmail.com

² PhD, Lecturer at the Department of Choreographic Art, Deputy Dean for Educational Work with Students at the Faculty of Arts named after Anatoly Avdiivskiy, Dragomanov Ukrainian State University, Ukraine. korotkevich13951395@gmail.com

³ Candidate Pedagogical Sciences, Associate Professor, Associate Professor at the Department of Pedagogy, Psychology, Primary, Pre-School Education and Management of Educational Institutions, Ferenc Rakoczi II Transcarpathian Hungarian University, Ukraine. basil.tvn@gmail.com

⁴ Candidate of Pedagogical Sciences, Associate Professor, Associate Professor of Theory and Methods of Primary Education Department, Educational and Scientific Institute of Pedagogy and Psychology, Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Ukraine. mozul.dubok@gmail.com

⁵ Doctor of Pedagogical Sciences, Professor, Professor of the Department of Primary and Preschool Education, Ivan Franko National University of Lviv, Ukraine. dutkaanna@ukr.net

Recibido: 05/04/26
Aceptado: 26/05/26

Cómo citar:

Smoliak, P., Korotkevych, K., Tiahur, V., Mozul, I., & Dutka, H. (2026). Edutainment as a tool for developing professional competence in higher education students. *Revista Eduweb*, 20(2), 137-156. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.9>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

 Open Acces

Resumen

El estudio examina el edutainment como un enfoque pedagógico innovador para el desarrollo de la competencia profesional en estudiantes de educación superior. La investigación tiene como objetivo fundamentar y verificar experimentalmente la efectividad de las condiciones pedagógicas y el apoyo metodológico basados en los principios del edutainment. Se implementó un diseño cuasiexperimental con 120 estudiantes de pregrado en especialidades pedagógicas, divididos en un grupo de control ($n = 59$) y un grupo experimental ($n = 61$). El grupo experimental estuvo expuesto a un modelo de instrucción basado en edutainment que integraba tecnologías digitales, gamificación, tareas interactivas y herramientas multimedia, mientras que el grupo de control siguió métodos de enseñanza tradicionales. La competencia profesional se evaluó utilizando criterios cognitivos, heurísticos y creativos en tres niveles (alto, medio, bajo). Los datos cuantitativos se analizaron mediante estadística descriptiva y la prueba de chi-cuadrado de Pearson. Los resultados demostraron una mejora sustancial en el grupo experimental, donde la proporción de estudiantes con un alto nivel de competencia alcanzó el 57,6%, en comparación con el 11,5% en el grupo de control. Los resultados de la prueba chi-cuadrado ($\chi^2 = 8,93$, $p < 0,05$) confirmaron diferencias estadísticamente significativas entre los grupos, lo que indica la efectividad de la metodología propuesta. En general, el estudio confirma que el edutainment es una herramienta pedagógica eficaz para mejorar la competencia profesional en la educación superior, con un impacto positivo tanto en el desarrollo cognitivo como socioprofesional de los futuros especialistas.

Palabras clave: competencia profesional, entretenimiento educativo, estudiantes, tecnologías digitales, sistema de principios y requisitos metodológicos.

Abstract

The study examines edutainment as an innovative pedagogical approach for developing professional competence in higher education students. The research aims to substantiate and experimentally verify the effectiveness of pedagogical conditions and methodological support based on edutainment principles. A quasi-experimental design was implemented involving 120 undergraduate students in pedagogical specialties, divided into control ($n = 59$) and experimental ($n = 61$) groups. The experimental group was exposed to an edutainment-based instructional model integrating digital technologies, gamification, interactive tasks, and multimedia tools, while the control group followed traditional teaching methods. Professional competence was assessed using cognitive, heuristic, and creative criteria at three levels (high, average, low). Quantitative data were analyzed using descriptive statistics and the Pearson chi-square test. The results demonstrated a substantial improvement in the experimental group, where the proportion of students with a high level of

competence reached 57.6%, compared to 11.5% in the control group. The chi-square test results ($\chi^2 = 8.93$, $p < 0.05$) confirmed statistically significant differences between groups, indicating the effectiveness of the proposed methodology. Overall, the study confirms that edutainment is an effective pedagogical tool for improving professional competence in higher education, with a positive impact on both cognitive and socio-professional development of future specialists.

Keywords: professional competence, edutainment, students, digital technologies, system of principles and methodological requirements.

Introduction

The transformation of higher education in the context of digitalization and societal change has significantly redefined the requirements for teacher training. Modern educators are expected not only to possess strong subject knowledge but also to demonstrate high levels of professional competence, including creativity, adaptability, digital literacy, and the ability to engage students effectively. In this regard, the integration of innovative pedagogical approaches into teacher education has become a critical priority. One such approach is edutainment, which combines educational content with elements of entertainment to enhance student engagement and learning outcomes (González-Fernández et al., 2024).

Despite the growing interest in edutainment across various educational levels, its application in the professional training of future teachers remains insufficiently explored. Existing studies primarily focus on general pedagogical contexts, motivation, or school-level education, whereas the specific impact of edutainment on the development of professional competence among higher education students – particularly in pedagogical specialties – has not been comprehensively investigated. Moreover, there is a lack of empirically validated models that integrate edutainment with structured pedagogical conditions and digital learning environments in teacher education (Flores & Calero, 2019).

At the same time, the increasing digitalization of education and the shift toward student-centered learning paradigms require the development of new instructional strategies that can effectively combine cognitive, emotional, and practical components of learning. Edutainment has the potential to address these challenges by fostering active participation, enhancing motivation, and supporting the development of higher-order thinking skills. However, the conditions under which this approach becomes pedagogically effective in higher education remain unclear and require systematic investigation.

Therefore, the relevance of this study stems from the need to address the identified scientific gap and develop effective pedagogical conditions for the development of professional competence in future teachers based on edutainment.

The study aims to substantiate and experimentally verify the effectiveness of an edutainment-based methodology for developing professional competence in students of pedagogical specialties.

Literature Review

The concept of edutainment, understood as the integration of educational content with entertainment elements, has gained increasing attention in contemporary pedagogical research. While early studies primarily focused on school education,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

recent research has expanded its application to higher education, where student engagement, motivation, and competency-based learning are critical challenges. In university contexts, edutainment is not merely a supplementary tool but a pedagogical strategy that supports student-centered learning and competence development.

Scholars emphasize that edutainment enhances learning effectiveness by combining cognitive and affective dimensions of the educational process. For example, edutainment-based instructional design integrates multimedia, storytelling, and interactive elements that contribute to deeper understanding and long-term knowledge retention. Empirical evidence from higher education demonstrates that such approaches significantly improve both motivation and academic performance (Ewelt-Knauer et al., 2025). These findings highlight the relevance of edutainment for modern university teaching, particularly in disciplines that require the integration of theoretical knowledge with practical application.

At the same time, edutainment aligns with constructivist learning theory, which emphasizes active knowledge construction through experience and interaction. From this perspective, students are not passive recipients of information but active participants in the learning process. The use of simulations, gamified tasks, and scenario-based learning environments enables learners to engage with content more deeply and develop higher-order thinking skills (Stapa & Ibaharim, 2020). Such approaches are particularly valuable in teacher education, where future professionals must develop not only knowledge but also pedagogical, communicative, and reflective competencies.

However, despite the growing body of research, the application of edutainment in higher education remains fragmented. Many studies focus on isolated tools (e.g., games, videos, or multimedia platforms) rather than comprehensive pedagogical models. Moreover, there is a lack of research that systematically connects edutainment with the formation of professional competence in students of pedagogical specialties. This indicates the need for integrated methodological approaches that combine digital technologies, pedagogical conditions, and competency-based frameworks.

Professional competence in higher education is increasingly understood as a multidimensional construct that includes cognitive, practical, social, and personal components. In this context, edutainment has been identified as a promising tool for supporting competence development through active and experiential learning.

Research indicates that edutainment contributes to the development of higher-order thinking skills, including critical thinking, creativity, and problem-solving. For instance, the use of interactive digital games and gamified tasks has been shown to stimulate analytical and creative thinking processes, particularly in language and communication-based disciplines (Stapa & Ibaharim, 2020). Similarly, approaches that combine games, mind-mapping, and social media tools enhance not only knowledge acquisition but also collaborative and communicative competencies (Alhajaji et al., 2020).

Another important aspect is the role of edutainment in bridging the gap between theoretical knowledge and practical application. Scenario-based learning and simulations allow students to engage in quasi-professional activities, thereby developing skills that are directly transferable to real-world contexts. This is particularly relevant in teacher education, where professional competence requires the ability to design, implement, and evaluate educational processes.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Despite these advantages, some researchers caution against the uncritical use of edutainment. The effectiveness of this approach depends on its pedagogical design and alignment with learning objectives. Without a clear methodological framework, edutainment may lead to superficial engagement rather than deep learning. Additionally, empirical studies reveal variability in outcomes depending on contextual factors, such as discipline, instructional design, and learner characteristics (Dubois et al., 2025).

Thus, while edutainment demonstrates significant potential for competence development, its effectiveness in higher education requires further empirical validation and methodological refinement.

Psychological Impact of Edutainment and Game-Based Learning on Young Adults

The psychological impact of edutainment and game-based learning is a key factor in explaining its effectiveness in higher education. Young adults, as learners, are characterized by a high level of cognitive development, autonomy, and a need for meaningful and engaging learning experiences. These characteristics influence how they respond to interactive and game-based educational environments.

From a motivational perspective, edutainment enhances both intrinsic and extrinsic motivation. Game elements such as rewards, challenges, and feedback mechanisms create a sense of achievement and engagement, which encourages sustained participation in learning activities (Febriyani et al., 2020). In higher education, where student motivation is often a critical issue, such mechanisms can significantly improve learning outcomes (Ewelt-Knauer et al., 2025).

Cognitively, edutainment supports deeper information processing by engaging multiple sensory channels. Multimedia and interactive content facilitate better understanding and retention of knowledge, while problem-based and scenario-driven tasks promote critical thinking and decision-making skills (Stapa & Ibaharim, 2020). These cognitive benefits are essential for the development of professional competence, particularly in fields that require analytical and reflective thinking.

Emotionally, edutainment contributes to reducing anxiety and creating a positive learning environment. The use of humor, storytelling, and immersive experiences helps to lower psychological barriers and encourages students to experiment and take risks in learning (Wanabuliandari & Ardianti, 2023). This is especially important in teacher education, where confidence and emotional resilience are key professional attributes.

From a social perspective, edutainment fosters collaboration and communication. Many game-based learning activities involve teamwork, discussion, and role-playing, which enhance interpersonal skills and prepare students for professional interaction (Corral-Joniaux & Moya-Joniaux, 2021). These social competencies are integral to professional competence, particularly in pedagogical contexts.

However, the psychological effects of edutainment are not universally positive. Some studies indicate that excessive reliance on entertainment elements may reduce academic rigor or lead to superficial assimilation of knowledge if the educational process does not have a clear pedagogical structure (Dubois et al., 2025). Furthermore, individual differences among students – such as

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

prior experience, motivation, and learning styles – may influence the effectiveness of edutainment.

Overall, the psychological dimension of edutainment highlights its potential to enhance motivation, engagement, and learning effectiveness among young adults, while also emphasizing the need for balanced and pedagogically grounded implementation.

Despite the growing interest in edutainment, the literature reveals several important gaps: there is a lack of comprehensive studies that examine edutainment as an integrated pedagogical system rather than a set of isolated tools; insufficient attention has been paid to its role in the formation of professional competence in students of pedagogical specialties; the interaction between psychological factors, digital technologies, and pedagogical conditions in edutainment-based learning environments remains underexplored.

Therefore, further research is needed to develop and empirically validate methodological approaches that integrate edutainment into higher education, particularly in the context of teacher training.

Methodology

Research Design

The study was conducted in three consecutive stages: diagnostic (ascertaining), formative, and control. At the diagnostic stage, the initial level of students' professional competence was assessed. During the formative stage, the experimental group participated in an instructional intervention based on edutainment principles, while the control group studied through traditional methods. At the control stage, post-intervention measurements were conducted to determine changes in competence levels and compare outcomes between groups.

Participants

A total of 120 undergraduate students enrolled in pedagogical specialties participated in the study. Participants were divided into:

- Experimental Group (EG): 61 students.
- Control Group (CG): 59 students.

The sample was selected using purposive sampling from the general student population of higher education institutions offering teacher-training programs.

Instruments

Data collection was based on validated pedagogical diagnostic tools, including:

1. **Structured questionnaires** to assess motivation, attitudes, and self-perceived competence.
2. **Knowledge tests** to evaluate the cognitive component of professional competence.
3. **Observation protocols** to record behavioral indicators during classroom activities.
4. **Reflective tasks and creative assignments** to assess heuristic and creative dimensions of competence.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Criteria and Indicators

Professional competence was operationalized through three interrelated criteria:

1. **Cognitive Criterion** – theoretical knowledge, understanding of pedagogical concepts, ability to apply educational technologies.
2. **Heuristic Criterion** – communication skills, problem-solving ability, reflective thinking, collaborative interaction.
3. **Creative Criterion** – innovation, flexibility, originality in pedagogical task performance, use of digital tools.

Each criterion was measured at three levels:

- High
- Average
- Low

Intervention Procedure

The experimental group received instruction using an **edutainment methodology**, integrating educational content with engaging, interactive learning elements. The intervention included:

- Gamification techniques.
- Multimedia presentations.
- Scenario-based learning.
- Simulations and role-play.
- Collaborative projects.
- Digital platforms and cloud tools.
- Humor, storytelling, and visual learning aids.

The intervention was implemented over an academic cycle within regular coursework.

Intervention Procedure (Revised and Expanded)

The instructional intervention based on edutainment principles was implemented during one academic semester (16 weeks) within the framework of regular coursework for students of pedagogical specialties. The total duration of the intervention comprised 64 academic hours, including both in-class and independent learning activities.

The intervention was structured into 32 sessions, each lasting 2 academic hours (90 minutes), conducted twice per week. In addition, students completed approximately 32 hours of guided independent work, involving digital tasks, project development, and reflective activities.

The structure of the intervention was organized into three consecutive phases:

1. **Introductory Phase** (Weeks 1–4; 8 sessions, 16 hours).

This phase aimed to familiarize students with the principles of edutainment and digital learning tools. Activities included: introductory lectures with multimedia

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

elements; guided discussions on edutainment concepts; initial gamified tasks and interactive exercises; training in the use of digital platforms and tools. Formative Phase (Weeks 5–12; 16 sessions, 32 hours).

This phase represented the core of the intervention and focused on the systematic development of professional competence. It included: scenario-based learning and simulations; role-playing activities reflecting real pedagogical situations; collaborative group projects using edutainment strategies; integration of gamification elements (points, badges, leaderboards); use of multimedia content (videos, animations, interactive presentations); application of cloud-based tools and online platforms.

2. Consolidation and Reflection Phase (Weeks 13–16; 8 sessions, 16 hours).

This phase aimed to reinforce learning outcomes and assess competence development. Activities included: presentation of student projects; reflective discussions and peer evaluation; final diagnostic tasks and testing; self-assessment using structured questionnaires.

Each session followed a standardized structure:

1. Introduction and motivation (10–15 minutes).
2. Main interactive activity (50–60 minutes).
3. Reflection and feedback (15–20 minutes).

The independent work component (32 hours) included: completion of gamified digital assignments; development of mini-projects using edutainment tools; participation in online discussions and forums; maintenance of reflective journals or digital portfolios.

Such structuring ensured the gradual development of cognitive, heuristic, and creative components of professional competence while maintaining a balance between educational content and entertainment elements.

Data Analysis

Quantitative data were processed using descriptive and inferential statistics. Frequency distributions, percentages, and comparative analyses were calculated for pre-test and post-test results. To determine the statistical significance of differences between the control and experimental groups, the Pearson chi-square test (χ^2) was applied.

The obtained empirical value ($\chi^2 = 8.93$) exceeded the critical value ($\chi^2_{crit} = 5.99$, $df = 2$, $p < 0.05$), confirming statistically significant differences in favor of the experimental group.

Validity and Reliability

To ensure methodological rigor:

- Research instruments were piloted prior to use.
- Triangulation of methods (testing, surveys, observation) was applied.
- Identical diagnostic criteria were used at the pre-test and post-test stages.
- Data interpretation was cross-checked by independent academic reviewers.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Ethical Considerations

Participation was voluntary. Students were informed about the purpose of the study, anonymity was guaranteed, and all collected data were used exclusively for scientific purposes in compliance with academic ethics standards.

Results and Discussion

Characteristics of the concept of "edutainment", the presence of which determines the specificity of the edutainment technology.

One promising area for developing professional competence among students in pedagogical specialties is edutainment. Let's briefly review the concept's characteristics in scientific sources. The concept of "edutainment" is understood as a form of educational process in which educational material is presented through game-based techniques and information services. In higher education, game elements using edutainment are only one of the tools built into other activities to support an effective educational process. The term "edutainment" is broader than just a game, since the game is only one element of this technology, which serves to transfer knowledge to students in exciting ways.

Let us outline the features, the presence of which determines the specificity of edutainment technology:

- **Game approach:** regardless of the individual's age, an effective learning process occurs due to the game's universality (Knysh et al., 2026).
- **Entertainment:** the main motive is entertainment, which removes the psychological burden from the educational process and ensures that students enjoy it, while simultaneously fostering a stable interest in learning.
- **Passion:** the child's direct interest in accumulating knowledge is important, which leads to the development of innovative new digital skills.
- **Modernity:** when using modern capabilities of relevant services, such as educational programs in multimedia formats, didactic games, video and audio materials, and other means, maximum student involvement in the educational process is achieved (Ge et al., 2023).

Today, edutainment is essential at all levels of education, particularly in higher education, where it is essential for developing the professional competence of future specialists.

We consider edutainment an innovative communication technology developed from pedagogical technology, which presents educational content in an entertaining form to attract the audience's attention and facilitate memorizing and assimilating the material.

The development of subconscious learning mechanisms is one of the mechanisms by which edutainment influences. When applying such innovative technology, the teacher uses a teaching style when presenting the material, which, in the educational process, creates a new didactic integrity: it provides an opportunity to free oneself from adhering to such strict didactic requirements as control, consistency, scientificity of teaching, etc. (Peña-Lapeira & Vargas-Puentes, 2019). Effective and unique educational potential arises under such conditions, and students can realize their individual capabilities and personal learning pace. As a result, the educational environment is not formally perceived. Any content that

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

spreads edutainment to a wide audience serves an educational purpose, satisfying students' thirst for knowledge, expanding individuals' horizons, addressing each person's social issues, and reinforcing the need for self-development and self-improvement. The above-described methodology is possible when media education is used as one of the means of achieving positive results and achieving certain intentions in implementing the media educational policy of higher education. Therefore, media education can serve as both a practical and a theoretical basis for the popularization and implementation of edutainment (Figueredo & Cuba, 2023).

Edutainment should be used moderately in classroom work with students, as it is an auxiliary technology that cannot serve as an alternative to academic education in a higher education institution. It should be noted that edutainment, due to its multi-channel action and diversity, can be used to activate verbal-logical and visual-figurative thinking (Pearl & Lesser, 2021).

Diagnostics of the formation of professional competence based on edutainment in students of pedagogical specialties.

To conduct the study, we identified the criteria, indicators, and levels of formation of professional competence in students of pedagogical specialties, based on edutainment, as determined by the structure and essence of the professional competence of the future specialist in the pedagogical direction. These proposed components correspond to the status of the methodological identity of professional training.

We have defined the criteria for the formation of professional competence in students of pedagogical specialties based on edutainment: cognitive, heuristic, and creative criteria, and outlined their indicators.

The cognitive criterion represents a system of theoretical and professional knowledge, as well as techniques, methods, and technologies for their application, based on edutainment. It requires a thorough mastery of knowledge and methodology for mastering professional disciplines of pedagogical training of future specialists of pedagogical specialties, the use of digital, innovative resources, and the ability of students of pedagogical specialties in the field of game technologies to independently search for work to form professional competence of students of pedagogical specialties.

The cognitive criterion includes the following indicators: knowledge of professional competence and edutainment; the degree of awareness among future specialists of pedagogical specialties in professional disciplines.

The heuristic criterion reflects the ability of a future specialist to demonstrate communicative skills and the best personal qualities in organizing edutainment-based gaming activities for students of pedagogical specialties, and the ability of each participant in the educational process to pay attention while mastering gaming skills. The development of reflective and communicative thinking is particularly important when considering the psychological characteristics of students of pedagogical specialties and the potential for forming professional competence through edutainment.

The following indicators heuristic outline the following criterion: the degree of mastery by students of pedagogical specialties of effective communication means based on edutainment; the formation of communicative and gaming abilities in students of pedagogical specialties in the process of professional activity; the desire

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

for a heuristic search for the formation and development of professional competence based on edutainment.

The creative criterion assumes that a future specialist in pedagogical specialties can apply organizational skills and acquired professional competencies during professional training, thereby contributing to the effective development of creativity, emotional sensitivity, fantasy, and imagination when using digital programs and gaming technologies. The creative criterion certifies the development of professional competence among students of pedagogical specialties, leading to positive results through edutainment.

The following indicators outline the creative criterion: the ability of a future specialist to apply acquired professional competencies in practical work based on edutainment; the degree of development of organizational skills during educational activity.

The proposed criteria and indicators enabled us to diagnose the levels of professional competence development among students in pedagogical specialties through edutainment. The state of formation of each isolated component of students' professional competence in pedagogical specialties, based on edutainment, should be determined according to the criteria outlined below at three levels: high, average, and low.

The main structural criteria, indicators, and levels of formation of professional competence based on edutainment that we have characterized and defined make it possible to conduct an experimental study among students of pedagogical specialties on the implementation of the developed pedagogical conditions and to prove their effectiveness.

120 students of pedagogical specialties were involved in the experimental research program to improve the quality of the educational process and the coherence of the formation of professional competence through edutainment.

To identify the state of formation of the outlined competence, an ascertaining stage of the experiment was conducted, which took place without violating the logic of the educational process and the course in natural conditions.

During further study at the formative stage, the experimental group implemented the developed author's pedagogical conditions for the formation of professional competence based on edutainment among students of pedagogical specialties. The educational process in the control group took place traditionally.

The ascertaining stage of the experiment.

Based on the established criteria, indicators, and levels of competence formation, an experiment was conducted from 2023 to 2025 and included the following stages: ascertaining, formative, and control.

The purpose of the ascertaining stage of the experiment was to diagnose the state of formation and determine the level of formation of professional competence among students of pedagogical specialties.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The structural main criteria (cognitive, heuristic, creative), indicators, and levels of formation of professional competence based on edutainment that we have characterized and defined make it possible to analyze the components.

The primary task of the ascertaining experiment was to analyze the levels of formation of professional competence through edutainment, using testing and survey methods.

To assess the state of formation of the motivational component of the outlined criteria for competence formation, based on the above-described indicators and taking into account the principles of edutainment, testing of respondents was conducted.

A high level of motivation to develop professional competence through edutainment was reported by 8.9% of respondents.

An average level of motivation to develop professional competence through edutainment was reported by 25.6% of respondents.

A low level of motivation to develop professional competence through edutainment was reported by 65.5% of respondents.

To investigate the levels of formation of the outlined competence in relation to the cognitive component was the second task of the ascertaining experiment using the methods of analysis, synthesis, and testing. The content of professional training for future specialists in the higher education process, based on edutainment, and the state of its methodological support were analyzed.

A high level of cognitive activity based on edutainment was reported by 7.8% of respondents.

An average level of cognitive activity based on edutainment was reported by 48.1% of respondents.

A low level of motivation to develop professional competence through edutainment was reported by 44.1% of respondents.

The next task of the ascertaining experiment study using the testing method was to assess the weighted average score for the formation of the creative component of professional competence based on edutainment according to the outlined criteria as follows:

A high level was presented by 12.1% of respondents.

An average level was presented by 41.0% of respondents.

A low level was presented by 46.9% of respondents.

Table 1.

State of formation of professional competence among students of pedagogical specialties based on edutainment (statistical cross-section)

Components	Levels		
	High	Average	Low
Motivational	8,9%	25,6%	65,5%
Cognitive	7,8%	48,1%	44,1%
Creative	12,1%	41,0%	46,9%

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

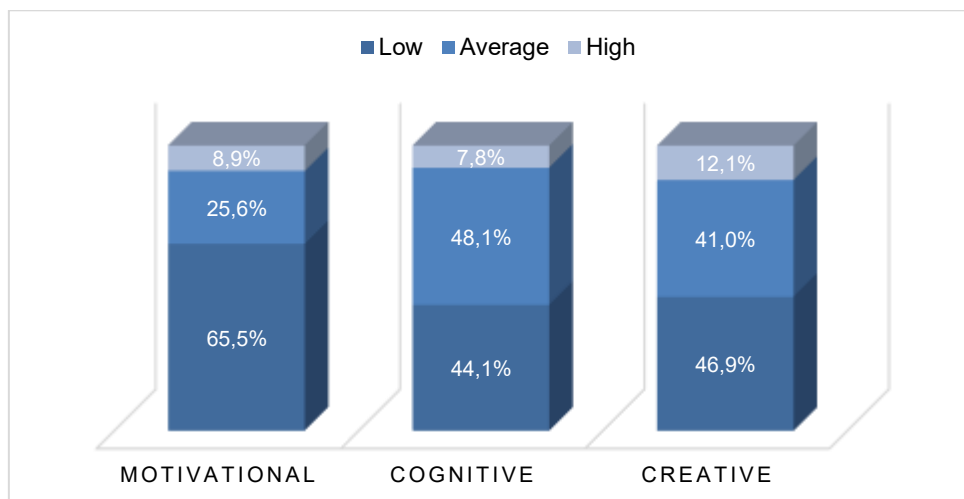


Figure 1. State of formation of professional competence among students of pedagogical specialties based on edutainment (statistical cross-section)

Thus, according to Table 1, the percentage of professional competence formation in students of pedagogical specialties at the beginning of the formative stage of the experiment is mainly at low and average levels, which makes it possible to develop methodological support for the formation of the outlined competence based on edutainment and to develop and implement pedagogical conditions. The ascertaining stage of the study showed the need to determine and implement pedagogical conditions, namely:

- Stimulating motivation in students of pedagogical specialties to use edutainment in the process of forming professional competence.
- Ensuring professional communication of the future specialist in pedagogical specialties by using social networks.
- Digitalization of the educational process with cloud services and innovative methodological support.
- Activation of independent work to develop professional competence in students of pedagogical specialties based on edutainment.

Experimental work on the formation of professional competence in students of pedagogical specialties based on edutainment.

Verification of the effectiveness of the author's experimental methodology was the task of the formative stage of the experiment, which aimed to develop students' professional competence in pedagogical specialties through edutainment.

A total of 120 respondents were involved in the formative stage of the experiment: 59 students of pedagogical specialties constituted the control group, and 61 students of pedagogical specialties constituted the experimental group. Applicants of the "bachelor" educational level were involved in the experiment.

At the formative stage of the experimental study, edutainment technology was introduced in EG, which helped students at higher education institutions focus during long-term lectures and practical classes and strengthened their motivation. Edutaining, as well as the integration of entertainment elements in the educational process, which can include the implementation of practical tasks in the materials of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

practical classes and lectures, enriched the educational process by considering examples from life, which is a way of interaction between the teacher and students.

The edutainment technology that was implemented in the EG included the following techniques:

- Use of images, short clips, sound effects, humorous, unexpected inserts in PowerPoint presentations.
- Use of videos with real-life examples as illustrations for theoretical material.
- Demonstration of practical application scenarios.
- Involvement of students with further discussion of the situation, to acting out humorous scenarios.
- Avoidance of monotony in presenting the material – the edutainment teacher should use (preferably with a comic effect) facial expressions, change the voice to maintain interest in the material of students.
- Use of unexpected jokes, where the element of unexpectedness should enhance the learning process of students.
- Demonstration with the involvement of the audience of examples of practical application.
- Involvement of all students, regardless of their knowledge and skill level.

In the EG, among the numerous advantages of edutainment technology, we have noted the following advantages for the formation of professional competence in students of pedagogical specialties in classes at a higher education institution:

- Increasing the level of satisfaction among students of pedagogical specialties through the process of completing tasks and obtaining information based on edutainment.
- Increasing the enthusiasm of students of pedagogical specialties for the topic of the lesson and interest in information that is difficult to understand and perceive.
- Improving the depth of internalization and understanding of acquired knowledge based on edutainment.
- Increasing the stability of acquired knowledge and increasing attention by involving the emotional sphere in students of pedagogical specialties.
- Edutainment seems to be a more natural way of interaction for students of pedagogical specialties – representatives of the digital generation – with educational material and a teacher.
- Helps overcome the challenges of using edutainment technology that teachers face in new realities, achieve the desired results, and improve the quality of the educational process.

The development of professional competence through edutainment among students in pedagogical specialties at EG was implemented using digital technologies. It involved developing a substantiated scientific approach to structuring learning and content. The priority task in this context is to identify a system of principles and methodological requirements that formed the basis of this process.

Among them, we highlight the following most effective ones:

The principle of social responsibility encompasses important aspects of digital learning, emphasizing responsibility and interaction between participants in the educational process and society. The content of this principle includes: taking into account values and ethical norms when using and developing digital platforms and educational materials; ensuring equal access to digital resources for all participants

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

in the educational process; protecting students' personal information; and avoiding discrimination among students in pedagogical specialties. The importance of engaging with society underscores the principle of social responsibility and the need to fulfill commitments to the world in digital learning, particularly by creating platforms and digital educational tools that promote diversity and social inclusion, while taking into account social, cultural, and economic contexts.

The principle of systematicity involves developing all components of professional competence in students of pedagogical specialties and creating an integrated system of influence on the formation of a personality in higher education based on edutainment. Taking into account the peculiarities of the digitalization of the educational process, the principle of systematicity involves the use of interdisciplinary tasks and projects, active interaction between various elements of the educational process, manifested through the use of digital complex platforms that ensure adaptation and interaction to the individual needs of the student, the transfer of information, the integration of various resources and means for the most effective educational process for students of pedagogical specialties.

The principle of professional orientation contributes to the formation of specific knowledge and skills necessary for successful professional activity, is designed to ensure the formation of professional competence, and to ensure interaction, based on the use of edutainment, between the educational process of students of pedagogical specialties and the needs of the modern labor market. The implementation of this principle involves the use of digital technologies based on edutainment for training, which realistically reflect the modern realities of a certain selected field (interactive tools: the use of simulations, virtual reality, etc.), the use of cases and practical tasks that recreate real situations from professional life, so that students of pedagogical specialties can apply theoretical knowledge in practice, gain practical experience and cooperate with the educational industry for professional development and creating opportunities for internships.

The principle of integrativity during the formation of professional competence in the conditions of digitalization of training based on edutainment determines the creation of a single and holistic system in students of pedagogical specialties that combines various aspects in the educational process (practical and theoretical training, educational components) and ensures their interaction based on edutainment for the effective formation of professional competence. Digital technologies for students in pedagogical specialties enable the development of a system for building professional competence that combines virtual simulations, interactive tasks, educational materials, and assessment tools. Students of pedagogical specialties in such a system receive a comprehensive experience, not just isolated fragments of information, an experience that, drawing on edutainment, takes into account various aspects of professional competence.

The principle of interactivity aims to create an effective educational environment and to foster an active role for students in pedagogical specialties in learning based on edutainment. This involves implementing group projects, engaging students from pedagogical specialties in discussions, and using game elements to stimulate activity (e.g., ratings, badges, competitions, etc., based on edutainment). This approach stimulates creative problem-solving and critical thinking among students in pedagogical specialties. This principle aims to create an interactive and dynamic environment where students in pedagogical specialties not only receive information but also develop their skills and competencies, actively engaging with information through edutainment.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The principle of individualization of learning provides students in pedagogical specialties with personalized, unique conditions based on edutainment, ensuring optimal development of their educational potential. Among the promising ways to implement the principle of individualization of learning, we highlight: the use of digital tools to create adaptive platforms that can adapt tasks and content in accordance with the individual needs of students of pedagogical specialties and the level of education of each individual; the introduction of digital systems for assessment that take into account the achievements of each student of pedagogical specialties, their individual progress; the creation of interactive digital resources that allow students of pedagogical specialties to study professional material in the form of games, perform tasks based on edutainment, adapted to learning styles and their needs; using digital platforms to provide consultations on course selection and individual advice on the formation of professional competence in students of pedagogical specialties, their career development and other aspects of learning. This principle in the digital educational space aims to create effective, optimal conditions for the educational development of each student in pedagogical specialties, taking into account their learning style, unique needs, and individual progress.

The principle of reflection involves systematic, active self-assessment by students in pedagogical specialties in the context of the digitalization of education and analysis of the educational process based on edutainment, which helps them become aware of their academic and personal development. This can be implemented through the use of electronic portfolios by students of pedagogical specialties to reflect impressions of learning and to collect student work, achievements, etc., ultimately forming professional competence and a personal "digital trace" of a student of pedagogical specialties, based on edutainment. The use of tests, questionnaires, and automated assessment tools enables students in pedagogical specialties to assess their skills, knowledge, and educational progress systematically. Students in pedagogical specialties should participate in forums and online discussions, where they can discuss their educational achievements through edutainment, interact with teachers and colleagues, and express their opinions. The principle of reflection contributes to self-awareness of one's own activities and self-education, creating an opportunity to develop the ability to evaluate and analyze actions independently and to improve the educational process to form professional competence in students of pedagogical specialties through edutainment.

At the formative stage of the research, under these circumstances, the pedagogical conditions proposed by us were implemented in the experimental group.

During the formative stage of the experiment, principles were proposed to verify its effectiveness and constitute the theoretical basis for the experimental study of the formation of professional competence through edutainment.

The purpose of the formative stage of the experiment is to verify pedagogical conditions in the educational process and to test the author's methodology for developing the outlined competence using edutainment game technologies.

During the formative experiment, the EG respondents mastered specially developed edutainment gaming technologies and methodological tools, which contributed to the development of students' digital literacy skills and stimulated their creative activity. In digital scribing, systematic discussions took place on the use of gaming technologies, cloud technologies, scribe presentations, PowerPoint, and online services.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Results of the experimental study.

Our study involved experimental testing of the effectiveness of the proposed methodology and pedagogical conditions for the formation of professional competence based on edutainment among students in pedagogical specialties.

A sample was taken from the general population of respondents: 59 students of pedagogical specialties constituted the control group, and 61 students of pedagogical specialties constituted the experimental group.

A final cross-section was conducted to determine the final level of formation of professional competence based on edutainment among students of pedagogical specialties and to identify the dynamics of changes in levels.

The final cross-section was conducted using the same criteria as the ascertaining cross-section to identify the dynamics of the problem's development and to compare the study's results across all identified components. Thus, after completion and before the start of the experiment's formative stage, the results of the diagnostic cross-sections were compared, enabling analysis of the dynamics of changes in formation levels.

We compared in detail the results of the control and experimental groups (in which the latest methodology was introduced). The results of the final cross-section of competence formation levels for the outlined competence, based on edutainment, among students of pedagogical specialties in the experimental and control groups, are presented in the tables.

Table 2.

Summary results of the final cut-off of the levels of formation of professional competence components based on edutainment among students in the control and experimental groups

Levels	Summary results of the final cross-section of the levels of formation of components	
	Control group (n = 59)	Experimental group (n = 61)
High	11,5%	57,6%
Average	56,6%	36,9%
Low	31,9%	5,5%

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

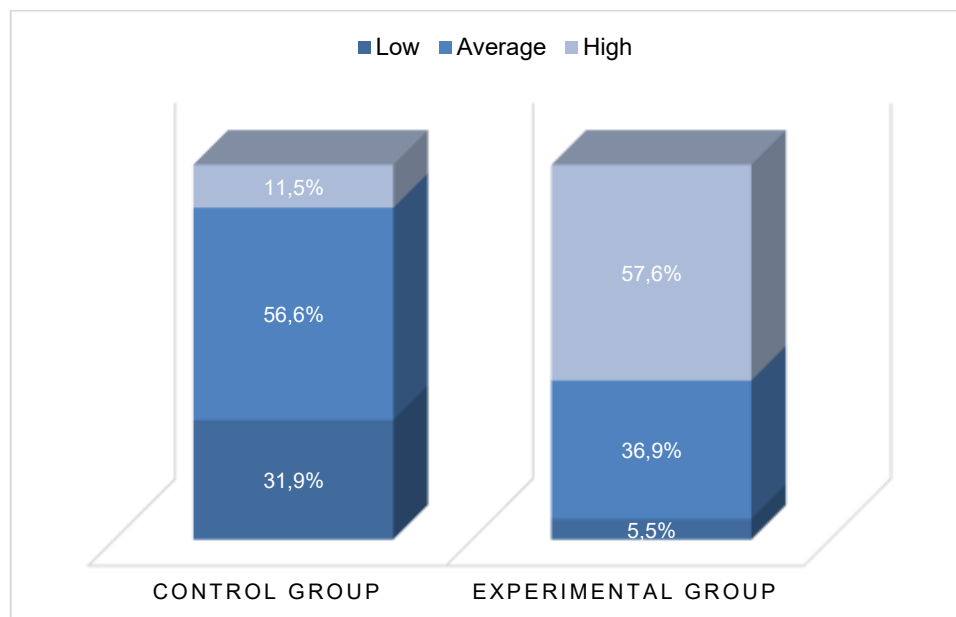


Figure 2. Summary results of the final cut-off of the levels of formation of professional competence components based on edutainment among students in the control and experimental groups.

The summarized results of the final cut of the levels of component formation according to all criteria, and the comparative analysis of the participants in the experimental and control groups, indicate significantly lower results for the control group and significantly higher results for the experimental group of students of pedagogical specialties.

Given the specific characteristics of the questionnaires administered to students for statistical data verification, we chose the χ^2 test to analyze the results.

The obtained summarized results of the final cut of the levels of formation of professional competence in students of pedagogical specialties in the experimental and control groups based on edutainment were calculated by the formula:

$$\chi^2 = N \cdot M \cdot \sum_{i=1}^L \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)^2}{\frac{n_i}{N} + \frac{m_i}{M}}$$

N – number of respondents in the experimental group of students of pedagogical specialties.

M – number of respondents in the control group of students in pedagogical specialties.

L – number of levels.

In the course of the calculations (using a critical value for $L-1=2$), the result $8.93 \geq 5.99$ confirms the effectiveness of the proposed methodology for developing professional competence in students in pedagogical specialties based on edutainment.

Thus, the effectiveness of the pedagogical conditions developed and implemented in the EG, as well as the methodological support for developing professional

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

competence in students of pedagogical specialties through edutainment, was experimentally verified. The effectiveness of the pedagogical conditions developed and implemented in the EG, as well as the methodological support developed, was confirmed. Verification of the experimental results using statistical methods (χ^2 criterion) confirms the feasibility and effectiveness of the pedagogical conditions developed and implemented in the EG, as well as the methodological support based on edutainment.

The results of the present study demonstrate a substantial increase in the level of professional competence among students in the experimental group, where the proportion of students with a high level reached 57.6%, compared to 11.5% in the control group. These findings confirm the effectiveness of edutainment-based pedagogical conditions and are consistent with a growing body of research emphasizing the positive impact of interactive and game-based learning approaches in higher education.

In particular, the obtained results align with the findings of Ewelt-Knauer et al. (2025), who reported that the integration of edutainment-based instructional videos significantly enhances both student motivation and academic performance. The improvement observed in our study can be explained by similar mechanisms, including increased engagement, emotional involvement, and the use of multimedia learning environments. These factors contribute to deeper cognitive processing and more effective knowledge acquisition.

The results are also consistent with earlier studies demonstrating that edutainment increases student motivation and engagement. For example, experimental research in higher education contexts has shown that students exposed to edutainment strategies demonstrate significantly higher levels of motivation and participation compared to those taught using traditional methods. This supports the conclusion that the motivational component plays a key role in the formation of professional competence.

At the same time, our findings correspond with broader research on gamification and interactive learning, which indicates that increased motivation and reduced cognitive load lead to higher levels of engagement and improved learning outcomes. The structured use of edutainment elements in our intervention – such as simulations, role-playing, and gamified tasks – likely contributed to these effects by creating a more dynamic and learner-centered educational environment.

However, the results of this study should also be interpreted in light of research that reports mixed or context-dependent effects of edutainment and related approaches. Some studies indicate that while motivation and engagement consistently improve, the impact on long-term academic performance may vary and is not always statistically significant. This suggests that the effectiveness of edutainment depends on the quality of instructional design, alignment with learning objectives, and the integration of cognitive and pedagogical components.

In comparison with studies that report limited effects of immersive or game-based technologies on academic achievement, the stronger results obtained in this research may be explained by the comprehensive approach that combines edutainment with clearly defined pedagogical conditions, assessment criteria, and systematic organization of the educational process. Unlike approaches that rely solely on technological tools, the present study emphasizes the importance of methodological support and structured implementation.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Overall, the findings confirm and extend existing research by demonstrating that edutainment can serve not only as a motivational tool but also as an effective means of developing professional competence in higher education students. At the same time, the comparison with previous studies highlights the necessity of pedagogically grounded and systematically designed interventions to achieve sustainable educational outcomes.

Conclusions

The present study substantiates and experimentally verifies the effectiveness of edutainment as an innovative pedagogical approach for the development of professional competence in higher education students. The results confirm that the integration of edutainment-based pedagogical conditions, supported by digital technologies and interactive methodologies, leads to statistically significant improvements in students' competence levels. In particular, the proportion of students demonstrating a high level of professional competence in the experimental group increased substantially compared to the control group (57.6% vs. 11.5%), which confirms the effectiveness of the proposed model.

The scientific contribution of the study lies in the development and validation of an integrated pedagogical framework that combines cognitive, heuristic, and creative components of professional competence with structured edutainment-based instructional design. Unlike fragmented approaches reported in previous studies, the proposed model ensures a systematic alignment between pedagogical conditions, digital tools, and competence-oriented outcomes.

At the same time, the findings should be interpreted with several limitations in mind. First, the study was conducted within a single academic context and involved a relatively limited sample of students in pedagogical specialties. Second, the duration of the intervention (one academic semester) does not allow for the assessment of the long-term sustainability of the acquired competencies. Third, potential variability related to individual learner characteristics and disciplinary differences was not fully explored.

In this regard, future research should focus on longitudinal designs to measure long-term retention and transfer of professional skills developed through edutainment. In particular, the following research directions are promising: conducting longitudinal studies (6–12 months or more) to assess the stability of the formed competencies; using repeated measurements (follow-up assessment) after the completion of the educational intervention; analyzing the transfer of skills into real professional activity (transfer of learning); using mixed methods to combine quantitative results with qualitative analysis of students' experiences; studying the influence of individual factors (motivation, learning style, digital competence) on the long-term retention of results; comparing the effectiveness of edutainment in different fields of training.

Thus, further research should be aimed not only at confirming the effectiveness of edutainment in the short term but also at identifying mechanisms for ensuring the sustainable and long-term development of professional competence, which is critically important for modern higher education.

Bibliographic references

Alhajaji, B. H., Algmadi, J. S., & Metwally, A. A. (2020). Exploring the success of GMT technique: Games, mind-mapping, and Twitter hashtags in teaching

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- vocabulary in EFL higher education environment. *International Journal of Higher Education*, 9(3), 290–299. <https://doi.org/10.5430/ijhe.v9n3p290>
- Corral-Joniaux, J. A., & Moya-Joniaux, C. A. (2021). Caracterización de las competencias profesionales que poseen los estudiantes de Licenciatura en Educación para la innovación y desarrollo de procesos educativos. *Luz*, 20(4), 108–120. <https://luz.uho.edu.cu/index.php/luz/article/view/1140>
- Dubois, E., Farolfi, S., Hafkamp-Ibanez, L., & Roussel, S. (2025). Environmental edutainment games and pro-environmental behavior of primary school students: Evidence from a field experiment. *Journal of Behavioral and Experimental Economics*, 119, 102474. <https://doi.org/10.1016/j.socec.2025.102474>
- Ewelt-Knauer, C., Herrmann, F., Mai, S. P. N., Pleger, A., & Schuetz, H. (2025). Keeping the balance: The impact of an instructional edutainment-based video series on students' motivation and performance. *Accounting Education*, 1–37. <https://doi.org/10.1080/09639284.2025.2482690>
- Febriyani, S., Suwono, H., & Ibrohim. (2020). Guided inquiry model combined with edutainment to increase junior high school students' science learning interest. *AIP Conference Proceedings*, 2215(1), 030029. <https://doi.org/10.1063/5.0003784>
- Figueredo, C. A., & Cuba, O. M. (2023). Procedimiento para la formación de competencias profesionales en los estudiantes de profesor de la Educación Técnica y Profesional de la rama Informática. *Luz*, 22(4), 49–63. <https://luz.uho.edu.cu/index.php/luz/article/view/1343>
- Flores, M. I. N., & Calero, L. V. (2019). Evaluation of transversal professional competences and educational innovation. *Revista Conrado*, 15(67), 234–240. <https://revista.conrado.ucf.edu.cu/index.php/conrado/article/view/1062>
- Ge, C., Wang, F. J., & Gao, Z. (2023). Research design based on children's participative edutainment products. In M. Kurosu & A. Hashizume (Eds.), *Human-computer interaction. HCII 2023* (Lecture Notes in Computer Science, Vol. 14012). Springer. https://doi.org/10.1007/978-3-031-35599-8_5
- González-Fernández, R., Ruiz-Cabezas, A., Medina Domínguez, M. C., Subía-Álava, A. B., & Delgado Salazar, J. L. (2024). Teachers' teaching and professional competences assessment. *Evaluation and Program Planning*, 103, 102396. <https://doi.org/10.1016/j.evalprogplan.2023.102396>
- Knysh, I., Chovriy, S., Vaculenko, S., Koycheva, T., Lytvynov, A., & Kuchai, O. (2026). Artificial Intelligence: a tool for quality training of future specialists in socio-economic specialties. *Revista Conrado*, 22(108), e4682. <https://conrado.ucf.edu.cu/index.php/conrado/article/view/4682>
- Pearl, D. K., & Lesser, L. M. (2021). Statistical edutainment that lines up and fits. *Teaching Statistics*, 43, 45–51. <https://doi.org/10.1111/test.12241>
- Peña-Lapeira, C. J., & Vargas-Puentes, L. (2019). Evaluation of university professional practice as part of the process of business strengthening and student competences. In K. S. Soliman (Ed.), *Vision 2025: Education excellence and management of innovations through sustainable economic competitive advantage* (pp. 10677–10687). International Business Information Management Association (IBIMA). <https://acortar.link/1pB9ve>
- Stapa, S. H., & Ibaharim, N. I. (2020). The use of edutainment in promoting higher order thinking skills in ESL writing among Malaysian university students. *Arab World English Journal*, (Special Issue 6), 49–66. <https://doi.org/10.24093/awej/call6.4>
- Wanabuliandari, S., & Ardianti, S. D. (2023). Effectiveness of edutainment module based on local excellence of Pantai Utara Indonesia reviewed from students' concept understanding. *Pegem Journal of Education and Instruction*, 13(3), 41–46. <https://doi.org/10.47750/pegegog.13.03.05>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Desarrollando la preparación para el uso de tecnología SMART en futuros profesionales: un enfoque cuasiexperimental

Developing readiness for SMART technology use in future professionals: A quasi-experimental approach

Ruslana Vlasenko¹  Olena Bukhniieva²  Ellina Panasenko³  Nadiia Oliinyk⁴  Tetiana Stoliarova⁵ 

Afiliación autor:

¹ Candidate of Biological Sciences, Associate Professor of The Department of Ecology and Geography, Faculty of Natural Sciences, Zhytomyr Ivan Franko State University, Ukraine. vlasenko_r76@ukr.net

² Candidate of Pedagogical Sciences, Associate Professor, Izmail State University of Humanities, Ukraine. bukhnievaolena@gmail.com

³ Doctor of Pedagogical Sciences, Professor, Head of the Practical Psychology Department, State Higher Educational Institution «Donbas State Pedagogical University», Ukraine. ellinapanasenko@ukr.net

⁴ Ph.D. in Pedagogy, Associate Professor, Department of Management, Kamianets-Podilskyi Ivan Ohienko National University, Ukraine. oliynuknu@gmail.com

⁵ Candidate of Pedagogical Sciences, Associate Professor, Department of Computer Science and Information Systems, State University of Trade and Economics, Ukraine. tetianasaenko@gmail.com

Recibido: 11/01/26

Aceptado: 28/04/26

Cómo citar:

Vlasenko, R., Bukhniieva, O., Panasenko, E., Oliinyk, N., & Stoliarova, T. (2026). Developing readiness for SMART technology use in future professionals: A quasi-experimental approach. *Revista Eduweb*, 20(2), 157-175. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.10>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

La rápida transformación digital de la educación superior exige la integración de herramientas innovadoras que potencien la formación profesional de los futuros profesionales. Este estudio tiene como objetivo verificar experimentalmente la efectividad de las condiciones pedagógicas y un sistema de formación estructurado diseñado para desarrollar la preparación de los estudiantes para la aplicación de herramientas digitales inteligentes en sus actividades profesionales. Se empleó un diseño cuasiexperimental de métodos mixtos, con la participación de 174 estudiantes divididos en un grupo experimental (n=88) y un grupo de control (n=86). Los datos se recopilaban mediante cuestionarios, observaciones, entrevistas y tareas diagnósticas, y se analizaron mediante estadística descriptiva y pruebas t de Student. La intervención incluyó la implementación de un entorno educativo orientado a las herramientas inteligentes (SMART) que integra laboratorios virtuales, plataformas en la nube y estrategias de aprendizaje interactivas como la gamificación y el aprendizaje basado en proyectos. Los resultados indican una mejora estadísticamente significativa en el grupo experimental, con un aumento en la proporción de estudiantes que demostraron un alto nivel de preparación, del 21,5% al 51,3%, mientras que la proporción con un bajo nivel disminuyó sustancialmente. Este estudio contribuye al campo al proporcionar validación empírica de un modelo con fundamento pedagógico que integra herramientas digitales con condiciones de instrucción específicas para potenciar los componentes motivacionales, cognitivos y basados en la actividad de la preparación profesional. Los resultados destacan que la eficacia de los entornos de aprendizaje inteligentes depende no solo de la infraestructura tecnológica, sino también de un diseño pedagógico sistemático. Estos hallazgos tienen implicaciones prácticas para la modernización de la educación superior y el desarrollo de las competencias digitales de los estudiantes, en consonancia con las demandas del mercado laboral.

Palabras clave: especialistas del futuro, tecnologías SMART, laboratorios virtuales, tecnologías SMART en la nube, entorno SMART.

Abstract

The rapid digital transformation of higher education necessitates the integration of innovative tools that enhance the professional training of future professionals. This study aims to experimentally verify the effectiveness of pedagogical conditions and a structured training system designed to develop students' readiness to apply smart digital tools in professional activities. A mixed-methods quasi-experimental design was employed, involving 174 students divided into experimental (n=88) and control (n=86) groups. Data were collected through questionnaires, observations, interviews, and diagnostic tasks, and analyzed using descriptive statistics and Student's t-tests. The intervention included the implementation of a SMART-oriented educational environment integrating

virtual laboratories, cloud-based platforms, and interactive learning strategies such as gamification and project-based learning. The findings indicate a statistically significant improvement in the experimental group, with the proportion of students demonstrating a high level of readiness increasing from 21.5% to 51.3%, while the share with a low level decreased substantially. The study contributes to the field by providing empirical validation of a pedagogically grounded model that integrates digital tools with targeted instructional conditions to enhance motivational, cognitive, and activity-based components of professional readiness. The results highlight that the effectiveness of smart learning environments depends not only on technological infrastructure but also on systematic pedagogical design. These findings have practical implications for modernizing higher education and developing students' digital competencies in line with labor market demands.

Keywords: future specialists, SMART technologies, virtual laboratories, cloud SMART technologies, SMART environment.

Introduction

The integration of digital technologies into higher education has become a defining feature of contemporary educational systems. Among these innovations, SMART technologies – encompassing intelligent devices, cloud-based platforms, interactive tools, and data-driven environments – offer significant potential for enhancing the quality of professional training. Their application enables flexible, personalized, and collaborative learning experiences that align with the demands of modern labor markets.

Despite the growing adoption of digital tools in higher education, their effective pedagogical integration remains a critical challenge. Existing research predominantly focuses on the technological capabilities of SMART environments or their general impact on learning outcomes. However, such approaches often overlook a key issue: students' readiness to meaningfully apply these technologies in real professional contexts. In practice, the mere availability of digital tools does not ensure their effective use, as students frequently lack the necessary motivation, structured knowledge, and practical skills.

Furthermore, current studies rarely provide empirically validated models that systematically integrate pedagogical conditions, instructional strategies, and digital tools into a coherent training system. The lack of experimental research examining how SMART-oriented environments influence the formation of students' readiness – particularly across motivational, cognitive, and activity-based dimensions – represents a significant gap in the literature.

Addressing this gap requires a shift from descriptive analyses of digital technologies toward evidence-based pedagogical frameworks that support their effective implementation in professional training. In particular, there is a need to identify and experimentally verify the pedagogical conditions that facilitate the development of students' readiness to apply SMART technologies in professional activities.

The present study aims to fill this gap by developing and empirically validating a structured training system based on a SMART-oriented educational environment. The research focuses on identifying key pedagogical conditions and assessing their impact on the formation of students' readiness to use digital tools in professional contexts through a quasi-experimental design.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The novelty of the study lies in: the integration of SMART technologies within a pedagogically grounded framework; the operationalization of readiness as a multidimensional construct (motivational, cognitive, and activity-based); the experimental verification of the effectiveness of the proposed approach in higher education settings.

Literature Review

The development of SMART technologies has generated a substantial body of research focused on their role in transforming higher education. However, despite the diversity of approaches, existing studies demonstrate significant fragmentation, methodological limitations, and a predominance of descriptive analyses over theoretically grounded and empirically validated models.

Early studies on SMART education primarily focus on its conceptualization as a technology-driven paradigm. For instance, Țălu (2020) emphasizes the systemic transformation of educational environments through digitalization, while Budhrani et al. (2018) interpret SMART learning as a flexible, personalized, and location-independent model. Although both approaches highlight accessibility and scalability, they remain largely declarative and lack operationalization of key constructs, particularly regarding learning outcomes and professional readiness. In contrast, Yamao & Lescano (2020) extend this perspective by linking SMART education to Industry 4.0 competencies, suggesting its alignment with socio-economic demands. However, their work, similar to earlier studies, does not provide a clear pedagogical framework for implementation. Thus, a key limitation across conceptual studies is the absence of a unified theoretical model that connects technological affordances with pedagogical processes and measurable educational outcomes.

A significant research strand explores the integration of SMART technologies within STEM/STEAM education. Gao et al. (2020) conceptualizes STEAM as an interdisciplinary framework. Belbase et al. (2021) further emphasize the role of project-based and inquiry-based learning in developing practical competencies. Despite these contributions, a comparative analysis reveals that these studies prioritize methodological integration (interdisciplinarity, project-based learning) over technological readiness. In other words, while SMART tools are implicitly present, they are not the central object of analysis. Moreover, the focus remains on learning outcomes rather than on the formation of students' ability to effectively apply SMART technologies in professional contexts. Thus, a conceptual gap emerges between technology-enhanced learning and readiness for technology application, which is insufficiently addressed in existing research.

Numerous studies highlight the positive pedagogical effects of SMART technologies. Costley & Lange (2017) demonstrate that well-designed digital environments reduce cognitive load and improve learning efficiency. Similarly, Zawacki-Richter et al. (2019) identify the transformative potential of artificial intelligence in enabling adaptive and personalized learning. At the same time, Marutschke et al. (2019) and Reyes et al. (2021) emphasize collaborative and project-based SMART environments as key factors in preparing students for globalized professional contexts. These findings are consistent in recognizing the importance of interaction, engagement, and flexibility.

However, a critical comparison reveals an important limitation: most studies examine isolated elements (e.g., AI tools, virtual environments, collaboration) rather than integrated pedagogical systems. As a result, the

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

cumulative impact of SMART technologies on the holistic development of professional competencies remains underexplored. Furthermore, Shernof et al. (2017) argue that the effectiveness of innovative technologies is contingent upon teacher readiness and pedagogical support, thereby challenging the implicit assumption in many studies that technology alone drives educational improvement.

Recent research increasingly focuses on technological ecosystems, including IoT, smart classrooms, and cloud-based platforms (Ferreira et al., 2024; 2025; Aguilera et al., 2025). These studies provide valuable insights into infrastructure development and user experience, highlighting the potential of SMART environments for interactive and inclusive learning. Nevertheless, compared to earlier pedagogical studies, this body of research demonstrates a shift toward technological determinism, where educational effectiveness is primarily attributed to technological innovation. In contrast, pedagogical variables – such as instructional design, motivation, and assessment – are often underrepresented.

This imbalance creates a theoretical inconsistency: while technology is increasingly sophisticated, its pedagogical integration remains insufficiently theorized and empirically validated.

A cross-analysis of the reviewed literature allows for the identification of several key trends and contradictions:

1. Dominance of descriptive and conceptual studies over experimental research.
2. Fragmentation of research focus, with separate examination of technologies, methodologies, and learning outcomes.
3. Insufficient attention to students' readiness as a multidimensional construct.
4. Lack of integrated pedagogical models that combine SMART technologies, instructional strategies, and assessment mechanisms.

Importantly, existing studies rarely conceptualize readiness as a holistic construct that includes motivational, cognitive, and activity-based components, nor do they empirically test conditions for its development.

To address these limitations, the present study is grounded in an integrative theoretical framework that combines: competency-based approach – emphasizing the development of practical and transferable skills required for professional activity; activity theory – focusing on the role of active engagement and practice in mastering SMART technologies; constructivist learning theory – highlighting the importance of learner-centered, interactive, and collaborative environments; systemic approach – ensuring the integration of technological, pedagogical, and organizational components into a coherent educational model.

Within this framework, readiness to use SMART technologies is conceptualized as a multidimensional construct comprising: motivational component (values, attitudes, and interest); cognitive component (knowledge and understanding); activity-based component (practical skills and application). Such an approach allows for overcoming the fragmentation observed in previous studies and provides a basis for the experimental validation of pedagogical conditions and training systems.

The aim of this study is to experimentally verify the effectiveness of pedagogical conditions and a SMART-oriented training system in developing future professionals' readiness to apply digital technologies in their professional activities.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Methodology

Research Design

This study employed a mixed-methods research design, integrating both qualitative and quantitative approaches to ensure a comprehensive analysis of the process of training future specialists to use SMART technologies. The research was conducted as a quasi-experimental study with control (CG) and experimental groups (EG), enabling the evaluation of the effectiveness of the proposed pedagogical conditions and training system.

The experimental design included three consecutive stages: ascertaining (diagnostic), formative (intervention), and control (evaluation), conducted during 2023–2025. This longitudinal structure ensured the consistency and reliability of the obtained results.

Participants

The study involved 174 students enrolled in higher education institutions. The participants were divided into two groups:

- Experimental Group (EG): 88 students.
- Control Group (CG): 86 students.

The groups were tested for initial homogeneity using an independent samples Student's t-test, confirming no statistically significant differences at the baseline ($p > 0.05$). This ensured comparability and internal validity of the experiment.

Procedure

The research procedure consisted of three stages:

1. *Ascertaining Stage (Diagnostic Phase)*

At this stage, the initial level of students' readiness was assessed. The results indicated that the majority of students demonstrated a low level of readiness (56.1%), highlighting the need for targeted pedagogical intervention.

2. *Formative Stage (Intervention Phase)*

During this phase, the experimental group was exposed to a SMART-oriented educational environment, which included:

- Integration of virtual laboratories and cloud technologies.
- Implementation of gamification, project-based learning, and digital collaboration tools.
- Use of platforms such as interactive applications, LMS systems, and online tools.
- Development of students' reflective and self-regulated learning skills.

The control group continued learning through traditional instructional methods.

Pedagogical conditions implemented in the EG included:

- Enhancing cognitive motivation through innovative teaching methods.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Developing digital competencies via interactive and collaborative tasks.
- Creating an integrated SMART educational environment.

3. Control Stage (Evaluation Phase)

At the final stage, the effectiveness of the intervention was assessed by comparing pre- and post-experimental results in both groups.

Instruments and Data Collection (Revised and Expanded)

To ensure the accuracy and methodological rigor of the study, a set of validated and reliable instruments was developed and applied to assess students' readiness to use SMART technologies.

Questionnaire Design and Measurement Scales. A structured questionnaire consisting of 10 items was developed to measure the motivational and cognitive components of readiness. The instrument employed a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), allowing for the quantification of students' attitudes, perceptions, and self-reported knowledge. The items were grouped into two subscales:

- Motivational (e.g., interest in SMART technologies, perceived relevance for professional development).
- Cognitive (e.g., understanding of SMART tools, ability to explain their application).

The activity-based component was assessed through performance-based diagnostic tasks, evaluated using an analytic rubric with three levels (low, average, high), based on predefined criteria such as task completion accuracy, independence, and appropriateness of tool use.

Observations and Interviews. Structured observation protocols were used to assess behavioral indicators of students' engagement and practical use of SMART technologies during classroom and independent activities. Semi-structured interviews were conducted to triangulate quantitative findings and clarify students' experiences, difficulties, and attitudes.

Validity Procedures

Several procedures were employed to ensure the validity of the instruments:

- Content validity was established through expert evaluation. Three independent experts in educational technology and pedagogy reviewed the questionnaire and diagnostic tasks for relevance, clarity, and alignment with the research objectives. Based on their feedback, ambiguous items were revised or eliminated.
- Construct validity was examined using exploratory factor analysis (EFA), which confirmed the two-factor structure of the questionnaire (motivational and cognitive components). Factor loadings exceeded 0.60, indicating satisfactory alignment between items and underlying constructs.
- Criterion-related validity was supported by correlating questionnaire results with performance-based task scores, demonstrating moderate to strong positive correlations ($r = 0.62-0.74$), confirming consistency between self-reported and observed competencies.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Reliability Analysis

The internal consistency of the questionnaire was assessed using Cronbach's alpha:

- Motivational subscale: $\alpha = 0.87$
- Cognitive subscale: $\alpha = 0.84$
- Overall scale: $\alpha = 0.89$

These values indicate a high level of reliability.

For the assessment of the activity-based component, inter-rater reliability was ensured by involving two independent evaluators. The level of agreement, calculated using Cohen's kappa, was $\kappa = 0.81$, indicating strong agreement.

A pilot study ($n = 30$) was conducted prior to the main experiment to test the clarity and reliability of the instruments. Minor revisions were made based on the pilot results.

Data Interpretation and Scaling

Based on the collected data, students' readiness levels were classified into three categories (low, average, high) using threshold values derived from normalized scores:

- Low level: 1.00–2.49
- Average level: 2.50–3.74
- High level: 3.75–5.00

This scaling approach ensured consistency across different measurement tools and enabled comparative analysis between groups.

Revised Validity and Reliability Statement

To enhance the robustness of the study, methodological triangulation was applied by combining quantitative (questionnaires, statistical analysis) and qualitative methods (observations, interviews). The use of validated instruments, standardized measurement scales, and reliability testing ensured the accuracy, consistency, and reproducibility of the findings.

Ethical Considerations

Participation in the study was voluntary. Students were informed about the purpose of the research, and confidentiality of responses was ensured. The study adhered to general ethical standards of educational research.

Methodological Contribution

Unlike many previous studies that focus primarily on descriptive analysis of SMART technologies, this research provides:

- A rigorous quasi-experimental design.
- Empirical validation of pedagogical conditions.
- A structured diagnostic framework for assessing readiness.
- Integration of quantitative and qualitative methods.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

This methodological approach enhances the reliability of findings and contributes to evidence-based implementation of SMART technologies in higher education.

Results and Discussion

The content and advantages of SMART technologies in the educational and professional activities of specialists.

A significant role in the conditions of global economic change is played by innovations aimed at qualitative change and the resolution of a range of issues related to the activation and introduction of innovations across all sectors of society. SMART technologies are currently the driving force behind economic growth, rapidly and purposefully implemented across all areas, taking into account global societal trends (Aguilera et al., 2025). We include in the concept of "SMART technologies" technologies designed for classes with students, using digital educational resources, a complex of interactive equipment, innovative teaching tools, and smart devices (gadgets, AI) in a digital environment, which ensures the interactivity of educational processes. SMART technologies in teaching help teachers organize students' active learning activities and create digital educational resources during and outside classes (Bautista, 2021).

The analysis of scientific literature showed that social services Instagram, Twitter, Facebook, Wiki website, Google services and tools, videos on the Internet and podcasts for distributing audio files, Youtube video hosting, blogs are SMART technologies that need to and can be used in higher education, pedagogical practice for the exchange of professional experience, professional development, communication, enrichment of the content of classes with new material, increasing students' motivation to study.

Thus, the SMART approach inspires innovations in education, a transformational approach to education, and societal development, and is an educational strategy (Yamao & Lescano, 2020).

Let us reveal the advantages of SMART technologies in the educational and professional activities of specialists. Modern SMART technologies make it possible for those thousands of kilometers away from a higher education institution to study. This was the first moving element that prompted the further development of modern SMART education worldwide, and the development of digital technologies made this possible more productively, more interestingly, and faster (Marutschke et al., 2019). SMART technologies in the educational sector significantly enhance the training of future specialists by enabling the activation of innovative learning processes through digital platforms and visualization tools that support error analysis and self-correction. They promote personalized learning by allowing students to access educational content flexibly in terms of time, pace, and learning needs.

In addition, multimedia and interactive tools facilitate the integration of disciplines and the practical application of knowledge in professional contexts. SMART education also redefines the teacher's role as a facilitator or navigator who guides students in accessing relevant information and applying modern educational approaches (Díaz-Parra et al., 2022).

Furthermore, the use of gamification increases student motivation, while adaptive learning environments support inclusivity and individualization. The expansion of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

digital resources, including electronic materials and video courses, enhances learning accessibility and continuity.

Overall, SMART technologies contribute not only to knowledge acquisition but to the creation of an innovative digital learning environment that fosters broad, interdisciplinary thinking rather than linear knowledge accumulation (Hernandez-de-Menendez et al., 2020).

The main components of SMART technologies and the role of research, virtual laboratories, and cloud SMART technologies in the training of future specialists – formation of an integrated intellectual virtual environment of higher education.

The main component of SMART technologies in the training of modern specialists is the use of SMART boards (interactive touch screens) connected to a media projector and a personal computer, as well as tablets (Aguayo et al., 2023).

Recently, higher education teachers have increasingly resorted to virtual laboratories. Therefore, the number of virtual classes or laboratories has increased significantly, we observe a small increase in the number of videos created for the educational process in higher education personally by teachers, which is associated with the capabilities and use of Skype, Zoom, Microsoft Teams, Google Meet, Intermedia AnyMeeting, GoToMeeting, Webex, RingCentral, etc. (Dominguez & Ochoa, 2017).

The main condition for using SMART technologies in higher education is the formation of a virtual, integrated intellectual environment that can be improved by all participants in the educational space and provided with appropriate educational content by both teachers and students. Such an innovative environment should evolve dynamically, taking into account progressive digital technologies in both communication and learning (Ferreira et al., 2025).

Recently, there has been an increase in interactive technologies associated with the use of various educational electronic resources. These are online boards that activate students' cognitive activity, provide a wide range of functionality for teachers and support their creativity, and contribute to the formation of digital, socially significant, professional competencies. An effective tool for improving the quality of education is deservedly considered to be game-based educational tools – gamification, which involves learning in the process of playing, when students use game rules to achieve real professional goals (Santana et al., 2022).

One of the first innovative such platforms was SMART amp – software, which appeared first and later became SMART Learning Suite Online. Today, it has been modernized into SMART Lumio – a cloud version of the software. Working with the tools and functionality of the SMART Notebook program is the basis of this technology, but in a cloud format. This significantly optimizes the use of a student's study time and simplifies teachers' work with an already familiar resource. Students can complete homework outside the educational institution at a time that is convenient for them, using any device. Students who cannot be in the classroom have the opportunity to complete tasks alongside those who are, under the teacher's guidance (Reyes et al., 2021).

SMART technologies are successfully integrated today into the two leading video conferencing platforms: Google Classroom (Google Meet) and Microsoft Teams.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Such integration allows them to expand their functionality further and provides the opportunity to work with technologies familiar to teachers (Ferreira et al., 2024).

Organization and methodology of the pedagogical experiment.

The continuation of theoretical research involved conducting a pedagogical experiment, which is the main means of verifying the reliability of the research results and assessing the practical significance and effectiveness of the developed pedagogically justified conditions and the proposed system for training future specialists to use SMART technologies in professional activities.

The main goal of the experimental work is to verify the effectiveness of implementing pedagogical conditions and the system for training future specialists to use SMART technologies in professional activities.

The respondents' level of readiness to use SMART technologies was assessed. According to the results of the questionnaire at the experiment's ascertaining stage, we observe a low level of cognitive interest in the phenomenon outlined among the majority of EG and CG respondents. Pedagogical conditions were outlined, and an innovative training system for future specialists in the use of SMART technologies in professional activities was developed. It was decided to create an educational SMART environment that would enable students to work with SMART technologies. At the ascertaining stage of the experiment, a questionnaire was administered to the same students, comprising 10 questions that reflected the indicators of the level of formation of the problem outlined.

The results of the study showed the following:

Diagnostics of EG and CG students showed that:

- 56.1% of students have a low level of readiness to use SMART technologies in professional activities.
- 22.5% of students have an average level of readiness to use SMART technologies in professional activities.
- 21.4% of students have a high level of readiness to use SMART technologies in professional activities.

Table 1.

Levels of students' readiness to use SMART technologies in professional activities (ascertaining stage)

Level of readiness	Percentage (%)
Low	56.1
Average	22.5
High	21.4

In the process of ascertaining the experiment, only 11.2% of respondents indicated that they are considering the possibility of using SMART technologies in classes in professional disciplines; 9% of respondents indicated that they independently perform exercises created using SMART technologies; 61% of respondents indicated that they want to master SMART technologies in classes in higher education. Students noted that while performing tasks, they encountered difficulties created by the use of SMART technologies.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

At the formative stage of the study, an experimental verification of pedagogical conditions and the training system for future specialists to use SMART technologies in professional activities was conducted.

Taking into account the results of the experiment's ascertaining stage, a program to prepare future teachers of philological specialties to use SMART technologies was developed.

In order to work successfully in the field of SMART-technologies, we developed an innovative SMART -complex of e-learning systems for EG students, which included:

- Educational content.
- Learning management system (LMS).
- Authoring tools.

SMART-education itself serves to use information combined with technologies that can be integrated into each other, namely mobile learning (m-learning), a combination of electronic educational process technologies (e-learning), flipped learning (f-learning), and ubiquitous learning (u-learning), which, based on a mixed model, fit into the traditional learning system (blended learning).

To introduce SMART learning in EG, we implemented SMART education paradigms to develop competencies, knowledge, and skills for interaction with the technical, social, and economic environment, grounded in pedagogical, organizational, and technological components.

When creating a space for SMART education of EG students, the main task was the resourceful use of SMART education, the formation of a higher-level personality – SMART person, the transformation of new knowledge, students' mastery of digital technologies, the ability to adapt to the external environment, innovative means of communication, skills in analyzing and generating information, the use of platforms, services, portals of the global Internet network and the formation of an integrated intellectual virtual environment where EG students were engaged.

In EG, training took place through the use of methodological techniques that, in our opinion, are the most effective in the process of preparing future specialists for the application of SMART technologies in professional activities, namely: the project method, storytelling, gamification, role-playing games, analysis of video situations, the method of independent creative activity, educational discussions, and the research method.

In the context of our study, the group of methods for organizing and implementing educational activities in the EG of students includes such methodological techniques and methods as: educational discussions, analysis of video situations, research method, method of independent creative activity, which are implemented using SMART -technology tools, such as: blogs, programs for conducting webinars, Facebook, YouTube, Word it out, Twitter, Instagram, SMART -textbook, LinguaLab, Kahoot, WiseMapping, Lyricstraining.

The group of methods for motivating and stimulating educational activities includes methodological techniques proposed by the EG, such as storytelling, role-playing games, and gamification, which can be implemented using Quizlet, Kahoot, Instagram, Lyricstraining, YouTube, Facebook, Twitter, and Learning Apps.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The group of methods for controlling and self-control includes the Method of Projects for the effective implementation of educational activities, and we offer SMART technology tools, such as Kahoot, ThingLink, and Learning Apps, to support their implementation.

In preparing EG students to use SMART technologies, we have chosen the following forms of instruction: training, lectures, research, practical classes, independent work, educational practice, group work, meetings with specialists, and individual consultations.

Implementing the developed pedagogical conditions in EG involves determining the requirements for students' knowledge, skills, and abilities.

Studies have shown that:

- 90% of students consider the Kahoot platform effective and useful for testing knowledge.
- 10% of students reported that it takes too long to complete tests on Kahoot.

Another effective tool for SMART materials is the use of Learning Apps to develop interactive electronic educational materials.

EG users who use Learning Apps to create electronic educational materials 100 percent agree that all users can use its materials free of charge and without indicating a link to the author, which is important during experimental research, for the development of interactive tasks in various subject disciplines, their storage, with the help of which you can check, train, consolidate knowledge in a game form in classes, during individual activities and the organization of independent work, in joint project and research activities.

Traditional methods of conducting classes were used in the CG.

Analysis of the results of the pedagogical experiment.

Using MS Excel and SPSS (Statistical Package for the Social Sciences), statistical calculations were performed during the formative stage. Statistical processing of empirical data was enabled by the use of the SPSS software package during experimental work, including creating and modifying databases, generating reports, and performing basic analyses, providing a wide range of options for presenting results in graphical, text, and tabular forms.

At the beginning of the formative stage of the experimental study, the correctness of the sample homogeneity of the CG (86 respondents) and the EG (88 respondents) was checked based on a statistical analysis of student results using the unpaired parametric Student's t-test, in order to compare the average score in two independent groups. The null hypothesis H_0 is that the EG and CG are homogeneous at the 5% significance level ($p < 0.05$).

We adhered to the following conditions for using the unpaired Student's t-test:

- The presence of no more than two (CG and EG) samples.
- The data were continuous (quantitative).
- Samples of EG and CG are independent.
- Equality of variances of the mean score (of the studied variable) in CG and EG.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Normal distribution of the mean score (of the studied trait).

We conclude that for CG, the standard error of deviation (Std. Error Mean) is 0.60; the standard deviation (Std. Deviation) is 0.657; and the mean score (Mean) is 3.95. We conclude that for EG, the standard error of deviation (Std. Error Mean) is 0.59; the standard deviation (Std. Deviation) is 0.637; and the mean score (Mean) is 3.74. The level of statistical significance is $0.06 > 0.05$ for the Livin criterion (Sig).

Statistical calculations using the parametric Student's t-test indicated that the CG and the EG belong to the same general population (homogeneous) at the 5% significance level.

At the beginning of the formative stage of the experiment, a comparison of the survey results showed that the CG and EG students had insufficiently formed educational and cognitive motives (8% and 9%), there were practically no motives for creative self-realization of students – the respondents did not show interest in the use of SMART technologies (5% and 4%). Motives for implementing SMART technologies in future professional activities were not formed (10% and 11%).

At the end of the formative stage of the experiment, the survey results showed that among EG students who had been working with SMART technologies for a long time, professional motives came to the fore – 44%, educational and cognitive motives – 38%, and motives for creative self-realization – 29%.

In CG students, the motives for using SMART technologies at the beginning and end of the formative stage remained practically unchanged.

At the end of the formative stage of the experiment, the reliability of the results was assessed by comparing two dependent samples using the paired Student's t-test.

The statement for H_0 was accepted that the discrepancy at the beginning and end of the formative stage between the average results of the CG and EG of the experiment, that is, the influence of the independent variable is random, and H_1 – an alternative hypothesis that this discrepancy is caused by the implementation of the developed pedagogical conditions and the system of training future specialists for the use of SMART technologies in professional activities.

Using the SPSS 16.0 program (for analysis of results), the standard deviation of the difference in values ("Std. Deviation") of the analyzed variables and the arithmetic mean ("Mean"), the number of degrees of freedom ("df"), the value of the paired Student's t-test and the level ("Sig. (2-tailed) of statistical significance p for the CG and for the EG before and after the experiment were calculated.

Since for the EG Sig = 0.000 according to the results of the Student's t-test, which is significantly less than 0.05, we reject the null hypothesis H_0 and accept the alternative hypothesis H_1 , which is that with a confidence level of 95%, the differences in the average values of the GPA of EG students are not random, which is caused by the implementation of the developed pedagogical conditions and the system of training future specialists for the use of SMART technologies in professional activities.

In Table 2 and Fig. 1, we present the general level of readiness of future specialists to use SMART technologies in professional activities across motivational, cognitive, and reflective components.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 2.

General level of readiness of future specialists to use SMART technologies in professional activities

	Readiness levels					
	High		Average		Low	
	EG	CG	EG	CG	EG	CG
At the beginning of the experiment	21,5%	21,3%	22,5%	22,5%	56,0%	56,2%
At the end of the experiment	51,3%	22,0%	42,5%	43,7%	6,2%	34,3%

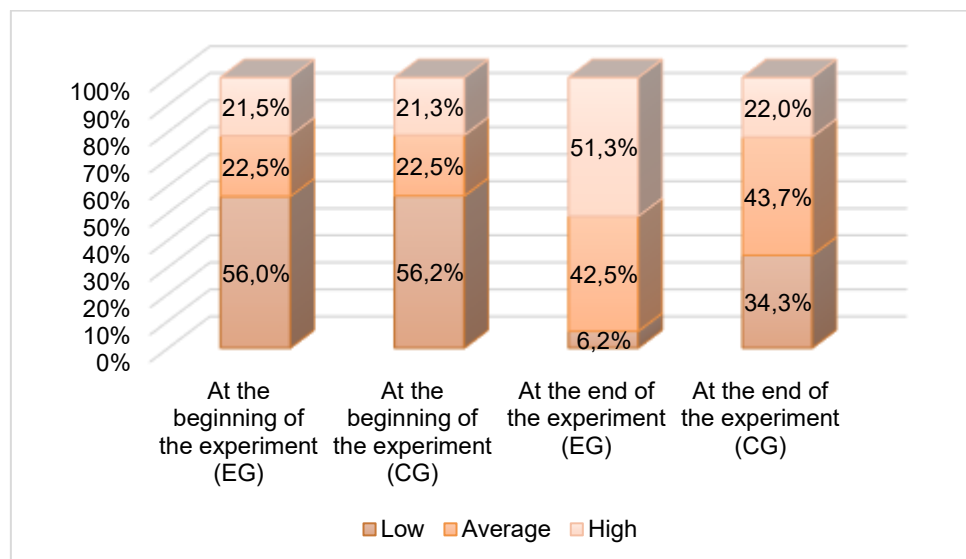


Figure 1. General level of readiness of future specialists to use SMART technologies in professional activities.

Analysis of the experimental study results shows that by the end of the study, the readiness indicators of future specialists to use SMART technologies in professional activities in the EG increased significantly.

In particular, the proportion of students with a low level has significantly decreased in the EG, while the proportion with an average level has increased. The number of students with a high level of readiness has increased significantly, whereas in the CG, the indicators have improved only slightly.

The results show that the developed and proposed pedagogical conditions and system of training future specialists for the use of SMART technologies in professional activities implemented in the EG stimulate the restructuring of the structure of motives of students' professional and educational activities, which contributes to the mastery of practical skills and theoretical knowledge through the use of SMART technologies in the educational process, provides self-determination, the development of self-analysis and reflection skills.

At the generalization stage, experimental data were systematized and interpreted using statistical methods; the materials of the experimental work were theoretically generalized and substantiated; conclusions and prospects for further research were drawn up.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The results of the present study demonstrate a statistically significant improvement in the readiness of future specialists to use SMART technologies in professional activities within the experimental group. While these findings generally align with prior research emphasizing the positive impact of digital and SMART environments on learning outcomes, a deeper critical analysis reveals several important nuances that both support and problematize existing assumptions.

The obtained results confirm the conclusions of Gao et al. (2020) and Costley & Lange (2017), who argue that interactive and well-designed digital environments enhance cognitive performance and learning efficiency. However, unlike these studies, which tend to treat technology as a primary driver of improvement, the present findings indicate that pedagogical structuring plays a more decisive role than the technology itself. The significant increase in readiness levels was not merely a result of exposure to SMART tools, but rather of their systematic integration within a pedagogically grounded framework. This suggests that prior research may overestimate the autonomous effect of technology, underestimating the importance of instructional design.

While Zawacki-Richter et al. (2019) highlight the transformative potential of intelligent technologies such as artificial intelligence, their conclusions are largely based on macro-level analyses of technological trends. In contrast, the current study provides micro-level empirical evidence showing that students initially demonstrate low readiness (56.1%) despite the availability of digital tools. This discrepancy points to a critical gap between technological potential and actual educational outcomes, indicating that accessibility does not equate to effective use. Thus, the findings challenge the implicit technological determinism present in part of the literature.

The results extend the work of Marutschke et al. (2019) and Reyes et al. (2021), who emphasize collaboration and project-based learning as key features of SMART environments. While their studies conceptually advocate for these approaches, they provide limited empirical validation. The present study not only supports their claims but also demonstrates that collaborative and interactive strategies are effective only when aligned with clearly defined pedagogical conditions, including motivation enhancement, structured guidance, and reflective practice. Without these conditions, the impact of such approaches may remain superficial.

At the same time, the findings partially contradict studies that assume rapid and universal adoption of SMART technologies by students. The low baseline readiness identified in this study supports the position of Shernof et al. (2017), who argue that both students and educators require targeted support for effective technology integration. This highlights an often-overlooked issue in the literature: the readiness gap, which acts as a mediating factor between technological innovation and educational effectiveness.

Another important insight concerns the multidimensional nature of readiness. While Belbase et al. (2021) focus primarily on interdisciplinary and methodological integration in STEM/STEAM education, their framework does not explicitly address the internal structure of readiness. The present study contributes to this discussion by empirically demonstrating that motivational, cognitive, and activity-based components develop unevenly and require differentiated pedagogical interventions. In particular, the rapid growth of motivational indicators compared to slower development of practical skills suggests that engagement alone is insufficient for ensuring competence.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Moreover, the findings reveal a potential limitation of SMART-based learning environments that is rarely discussed in previous studies. While most research highlights increased motivation and engagement, the current results suggest that initial exposure to SMART technologies may generate cognitive overload or resistance, especially among students with low prior experience. This implies that the effectiveness of SMART environments may be non-linear and dependent on gradual adaptation, a factor that is largely absent in existing models.

From a broader perspective, the study challenges the prevailing fragmentation in the literature, where technologies, pedagogical strategies, and learning outcomes are often examined in isolation. The results demonstrate that the effectiveness of SMART technologies emerges only within an integrated system that combines technological tools with pedagogical conditions and structured learning processes. This systemic interaction appears to be the key mechanism underlying the observed improvements.

However, despite these contributions, the findings should be interpreted with caution. The quasi-experimental design, while robust, does not fully eliminate the influence of external variables such as individual differences in digital literacy or instructor competence. Additionally, the relatively short duration of the intervention limits the ability to assess long-term effects, particularly regarding the sustainability of the acquired competencies.

In this context, the study not only confirms but also critically reinterprets existing research by demonstrating that:

- SMART technologies are not inherently effective without pedagogical mediation.
- Readiness is a prerequisite rather than a byproduct of technology use.
- And educational outcomes depend on the alignment between technological, pedagogical, and motivational factors.

Thus, the findings contribute to a more nuanced understanding of SMART education, shifting the focus from technological innovation to pedagogically grounded and empirically validated systems of professional training.

Conclusions

This study provides empirical evidence on the effectiveness of a pedagogically grounded system for developing future specialists' readiness to use SMART technologies in professional activities. The findings confirm that the integration of SMART technologies alone does not ensure educational effectiveness; rather, their impact depends on the systematic implementation of pedagogical conditions that structure students' learning experiences.

The results of the quasi-experimental study demonstrate statistically significant improvements in the experimental group across motivational, cognitive, and activity-based components of readiness. In particular, the proportion of students with a high level of readiness increased substantially, while the share of those with a low level decreased. These findings validate the effectiveness of the proposed SMART-oriented educational environment and confirm the importance of combining interactive tools, cloud technologies, virtual laboratories, and student-centered instructional strategies.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

From a theoretical perspective, the study contributes to the advancement of SMART education research by addressing the fragmentation observed in existing literature. It proposes and empirically supports a multidimensional conceptualization of readiness as an integrative construct that includes motivational, cognitive, and activity-based components. Furthermore, the study demonstrates that the effectiveness of SMART technologies should be understood within a systemic framework that integrates technological, pedagogical, and organizational dimensions, thereby moving beyond technology-centered approaches.

At the methodological level, the research contributes by applying a mixed-methods quasi-experimental design, validated measurement instruments, and statistical analysis to assess changes in students' readiness. This approach strengthens the evidence base for the pedagogical integration of SMART technologies and provides a replicable model for future studies.

From a practical standpoint, the findings offer actionable insights for higher education institutions. The proposed pedagogical conditions – enhancing motivation, developing digital competencies through interactive tasks, and creating an integrated SMART learning environment – can be effectively implemented to improve the quality of professional training and align educational outcomes with labor market demands.

However, several limitations should be acknowledged. The study was conducted within a specific institutional and disciplinary context, which may limit the generalizability of the findings. Additionally, the duration of the intervention was relatively limited, restricting the ability to assess long-term effects and sustainability of the acquired competencies. The reliance on a quasi-experimental design also implies potential influence of uncontrolled external variables.

Future research should focus on expanding the sample across diverse educational contexts and disciplines, as well as conducting longitudinal studies to evaluate the long-term impact of SMART-oriented learning environments. Further investigation is also needed to explore the role of emerging technologies, such as artificial intelligence and learning analytics, in enhancing adaptive and personalized learning. In addition, more attention should be given to the interaction between student readiness and teacher competencies as a critical factor in the effective implementation of SMART technologies.

In conclusion, the study substantiates that the effectiveness of SMART technologies in higher education is not determined by technological innovation alone, but by their integration into a coherent pedagogical system. This finding has important implications for both theory and practice, emphasizing the need for a shift from technology-driven to pedagogy-driven models of digital transformation in education.

Bibliographic references

- Aguayo, C., Videla, R., López-Cortés, F., Rossel, S., & Ibacache, C. (2023). Ethical enactivism for smart and inclusive STEAM learning design. *Heliyon*, 9(9), e19205. <https://doi.org/10.1016/j.heliyon.2023.e19205>
- Aguilera, R. C., Mosqueda, M. A. A., Mosqueda, M. E. A., & Beltran, S. V. (2025). Artificial intelligence, Internet of Things, and blockchain in education: Towards personalized, inclusive, and sustainable learning with social impact. *Fractals*, 33(01), 1–11. <https://doi.org/10.1142/S0218348X25500100>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Bautista, A. (2021). STEAM education: Contributing evidence of validity and effectiveness. *Journal for the Study of Education and Development*, 44(4), 755–768. <https://doi.org/10.1080/02103702.2021.1926678>
- Belbase, S., Mainali, B. R., Kasemsukpipat, W., Tairab, H., Gochoo, M., & Jarrah, A. (2021). At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: Prospects, priorities, processes, and problems. *International Journal of Mathematical Education in Science and Technology*, 53(11), 2919–2955. <https://doi.org/10.1080/0020739X.2021.1922943>
- Budhrani, K., Ji, Y., & Lim, J. H. (2018). Unpacking conceptual elements of smart learning in the Korean scholarly discourse. *Smart Learning Environments*, 5, 23. <https://doi.org/10.1186/s40561-018-0069-7>
- Costley, J., & Lange, C. (2017). The mediating effects of germane cognitive load on the relationship between instructional design and students' future behavioral intention. *The Electronic Journal of e-Learning*, 15(2), 174–187. <https://eric.ed.gov/?id=EJ1141882>
- Díaz-Parra, O., Fuentes-Penna, A., Barrera-Cámara, R. A., Trejo-Macotela, F. R., Ramos Fernández, J. C., Ruiz Vanoye, J. A., Zezzatti, A. O., & Rodríguez Flores, J. (2022). Smart education and future trends. *International Journal of Combinatorial Optimization Problems and Informatics*, 13(1), 65–74. <https://ijcopi.org/ojs/article/view/294>
- Domínguez, F., & Ochoa, X. (2017). Smart objects in education: An early survey to assess opportunities and challenges. In *2017 Fourth International Conference on eDemocracy & eGovernment (ICEDEG)* (pp. 216–220). IEEE. <https://doi.org/10.1109/ICEDEG.2017.7962537>
- Ferreira, A., Lima, D. A., Oliveira, W., Bittencourt, I. I., Dermeval, D., Reimers, F., & Isotani, S. (2025). Exploring Brazilian teachers' perceptions and a priori needs to design smart classrooms. *International Journal of Artificial Intelligence in Education*, 35, 914–965. <https://doi.org/10.1007/s40593-024-00410-4>
- Ferreira, A., Oliveira, W., De Amorim Silva, R., Hamari, J., & Isotani, S. (2024). Internet of Things for smart education: A systematic literature review. In *2024 IEEE International Conference on Advanced Learning Technologies (ICALT)* (pp. 179–181). IEEE. <https://doi.org/10.1109/ICALT61570.2024.00058>
- Gao, X., Li, P., Shen, J., & Sun, H. (2020). Reviewing assessment of student learning in interdisciplinary STEM education. *International Journal of STEM Education*, 7(1), 24. <https://doi.org/10.1186/s40594-020-00225-4>
- Hernandez-de-Menendez, M., Escobar Díaz, C. A., & Morales-Menendez, R. (2020). Engineering education for smart 4.0 technology: A review. *International Journal of Interactive Design and Manufacturing*, 14, 789–803. <https://doi.org/10.1007/s12008-020-00672-x>
- Marutschke, D. M., Kryssanov, V., Chaminda, H. T., & Brockmann, P. (2019). Smart education in an interconnected world: Virtual, collaborative, project-based courses to teach global software engineering. In V. Uskov, R. Howlett, & L. Jain (Eds.), *Smart Education and e-Learning 2019* (Smart Innovation, Systems and Technologies, Vol. 144, pp. 33–52). Springer. https://doi.org/10.1007/978-981-13-8260-4_4
- Reyes, V., McLay, K., Thomasse, L., Olave-Encina, K., Karimi, A., Rahman, M. T., Seneviratne, L., & Tran, T. L. N. (2021). Enacting smart pedagogy in higher education contexts: Sensemaking through collaborative biography. *Technology, Knowledge and Learning*, 26, 1153–1168. <https://doi.org/10.1007/s10758-021-09495-5>
- Santana, R., Rodríguez, A., Rybarczyk, Y., Méndez, G. G., Vera, F., & Rossi, G. (2022). A study on user experience of smart glasses for higher education students. In *2022 17th Iberian Conference on Information Systems and*

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Technologies (C/ISTI)* (pp. 179–181). IEEE.
<https://doi.org/10.23919/CISTI54924.2022.9820326>
- Shernof, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education. *International Journal of STEM Education*, 4(1), 1–16. <https://doi.org/10.1186/s40594-017-0068-1>
- Țălu, Ș. (2020). New perspectives in the implementation of smart technologies in higher education. *Advances in Economics, Business and Management Research*, 138, 253–257. <https://doi.org/10.2991/aebmr.k.200502.042>
- Yamao, E., & Lescano, N. L. (2020). Smart Campus as a learning platform for Industry 4.0 and IoT ready students in higher education. In *Proceedings of the 2020 IEEE International Symposium on Accreditation of Engineering and Computing Education (ICACIT)* (pp. 1–4). IEEE.
<https://doi.org/10.1109/ICACIT50253.2020.9277679>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education: Where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 39. <https://doi.org/10.1186/s41239-019-0171-0>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Fomentar una identidad investigadora en la formación de futuros docentes en el Reino Unido

Fostering the researcher identity in UK student teacher education

Olena Bartosh¹ Oleksandra Kanyuk² Daryna Stanko³ Dana Danko⁴ Iryna Kozubovska⁵

Afiliación autor:

¹ Candidate of Pedagogical Sciences, Professor, Department of Sociology and Social Work, Uzhhorod National University, Uzhhorod, Ukraine.

olena.bartosh@uzhnu.edu.ua

² Candidate of Pedagogical Sciences, Associate Professor, Department of Foreign Languages, Uzhhorod National University, Uzhhorod, Ukraine.

oleksandra.kanyuk@uzhnu.edu.ua

³ Doctor of Philological Sciences, Associate Professor, Department of English Philology, Uzhhorod National University, Uzhhorod, Ukraine.

⁴ Doctor of Psychological Sciences, Associate Professor, Department of Social Medicine and Hygiene, Uzhhorod National University, Uzhhorod, Ukraine.

dana.danko@uzhnu.edu.ua

⁵ Doctor of Pedagogical Sciences, Professor, Department of General Pedagogy and Pedagogy of Higher School, Uzhhorod National University, Uzhhorod, Ukraine.

kozub@hotmail.com

Recibido: 05/04/26

Aceptado: 30/05/26

Cómo citar:

Bartosh, O., Kanyuk, O., Stanko, D., Danko, D., & Kozubovska, I. (2026). Fostering the researcher identity in UK student teacher education. *Revista Eduweb*, 20(2), 176-188.

<https://doi.org/10.46502/issn.1856-7576/2026.20.02.11>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Resumen

Este artículo explora el desarrollo de la identidad del investigador en el contexto de la formación docente en el Reino Unido. En respuesta a las cambiantes exigencias del panorama educativo actual, el estudio analiza cómo la cultura investigadora del futuro docente se transforma de una habilidad opcional a una necesidad profesional fundamental. Un elemento central es el nexo investigación/docencia, que fomenta la transición de los métodos de instrucción tradicionales a un paradigma de desarrollo orientado a la investigación. Basándose en el modelo académico británico, el artículo examina la integración de competencias gnósticas, diagnósticas y reflexivas en los planes de estudio. Los hallazgos subrayan que fomentar la identidad del futuro docente investigador es un proceso multifacético que involucra componentes motivacionales-axiológicos, evaluativos-resultativos, procedimentales y prácticos. Elementos clave, como el uso de diarios reflexivos y módulos basados en la indagación, se identifican como fundamentales para desarrollar la autonomía del estudiante y la independencia metacognitiva. El fomento de las competencias de investigación en los planes de estudio de formación docente se define por la flexibilidad cognitiva y la generatividad. La flexibilidad cognitiva implica la adaptación didáctica de los planes de estudio para alinear las actividades de aprendizaje con los perfiles cognitivos de los estudiantes. Por su parte, la generatividad cognitiva refleja el potencial del plan de estudios para cultivar un intelecto creativo, fundamentado en marcos cognitivos basados en la indagación. El estudio concluye que, al priorizar la práctica basada, el modelo británico proporciona un marco para transformar a los futuros docentes de receptores pasivos de conocimiento en profesionales autónomos, creativos y resilientes.

Palabras clave: investigación pedagógica, formación del profesorado, profesor-investigador, cultura de la investigación, I+D.

Abstract

This article explores the development of a researcher's identity within the context of student teacher education in the UK. In response to the shifting demands of the modern educational landscape, the study analyzes how a future teacher's research culture transforms from an optional skill into a core professional necessity. Central to this is the "research/teaching nexus," which fosters a transition from traditional instructional methods to a research-oriented developmental paradigm. Drawing on the British academic model, the paper examines the integration of gnostic, diagnostic, and reflective competencies within curricula. The findings underscore that fostering a future teacher researcher identity is a multifaceted process involving motivational-axiological, evaluative-resultative, procedural, and practical components. Key elements, such as the use of reflective diaries and inquiry-led modules, are identified as critical for developing learner autonomy and metacognitive independence.

Fostering research competencies within teacher education curricula is defined by cognitive flexibility and generativity. Cognitive flexibility entails the didactic adaptation of curricula to align learning activities with students' cognitive profiles. Meanwhile, cognitive generativity reflects the curriculum's potential to cultivate a creative intellect, grounded in inquiry-based cognitive frameworks. The study concludes that by prioritizing research-based practice, the British model provides a framework for transforming student teachers from passive recipients of knowledge into autonomous, creative, and resilient practitioners.

Keywords: pedagogical research, teacher education, teacher-researcher, research culture, R&D.

Introduction

Nowadays, politics, economics, and education are undergoing major changes. Education in this context deserves much attention, as the implementation of progressive shifts in politics or economics is unattainable without highly educated and qualified specialists. Modern society requires educators who demonstrate not only a high level of professional training but also a research culture – readiness to conduct research within pedagogical practice, scientific independence, the ability to systematically analyze school-based educational processes, creativity in identifying and forecasting pedagogical phenomena, productive thinking skills, efficient information processing, and a high standard of communication and ethical behavior. Several factors define the necessity for a research approach (R&D) applied to pedagogical activity:

- Socio-economic changes reshape the function of the education system. The modern educational paradigm focuses on teachers who bring creativity and unconventional thinking to the classroom. R&D serves as a primary mechanism for updating educational practices.
- The humanization and humanitarianization of education direct the teacher's efforts toward adapting the learning process to the students' individual needs and facilitating their self-disclosure.
- The emergence of new types of educational institutions demands a continuous search for non-traditional organizational forms and the integration of innovative technologies. In this context, the role of pedagogical research significantly intensifies.
- A shift in how teachers perceive and apply pedagogical innovations ensures their active involvement in purposeful professional development.

The main objective of this study is to identify the specific features and mechanisms of research skills formation among student teachers in the UK, with a focus on fostering a professional “researcher identity” within the initial teacher training system.

Literature Review

Effective teaching is built on the principle that teachers should study their own work. The process of planning, acting, and reflecting is a spiral that leads to higher levels of expertise (la Velle, 2024).

Currently, one of the leading global trends in higher education is the integration of a research component into the training of future specialists, commonly referred to as the research/teaching nexus (Bartosh et al., 2023). The implementation of this research component within university curricula varies across higher education

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

institutions. Specifically, it may be integrated directly into subject-specific courses or facilitated through dedicated courses on research methodology (Bartosh, 2023).

Scholars Clark and Hordosy (2019), Joseph-Richard, & Jessop (2020), Perron et al. (2020) advocate for a consistent and holistic approach to developing students' research skills. It should be emphasized that in numerous international research universities, such an approach is considered an imperative.

Therefore, the objectives and content of teacher education (TE) are currently being revised. This primarily concerns the cultivation of a student's creative potential and the fostering of a need for self-actualization and self-expression, not only during the training period in the higher education institution, but throughout the entire lifespan. The educational process is being reoriented from a purely instructional to a developmental paradigm, resulting in a model that meets the following criteria: professional mobility, adaptability to the information environment, high intellectual capacity, professional expertise, creative abilities, critical thinking, autonomy, initiative, and a commitment to self-improvement.

The issue of scientific research and the transition of TE toward a research-oriented approach is highly relevant across Europe.

Belgium has focused on structural funding, moving from a purely vocational training model to evidence-based teaching, enabling pedagogical departments to compete with other scientific fields for prestige and resources (Organisation for Economic Co-operation and Development, 2024).

In Denmark, this trend is illustrated by the establishment of research-focused universities, which actively link academic research with societal needs, facilitating high-level research cooperation and strategic synergies with global academic partners (University of Southern Denmark, 2026; Danish School of Education, 2026).

In Finland, TE has been university-based for decades and has a strong research-based approach, prioritizing research methodology to equip future teachers with the skills to independently analyze their own practice (Chung, 2023).

Ireland demonstrates its path with specific scholarship programs for school educators engaged in research. The Irish National Teachers' Organisation (2026) and the Teaching Council of Ireland (2026) offer grants to support teachers who implement educational research projects during their ongoing professional learning and integrate academic research into their classrooms to enhance student learning. Research should align with national priorities. Thus, it strengthens the links between research, policy, and practice.

TE in Portugal is designed to move beyond simple pedagogical training to develop "reflective practitioners" (Ferreira, & Cravino, 2022).

Spain has elevated scientific research to a mandatory requirement within a teacher's professional activities. This shift is primarily driven by national legislation and strict accreditation systems that link career progression directly to research output. Boletín oficial del estado legislación consolidada (2023) mandates that universities must foster an environment where teaching is constantly updated through active research. Every six years, teachers submit their best five research outputs to the National Commission for the Evaluation of Research Activity. A positive evaluation

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

results in a permanent salary increase. Thus, Spain has transitioned to a model where the “teacher-researcher” profile is legally and financially reinforced, ensuring that higher education is strictly tied to the production of new scientific knowledge.

Sweden focuses on developing educational institutions for training in education, science, and educational technology, alongside significant investments in educational research. The Swedish Institute for Educational Research (2026) specifically funds research aimed at improving classroom practices, prioritizing projects in which teachers are active participants and ensuring that findings are directly applicable to schools.

Overall, there is a notable increase across Europe in the number of teachers who pursue further education and conduct scientific research. The Organisation for Economic Co-operation and Development’s international survey (2024) reports that, in Europe, the “teaching researcher” model is currently at the center of several systemic controversies regarding workload and professional identity:

- The “publish or perish” paradox. There is a sharp tension between research-driven career metrics and teaching duties. Since promotions and funding are largely tied to publication output, researchers often view teaching as a hinder to their professional advancement.
- Invisible labor. Official contracts only account for “contact hours” in the classroom. This ignores the massive amount of time required for curriculum design, grading, and student pastoral care, leading to chronic overwork and burnout.
- Precarious contracts. Researchers often combine teaching loads on short-term contracts. This instability forces them to conduct research during unpaid personal time to remain competitive for permanent positions.
- The controversial “teaching-only” track. It is intended to reduce research pressure, often leading to the stigmatized “second-class” role, creating a hierarchy that devalues pedagogical expertise compared to scientific discovery.

According to Loughran et al. (2016), TE is a developmental process designed to produce insightful, well-informed, and highly skilled professionals.

Consequently, it is essential to examine how TE evolves to meet the demands of modern classrooms, which are increasingly influenced by technological transformations, global integration, and shifting populations (Townsend, 2011).

Methodology

The following research methods have been applied: (i) Theoretical – a secondary analysis of academic literature was conducted to synthesize existing data. This approach incorporates international academic sources to ensure global relevance. It was conducted in distinct phases. During the initial identification phase, search queries were formulated using keywords such as “R&D in teacher education,” “research-based learning,” and “higher education teacher training” across peer-reviewed academic sources published within the last 10 years, ensuring a focus on contemporary global trends. In the synthesis phase, the selected materials were categorized and evaluated based on their relevance to both theoretical frameworks and practical applications in student-teacher training. (ii) Comparative – to identify the significance of R&D for both the theoretical and practical training of student teachers within higher education institutions.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

British pedagogical practices were examined as part of the UK–Ukraine University Twinning Scheme “Strengthening democracy through work with various social groups: the military and veterans, community representatives, and national communities” in cooperation between Uzhhorod National University and the University of Lancashire (2022–2026).

Results and Discussion

Integrating research skills into TE is central to the British academic model. Unlike general educational research, pedagogical inquiry involves teachers as active participants in the research process (Elliott, 2001). Consequently, the cultivation of research competencies is a fundamental element in the professional development of a teacher-researcher. In this context, skills are defined as a teacher's readiness to perform practical and theoretical tasks with precision and conscious intent, drawing upon both academic knowledge and experience.

Drawing on a synthesis of existing classifications by British scholars and the UK Department of Education (2024a), we categorize the skills for a teacher-researcher into several key groups:

- *Gnostic skills* – the intellectual perception and conceptualization of information, as well as cognitive activities employed in research, such as comparison, analysis, synthesis, abstraction, generalization, and hypothesis formulation.
- *Information research skills* – the ability to work with diverse information sources and to represent ideas and findings concretely through visual aids such as models, diagrams, and graphs.
- *Constructive-design skills* – effective planning in educational research, the construction of research models, self-analysis, self-monitoring, and the regulation of actions during the problem-solving process.
- *Diagnostic skills* – practical application of research methods aimed at studying the individual characteristics of students, their achievements, and difficulties experienced. These skills include conducting pedagogical experiments, observing and evaluating facts and events, and processing empirical data obtained through various research techniques.
- *Communicative skills* – the ability to conduct collaborative research, demonstrate assistance and peer review, and present the results of individual and collective research publicly in a professional, reasoned manner consistent with scientific ethics.
- *Prognostic skills* – the ability to predict the outcomes of scientific research as a whole and its individual stages, as well as to identify potential complications during the research.
- *Reflective skills* – the ability for self-knowledge, self-assessment of professional activity and behavior, and self-actualization.

Significant attention is paid to the development of research skills in student teachers during the development of curricula, which, in British education, are characterized by cognitive flexibility and generativity (Murray et al., 2009). The cognitive flexibility of a curriculum refers to its capacity for the cognitive adjustment of both individual and collective work, specifically, the didactic focusing of content and teaching methods on the cognitive characteristics of learning activity. Cognitive generativity refers to the curriculum's ability to foster a mindset that creatively employs research-based, constructivist, and hermeneutic forms of human cognition.

Besides, in the British education system, specific strategies for developing research

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

skills in student teachers have been elaborated (Department of Education, 2024a; Department of Education, 2024b; Healey & Jenkins, 2009). These strategies represent a stable complex of actions purposefully organized by an educator to solve various types of research tasks embedded in lecture content, independent study assignments, and assessment materials. These strategies define the content, methods, and technologies of research activity, characterizing the executive activity of future teacher-researchers: methods of data processing, evaluation, and reflection. The foundation for determining the content and technologies of R&D within each strategy is the leading research method employed. The algorithmic strategy aims to master the research technologies and the methods for empirical data processing. The primary teaching methods used are the partially exploratory method and problem-based instruction. Through these methods, skills in information processing, the establishment of interdisciplinary links, and the application of research methods from related sciences are developed. The creative strategy orients teachers toward reflecting on their research experience to solve new research problems and transfer known solution methods to unfamiliar areas. This strategy is represented by case studies (descriptions and analyses of real pedagogical situations), analytical reporting, peer and self-review, expert activity, and abstract writing.

Byrne and Butcher (2020) claim that the development of research skills takes place during the theoretical and practical training of student teachers. As a result, a student teacher develops the readiness to perform R&D that encompasses motivational-axiological, evaluative-resultative, procedural, and practical components.

- *The motivational-axiological component.* It characterizes an individual's attitude toward R&D, specifically: the level of development of research interest, the desire and aspiration to demonstrate initiative and autonomy in solving research tasks, and the awareness of the need to engage in R&D. Students become motivated to conduct research when their personal interest and external goals work together. In this context, an orientation toward the process and methods of R&D serves as an indicator of internal cognitive motives. This orientation manifests in an interest in active research, the search for methods of its implementation, the pursuit of rational ways to solve research tasks, and a commitment to self-improvement. This component involves helping student teachers understand that science and research are key to social progress. It also emphasizes that a teacher's own research work should be seen as a core professional value. The cultivation of motivation for R&D typically begins with the student teacher's interest in a specific pedagogical issue or its individual aspects, and through the manifestation of intellectual initiative – the desire to independently find new information, propose ideas, develop projects, and master other fields of knowledge, which enhances the quality of student learning outcomes.

Thus, students gradually move from basic curiosity to higher levels of professional initiative. They progress from simply observing pedagogical phenomena to solving practical problems using scientific knowledge and conducting research. Ultimately, these student teachers become young scholars who value research. This process is significantly facilitated by the faculty members.

- *The procedural component.* It serves as a conceptual framework for practical application and comprises a system of students' knowledge about the essence of research in schools, the methodological characteristics of pedagogical research, and relevant techniques and methods of activity. The content of TE in the UK may vary across different higher education institutions. Besides

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

specialized training, all programs focus on developing students' research skills. By using research-based education, schools turn students from passive learners into active knowledge producers. This model focuses on the areas, such as connecting students with faculty research, encouraging teamwork across different subjects, and sharing student work publicly. While this is most common for Master's and Doctoral levels, the foundations of research knowledge and skills are established as early as the undergraduate level. The modules are designed to develop students' aptitude for inquiry-based activities and creative problem-solving in educational contexts; to facilitate the mastery of the theory and practice of scholarly pedagogical research; to build proficiency in working with diverse information sources; and to ensure the acquisition of a comprehensive knowledge system for organizing and conducting pedagogical research.

The organization of TE is based on the notion that a teacher's R&D constitutes a system-forming strategic priority within the educational process. Effectiveness is attributed not to the breadth of an individual's knowledge but rather to their proficiency in the instruments of acquiring, organizing, and applying knowledge from diverse information sources. To achieve these objectives, it is essential to align the instructional process with the principles of scientific inquiry. Achieving these goals requires a research-focused education. This approach links learning content directly with research skills and intellectual development.

The procedural component encompasses the conditions for organizing the educational process to develop the research skills of student teachers: the integration of educational modules into professional training to provide student teachers with scientific knowledge and to cultivate constructive, prognostic, and other skills necessary for research activities; the specific design of courses with a research trajectory; student-faculty collaboration; continuous self-development of students; and the integration of theory and practice. By providing mentorship, promoting autonomy, and using innovative tools, the system helps student researchers present and share their work with the wider academic community.

An analysis of sources (Universities Council for the Education of Teachers, 2019) provides grounds for identifying the following directions in TE aimed at developing the research skills of student teachers:

- Conceptual exploration – examining the essence of the concepts “research activity” and “school-based research activity” during lectures, practical sessions, and seminars, as well as identifying the objectives, tasks, methods, principles, and tools for their implementation.
- Placement strategy – assigning student teachers to practices in schools that already run research projects, so they can join ongoing activities.
- Extracurricular engagement – using the potential of extracurricular activity, including meetings with famous scholars, applying for student research grants, and attending academic conferences.
- The “Bridge Model” – utilizing research activities within higher education institutions as a functional “bridge” for transitioning to various forms of research within professional pedagogical practice.

It should be noted that particular importance in organizing the instructional process is placed on independent study. A significant portion of training, as defined by the curriculum, consists of students' independent work, or learner autonomy. While developing autonomy within the university, the student teachers consistently engage

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

in reflection on the problems or situations arising during the lesson. The very idea of “teaching autonomy” may appear paradoxical. However, there is no inherent contradiction. No specific course is dedicated solely to teaching autonomy. Instead, it gradually becomes an integral part of the learner’s personality through the purposeful transfer of responsibility for learning outcomes from an instructor to a student. Little (1991; 1995) claims that autonomy is not synonymous with self-instruction. It is not limited to acquiring knowledge without teacher assistance, nor does it imply that an instructor is absolved of responsibility for the educational outcomes.

Let us examine the process of diminishing teacher control over students’ educational and cognitive activities within higher education institutions in the UK. Alexander et al. (2019) identify five distinct stages of the educator’s role in the acquisition of learner autonomy.

During the initial phase, an educator controls the entire learning process, providing knowledge, selecting study materials, monitoring, and correcting the student’s progress.

In the observation stage, a teacher simultaneously engages students in more active educational and cognitive activities and the process of self-reflection. Occasionally, this stage incorporates limited opportunities for students to make independent decisions, such as conducting small-scale experiments.

The pedagogical support stage is characterized by the students’ ability to self-organize group work during class. Responsibility for learning outcomes is shared among all participants in the educational process.

At the recommendation stage, students may partially or fully conduct lessons, independently researching the required material, selecting tasks, and organizing project-based activities. A teacher acts as a consultant, providing guidance only when students need deeper information or want to verify their decisions. By the end of the course, students are expected to demonstrate professional competence developed through this increased learner autonomy.

The concluding stage presupposes a high level of learner autonomy, specifically the ability for continuous study without teacher intervention. Furthermore, at this point, an educator is to determine whether students have sufficiently developed metacognitive strategies – actions that enable the monitoring of one’s own cognitive processes and the coordination of the learning process.

However, this approach does not always proceed at the same pace. A student might be very independent with one task but still need guidance with another. Because of this, teachers must constantly reflect on how they structure lessons and check if students are achieving the desired outcomes, and whether they are maintaining academic success.

- *The evaluative-resultative component.* It constitutes a system of students’ skills in self-analysis and self-monitoring of their R&D. In the process of self-monitoring and reflection, students analyze the results of their activities, reflect on their actions, and adjust or refine their practical performance. Self-monitoring plays a significant role in shaping a student’s self-esteem. The results of self-monitoring allow students to assess their abilities while identifying areas for improvement.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

This component indicates the effectiveness of developing a student teacher-researcher during TE, including the motivation for choosing the teaching profession, the formation of personal and professional qualities, and the ability for pedagogical research. This entails the presentation of research findings and their evaluation by the teacher-researchers themselves, as well as other stakeholders (educators, administration, students, school teachers, various pedagogical organizations, etc.). If the research was conducted within a school setting (e.g., studying a student's personality, interpersonal dynamics within student or staff collectives, management styles, or developing original teaching methodologies for specific subjects), teachers from that institution are typically involved in the analysis and evaluation of the results. Reflection entails a conscious, critical analysis of one's own assumptions, beliefs, and conclusions at the beginning, throughout, and especially upon the completion of the research. Reflecting on the specific outcomes of research activities serves as the foundation for further reflection, which generates new, previously undefined ideas. The evaluation of pedagogical research activities also includes an analysis of portfolios and reflective diaries, the maintenance of which is mandatory. Keeping a reflective diary helps beginning teachers and students to transition from the "student" role to the "teacher" role, allowing tracking the progress, which greatly increases professional confidence. Diaries serve as a means of navigating the complex psychosocial environment of the school. Teachers use them to analyze critical incidents, manage stress and prevent burnout, transforming emotional challenges into constructive strategies. Reflective writing forces teachers to critically compare theoretical knowledge with real situations in the classroom. This contributes to a deeper understanding of students' needs and to adapting teaching methods.

- *The practical component.* The school-based practice allows student teachers to apply what they have learned in a practical setting. It gives students the chance to use and deepen their knowledge in real classrooms. This experience helps them strengthen their research skills and serves as a vital step in turning everyday teaching into a base for scientific research. The practice placement provides particularly favorable conditions for the development of research skills.

A substantial shift in TE is the marked increase in the scope of practical research, a significant portion of which is conducted during school placements. Thus, the necessary conditions for student self-development and self-actualization are provided. As an integral component of TE, pedagogical practice is aimed at the creative application of acquired theoretical knowledge, specifically from courses in pedagogy, psychology, methodology, and specialized courses, and the formation of practical skills essential for professional pedagogical activity.

When training future teachers, developing research skills during school practice involves more than just a deep study of the subjects they teach. It involves a specific form of research-oriented thinking that encompasses not only the technical performance of professional duties and the pursuit of optimal pedagogical technologies but also the elucidation of the essence of pedagogical communication. This requires future teachers to have a profound awareness of their actions within the professional context, which influences the development of students' personalities. Such self-reflection becomes a source of high pedagogical efficiency through the application of innovative technologies and teaching methods. Most importantly, it serves as a vector for continuous self-education and lifelong learning. Pedagogical practice occupies a central role in TE. Government documents consistently emphasize its significance for enhancing the quality of TE and refining research activities. Pedagogical practice of student teachers is categorized into three types: school-based practice, provided by professional mentors and curriculum

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

leaders; a two-week internship conducted at a teacher training center; and a one-year internship course based at the university. The most prevalent form of practice in the majority of UK universities and liberal arts colleges is the one-year internship course designed for individuals who already hold a specialized higher education degree (typically at the Bachelor's level). Concentrating professional pedagogical training within a single year offers distinct advantages: through the organization of an extended practice, student teachers have the opportunity not only to outline but also to resolve a comprehensive range of practical and educational tasks. The practice objectives include: elevating professional skills essential for independent school-based work to a high level; consolidating theoretical knowledge acquired in previous courses; observing and analyzing the school's educational process; conducting independent work with students; and participating in specialized seminars regularly held by university faculty. Such a structural approach to educational content ensures the attainment of a higher level of professional training for the student teacher-researcher.

The development of research skills during school placement is a process of the student's voluntary transition into the role of a researcher. It is driven by an internal source of personal development, providing freedom in selecting goals, methods, and means of implementation, while maintaining a focus on reflexive activity. Consequently, pedagogical practice serves as a structured form of the research process. It becomes a motivated, self-organized activity by the scientific inquiry and a personal commitment to the issues under study, aimed at generating new knowledge. It should be noted that the researched problems can vary significantly, encompassing both instructional and social-behavioral aspects. Examples include researching the causes of underachievement in specific students, the influence of family upbringing on student behavior, and the effectiveness of various teaching methodologies. Thus, the individual research activities of student teachers stimulate a reflexive perception of material and develop the ability to formulate problems and critically select information.

During the period of pedagogical practice, it is crucial not only to actualize and refine the student teacher's theoretical knowledge on R&D but also to teach the practical application. On one hand, this research-based approach helps students to master the system of actions and professional relationships inherent to a school teacher. On the other hand, it helps them understand themselves and their professional behavior better. This allows future teachers to see how they are developing and how they will continue to develop while engaging in R&D during the practice.

Keeping a research diary during studies and practice plays a key role in developing students' research skills. In the UK, it is considered a vital research method and is extensively practiced. It is viewed as an intrinsic component of the research process rather than merely a tool for data collection or the recording and analysis of findings. Several characteristics render diaries particularly relevant: they reflect daily observations of both one's own professional activities and those of colleagues. Research diaries are effective for several reasons. They are easier to organize than other methods and can include various types of data. They allow students to record fresh ideas immediately. By documenting both successes and failures, the diaries provide a rich source of information for later, more detailed analysis.

A research diary is a tool for personal growth. It connects previous experience with classroom practice and records a student's reflections. By keeping a diary, students can track their progress and the social context of their teaching. These diaries include observations, interviews, and even photos, alongside thoughts on research methods and self-assessment. Most importantly, the diary ensures that data,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

reflection, and analysis always go hand in hand.

Despite the UK's emphasis on the "teacher-researcher" model, several barriers hinder its implementation (University College London, 2021). Recent reforms have shifted focus toward a "technical-rationalist" approach, prioritizing standardized techniques over deep inquiry. This is complicated by "performative pressure," where heavy workloads force trainees to prioritize survival over research. Furthermore, a lack of specialized mentorship and inconsistent curricula across providers results in an uneven development of research skills among new teachers.

Conclusions

Today's education is moving away from traditional teaching toward a model focused on R&D. This study shows that being able to conduct research is no longer just an extra skill. It is now a basic requirement for teachers. Because the world is changing so fast, modern educators must be more than just subject experts. They need to be autonomous professionals who can reflect on and improve their own work.

An examination of the British academic model highlights that the transformation of a student-teacher into a professional teacher-researcher is the result of a systematic development of diverse competencies. The skills, such as gnostic, diagnostic, reflective, and prognostic, ensure that pedagogical inquiry is an active and conscious process. Furthermore, the development of research skills is a multifaceted process that integrates motivational-axiological, evaluative-resultative, procedural, and practical components.

Fostering a research culture begins with a shift in perception. Students are taught to value scientific inquiry. The strategic priority of research activity in TE acts as a system-forming element, where content mastery and research culture are linked. The application of specific frameworks and strategic placement programs facilitates a smooth transition from theoretical inquiry to professional practice. This fostering of learner autonomy is essential for the training of teacher-researchers, capable of self-actualization and lifelong learning. Autonomy is a purposeful process where responsibility for learning outcomes is gradually transferred from an instructor to a student, without an instructor losing accountability for the final educational results. The development of autonomy involves a systematic reduction of teacher control, transitioning through stages where the educator's role shifts from a primary controller to a facilitator of student initiative. There is no standalone course for "teaching autonomy." Instead, it is cultivated as an integral personality trait through consistent reflection and independent study within the existing curriculum. The use of tools like the "reflective diary" supports this growth, transforming daily school-based experiences into deep professional self-analysis.

In conclusion, the readiness of a student teacher to conduct research is the synergy of four essential components: motivational-axiological, evaluative-resultative, procedural, and practical. A personal commitment to research, together with strong theory and self-reflection, prepares future teachers to do more than just follow a curriculum. It gives them the tools they need for constant professional growth.

Future research will investigate specific modalities and practical instruments, such as interactive technologies and action research, designed to sustain the research competencies of pre-service teachers. Furthermore, emphasis will be placed on strategies for integrating research into daily classroom activities, thereby bridging the gap between initial teacher education and professional practice.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Bibliographical References

- Alexander, O., Argent, S., & Spencer, J. (2019). *EAP Essentials: A teacher's guide to principles and practice* (2nd ed.). Reading: Garnet Publishing.
- Bartosh, O., Danko, D., Kanyuk, O., Hodovanets, N., & Myhalyna, Z. (2023). Research-based learning in the education process of a higher education institution. *Amazonia Investiga*, 12(64), 208-216. <https://doi.org/10.34069/AI/2023.64.04.20>
- Bartosh, O. (2023). Ucrainiano [Integration of research informed component in the training process of future specialists in higher education establishments]. *Scientific Bulletin of Uzhhorod University. Series: «Pedagogy. Social Work»*, 1(52), 19–23. <https://doi.org/10.24144/2524-0609.2023.52.19-23>
- Boletín oficial del estado legislación consolidada. (2023). *Ley Orgánica 2/2023, de 22 de marzo, del Sistema Universitario*. Jefatura del Estado «BOE» núm. 70, de 23 de marzo de 2023 Referencia: BOE-A-2023-7500. <https://www.boe.es/buscar/pdf/2023/BOE-A-2023-7500-consolidado.pdf>
- Byrne, N., & Butcher, Ch. (2020). *An introduction to teaching in UK higher education. A guide for international and transnational teachers*. London: Routledge. <https://doi.org/10.4324/9780429197161>
- Chung, J. (2023). Research-informed teacher education, teacher autonomy and teacher agency: the example of Finland. *London Review of Education*, 21(1), 13. <https://doi.org/10.14324/LRE.21.1.13>
- Clark, T., & Hordosy, R. (2019). Undergraduate experiences of the research/teaching nexus across the whole student lifecycle. *Teaching in Higher Education*, 24(3), 412–427. <https://doi.org/10.1080/13562517.2018.1544123>
- Danish School of Education. (2026). *Research at the Danish School of Education*. <https://dpu.au.dk/en/research>
- Department of Education. (2024a). *Initial teacher training and early career framework* (ITTECF). https://assets.publishing.service.gov.uk/media/661d24ac08c3be25cfbd3e61/Initial_Teacher_Training_and_Early_Career_Framework.pdf
- Department of Education. (2024b). *Teacher training school placements*. <https://getintoteaching.education.gov.uk/train-to-be-a-teacher/school-placements>
- Elliott, J. (2001). Making evidence-based practice educational. *British Educational Research Journal*, 27(5), 555–574. <https://doi.org/10.1080/01411920120095735>
- Ferreira T., & Cravino, J.P. (2022). Pedagogical training of teachers in Portuguese public higher education institutions. *En EDULEARN22 Proceedings* (pp. 3338–3346). IATED Academy. <https://doi.org/10.21125/edulearn.2022.0818>
- Healey, M., & Jenkins, A. (2009). *Developing undergraduate research and inquiry*. UK: Higher Education Academy. https://s3.eu-west-2.amazonaws.com/assets.creode.advancehe-document-manager/documents/hea/private/developingundergraduate_final_1568036694.pdf
- Irish National Teachers' Organisation (2026). *Who we are*. <https://www.into.ie/about/>
- la Velle, L. (2024). Teacher-as-researcher: a foundational principle for teacher education. *Journal of Education for Teaching*, 50(3), 367–370. <https://doi.org/10.1080/02607476.2024.2361498>
- Little, D. (1991). *Learner autonomy 1: Definitions, issues and problems*. Dublin. Authentik.
- Little, D. (1995). Learning as dialogue: the dependence of learner autonomy on teacher autonomy. *System*, 23(2), 175-181. [https://doi.org/10.1016/0346-251X\(95\)00006-6](https://doi.org/10.1016/0346-251X(95)00006-6)
- Loughran, J., Keast, S., & Cooper, R. (2016). Pedagogical reasoning in teacher education. In J. Loughran and M.L. Hamilton. (Eds.). *International handbook of*

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- teacher education* (pp.387–421). Dordrecht: Springer Press.
https://doi.org/10.1007/978-981-10-0366-0_10
- Murray, O., Campbell, A., Hextall, I., Hulme, M., Jones, M., Mahony, P., Menter, I., Procter, R., & Wall, K. (2009). Research and teacher education in the UK: Building capacity. *Teaching and Teacher Education*, 25(7), 944–950.
<https://doi.org/10.1016/j.tate.2009.01.011>
- Organisation for Economic Co-operation and Development. (2024). *Teaching and Learning International Survey*. https://www.oecd.org/en/publications/results-from-talis-2024_90df6235-en.html
- Joseph-Richard, P., & Jessop, T. (2020). A phenomenographic study of research informed teaching through the eyes of Masters' students. *Studies in Higher Education*, 45(4), 847–861. <https://doi.org/10.1080/03075079.2018.1554640>
- Perron, B.E., Victor, B.G., Hiltz, B.S., & Ryan, J. (2020). Teaching note – data science in the MSW curriculum: Innovating training in statistics and research methods. *Journal of Social Work Education*, 58(1), 193–198.
<https://doi.org/10.1080/10437797.2020.1764891>
- Swedish Institute for Educational Research. (2026). *About us*.
<https://www.skolfi.se/other-languages/english/>
- Teaching Council of Ireland. (2026). *Research Support Framework*.
<https://www.teachingcouncil.ie/professional-learning/research/research-support-framework/>
- Townsend, T. (2011). Searching high and searching low, searching east and searching west: Looking for trust in teacher education. *Journal of Education for Teaching*, 37(4), 483–499. <https://doi.org/10.1080/02607476.2011.611017>
- University College London. (2021). *The Core Content Framework and the fallacy of a teacher training 'curriculum'*. <https://blogs.ucl.ac.uk/ioe/2021/09/02/the-core-content-framework-and-the-fallacy-of-a-teacher-training-curriculum/>
- Universities Council for the Education of Teachers. (2019). *Building research-informed teacher education communities: a UCET Framework*. London: UCET.
<https://www.ucet.ac.uk/downloads/10989-Building-Research-Informed-Teacher-Education-Communities-%28July-2019%29.pdf>
- University of Lancashire. (2022–2026). *UCLan twins with Ukrainian university*.
<https://www.lancashire.ac.uk/news/uclan-twins-with-ukrainian-university>
- University of Southern Denmark (2026). *Research at SDU*.
<https://www.sdu.dk/en/forskning>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
 Internacional (CC BY 4.0)

Mejorar la educación en derecho penal, procesal y forense mediante las TIC y la integración de la práctica del CEDH

Enhancing criminal law, procedure, and forensics education through ICT and the integration of ECHR practice

Dmytro Baranenko¹  Zoriana Dilna²  Ruslan Komisarchuk³  Anastasiia Khylichenko⁴  Veronika Ivanova⁵ 

Afiliación autor:

¹ Doctor of Legal Sciences, Professor, Head of the Department of Theory and History of State and Law of Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine. baranenko21@gmail.com

² PhD in Law, Associate Professor of the Department of Criminal Law Disciplines Lviv State University of Internal Affairs, Lviv, Ukraine. zoriana1@ukr.net

³ Ph.D., in Law, Associate Professor, Associate Professor of the Department of Criminal Law Disciplines of the Odesa State University of Internal Affairs, Departments of Criminal Law Disciplines of the Institute of Law and Security of the Odesa State University of Internal Affairs, Odesa, Ukraine. ruslan133@gmail.com

⁴ Ph.D., in Law, Associate Professor of the Department of Criminal Law Associate Professor, National University "Odesa Law Academy", Odesa, Ukraine. khylichenko25.onua@gmail.com

⁵ Ph.D., Associate Professor of the Department of Criminal Law Associate Professor, National University "Odesa Law Academy", Odesa, Ukraine. veronika.k.onua@gmail.com

Recibido: 26/01/26
Aceptado: 30/04/26

Cómo citar:

Baranenko, D., Dilna, Z., Komisarchuk, R., Khylichenko, A., & Ivanova, V. (2026). Enhancing criminal law, procedure, and forensics education through ICT and the integration of ECHR practice. *Revista Eduweb*, 20(2), 189-207. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.12>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Resumen

El rápido desarrollo de las tecnologías de la información y la comunicación (TIC) ofrece oportunidades para la enseñanza innovadora y el aprendizaje interactivo en la formación jurídica, especialmente en derecho penal, procedimiento penal y criminología. Este estudio tiene como objetivo fundamentar los principios teóricos y prácticos para mejorar el proceso educativo mediante la integración de las TIC y la jurisprudencia del Tribunal Europeo de Derechos Humanos (TEDH), a la vez que ofrece recomendaciones para optimizar la formación de futuros profesionales del derecho. El estudio emplea un enfoque conceptual y normativo, que combina el análisis jurídico doctrinal y comparativo, el análisis de políticas y la modelización conceptual, utilizando fuentes secundarias para desarrollar un marco que integre las herramientas de las TIC con los estándares del Tribunal Europeo de Derechos Humanos en la formación jurídica. El estudio identifica los métodos más eficaces para analizar los precedentes del TEDH dentro del proceso educativo y subraya el papel del aprendizaje interactivo en el desarrollo de competencias profesionales. Se abordan los riesgos asociados a la implementación de las TIC, incluidas las limitaciones técnicas y los retos pedagógicos, junto con estrategias para su mitigación. Los resultados demuestran que la combinación de las TIC con las normas jurídicas internacionales mejora la modernización de la formación jurídica y la calidad de la formación especializada, así como su eficacia general.

Palabras clave: TIC, currículo, educación, proceso penal, derecho procesal penal, investigación previa al juicio.

Abstract

The rapid development of information and communication technologies (ICT) provides opportunities for innovative teaching and interactive learning in legal education, particularly in criminal law, criminal procedure, and criminology. This study aims to substantiate the theoretical and practical principles of enhancing the educational process by integrating ICT and the practice of the European Court of Human Rights (ECHR), while offering recommendations to improve the training of future legal professionals. The study employs a conceptual and normative approach, combining doctrinal and comparative legal analysis, policy analysis, and conceptual modeling, using secondary sources to develop a framework integrating ICT tools with European Court of Human Rights standards in legal education. The study identifies the most effective methods for analyzing ECHR precedents within the educational process and emphasizes the role of interactive learning in developing professional competencies. Risks associated with ICT implementation, including technical limitations and pedagogical challenges, are addressed alongside strategies for their mitigation. The results demonstrate that combining ICT with international legal standards

enhances the modernization of legal education and improves the quality of specialist training, overall effectiveness.

Keywords: ICT, curriculum, education, criminal proceedings, criminal procedural law, pre-trial investigation.

Introduction

Digitalization of the educational space and the reform of legal training are key directions in the modernization of higher education. In the context of Ukraine's integration into the European Union, particular importance is attached to aligning educational programs with international human rights standards developed in the practice of the European Court of Human Rights. Such an orientation contributes to the harmonization of the national legal system with the European legal framework and promotes the development of professional competencies that enable future legal specialists to apply the principles of the rule of law in practical activities. At the same time, the development of innovative teaching methodologies based on information and communication technologies (ICT) is considered an important tool for improving the quality of competence-based legal education. Digital learning platforms, virtual simulations, and collaborative problem-solving tools expand the possibilities of traditional teaching methods and create conditions for interactive learning, teamwork, and the independent construction of knowledge by students.

Despite the growing body of academic literature devoted to the digitalization of legal education, extended reality technologies, open-source intelligence tools, and the application of ECHR standards in criminal justice, these issues are often examined separately. Existing research predominantly focuses either on technological innovations in education or on the doctrinal analysis of human rights jurisprudence, without offering an integrated conceptual model that systematically connects ICT-based educational tools with the normative requirements arising from the practice of the European Court of Human Rights. As a result, a theoretical gap persists in the field of Education and Technology regarding the absence of a coherent framework that aligns digital legal education with international human rights standards in criminal law and forensic training. This study seeks to address this gap by proposing a structured conceptual model that integrates technological, pedagogical, and normative dimensions in the modernization of legal education.

The research objectives include:

To analyze the current state of the use of information and communication technologies in teaching criminal law, criminal procedure, and forensics in higher legal education institutions, with particular attention to electronic learning platforms, virtual trial simulations, and digital forensic laboratories as tools for competence-based legal training.

To examine the role of the case law of the European Court of Human Rights in shaping human rights-oriented standards in criminal justice and to determine methodological approaches for incorporating ECHR jurisprudence into legal education.

To develop and substantiate a conceptual framework for integrating ICT-based educational tools with ECHR standards in the teaching of criminal law disciplines, aimed at strengthening the professional competencies of future legal practitioners.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

In accordance with the stated objectives, the study addresses the following research questions:

- 1) How can information and communication technologies be conceptually integrated into legal education in a manner consistent with the standards developed in the practice of the European Court of Human Rights?
- 2) What structural components should a conceptual framework include in order to align ICT-based legal education with human rights-oriented criminal justice training?
- 3) What normative and pedagogical implications arise from the integration of digital educational tools and ECHR jurisprudence in the preparation of future legal professionals?

Despite the growing body of research on ICT in legal and forensic education, a significant gap persists due to the lack of a holistic and integrated framework that combines technological tools, pedagogical approaches, and the normative standards of the European Court of Human Rights (ECHR). Existing studies tend to examine digital technologies—such as artificial intelligence (AI), virtual reality (VR), and open-source intelligence (OSINT) — In isolation, without systematically linking them to competency-based and evidence-based legal training or embedding them within ECHR jurisprudence.

At the same time, although ECHR case law is well developed in doctrinal scholarship, its practical integration into technology-enhanced learning environments and simulation-based legal education remains insufficiently explored. Furthermore, limited attention has been given to preparing future legal professionals to critically evaluate digital evidence and algorithmic outputs in accordance with fair trial guarantees. Similarly, ethical concerns—such as bias and data reliability—are often overlooked in the design of educational frameworks.

Consequently, there is a clear need for an interdisciplinary conceptual model that integrates ICT, pedagogical strategies, and human rights standards to foster the development of legally competent, digitally literate, and normatively grounded professionals.

Contribution:

This research makes a significant contribution by formalizing a comprehensive conceptual framework that integrates information and communication technologies with the pedagogical principles of competency-based learning and the human rights standards derived from the European Court of Human Rights. Unlike previous studies, which treat technological innovations in legal education, forensic training, or ECHR jurisprudence in isolation, this study unifies these dimensions into a single model that guides curriculum design, methodological development, and the systematic formation of professional competencies in criminal law and forensic sciences.

Conceptual Framework and Literature Review

The purpose of this research is to develop a conceptual framework for integrating information and communication technologies into the teaching of criminal law, criminal procedure, and forensics in higher legal education, based on the standards developed in the practice of the European Court of Human Rights. The study aims to substantiate the pedagogical and normative foundations of such integration and

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

to identify methodological approaches that enhance the development of professional competencies of future legal practitioners.

The object of the research is the educational process in higher legal educational institutions and the improvement of the qualifications of lawyers in the field of criminal law, procedure and forensics. The subject of the research is the methods, means and technologies of using ICT in teaching criminal law disciplines, as well as mechanisms for integrating the practice of the ECHR into curricula and practical training of future lawyers.

The article uses scientific terminology in the following context.

Information and communication technologies (ICT) are a set of technical and software tools that provide processing, storage and transmission of information for educational or professional purposes (Selwyn, 2007; Jeffery et al., 2021).

The case law of the European Court of Human Rights is a collection of decisions, precedents, and interpretations of the Convention for the Protection of Human Rights, which define standards for respect for human rights and fair trial in criminal proceedings (McBride, 2021).

Open-Source Intelligence (OSINT) is a method of collecting and analyzing information from open sources, which is used in criminal investigations and legal practice (Torbas, 2024; Matvienko & Tsyvin, 2024). Virtual learning environments are interactive educational platforms that use augmented and virtual reality to create realistic learning scenarios in forensics and legal disciplines (Pringle et al., 2022; Mayne & Green, 2020).

Methodological recommendations are a system of guidelines and practical advice for teachers on the organization of the educational process, the use of ICT, and the integration of international legal standards (Baadzhi, 2023; Yu, 2023).

An important area of modern research is the introduction of information and communication technologies in the training of specialists in criminal law, process and forensics. The experience of foreign scientists indicates the high effectiveness of the use of digital environments, interactive platforms and immersive technologies in legal and forensic education. Thus, Pringle et al. (2022) analyze the possibilities of using virtual reality technologies and elements of educational games in teaching forensic sciences. The authors prove that virtual laboratories and simulations create a safe and at the same time realistic environment for students to practice practical skills, in particular regarding the inspection of the scene, collection and analysis of evidence. The results of the study demonstrate that VR environments contribute to the formation of critical thinking, increase motivation and ensure deeper assimilation of the material and are important for forensic education, as they allow for the creation of learning models that are as close as possible to practice, which meets modern challenges in the field of criminal justice and requires taking into account the standards of the European Court of Human Rights.

In turn, Jeffery et al. (2021) consider the prospects for using interactive educational platforms, in particular the Thinglink platform, which provide openness, flexibility and multi-level interactivity. The study shows that such digital tools allow for the implementation of the concept of blended and online learning, combining theoretical knowledge with practical activities. An important aspect is the creation of conditions for experimental learning, which is based on the active interaction of students with

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

educational content, including the modeling of complex objects and situations. In our opinion, in the context of training lawyers and investigators, such an approach can be used to organize virtual court sessions, simulators of investigative actions or simulation cases that reflect the practice of the ECHR. This creates conditions for a deeper understanding of the role of international human rights standards in criminal proceedings and the formation of the necessary professional competencies.

At the same time, Selwyn (2007) offers a critical view of the use of computer technologies in higher education. The author notes that although ICTs open up new opportunities for learning, their effectiveness depends on proper pedagogical integration, methodological support and consideration of social aspects. Among the risks are superficial assimilation of material, excessive dependence of students on technological means and inequality of access to resources. This approach is extremely important in the field of legal education, as it shows that the introduction of technologies in itself does not guarantee an improvement in the quality of education. A systematic combination of ICTs with traditional educational methods is necessary, which will ensure a balance between the development of practical skills and the formation of critical and analytical thinking.

Mayne & Green (2020) in their article analyze the possibilities of using virtual reality technologies (hereinafter referred to as VR) for the teaching and learning of forensics, in particular in the field of crime scene investigation. The authors emphasize that VR allows students to practice crime scene inspection skills in conditions that are as close to real-life as possible, but without the need to create physical laboratories or forensic testing grounds. The main conclusions of the study are that VR contributes to the development of spatial thinking, the formation of a systematic approach to evidence analysis, and increases the level of student involvement in the learning process.

Further, Nilendu (2024) considers the problem of implementing evidence-based education in the training of specialists in the field of forensic science. The author emphasizes that the educational process should be based on scientifically proven methods that ensure the effectiveness of training, and not on the formal assimilation of theoretical material. An important aspect is the orientation to the practical needs of criminal justice and the use of modern pedagogical tools, including digital technologies. In the study, the author concludes that it is a systematic approach to the educational process, built on the principles of evidence, that allows preparing specialists who are able to think critically and make informed decisions in complex situations of the criminal process. The significance of this work for the topic under study is that it substantiates the need to combine ICT with modern educational approaches that guarantee not only technical innovation, but also methodological reliability, which is critically important for the integration of ECHR standards into training.

At the same time, Custers & Stevens (2024) focus on the issue of using digital data as evidence in criminal proceedings. In their monograph, they analyze the features of the use of electronic evidence in criminal courts, including issues of its authenticity, admissibility and interpretation. The authors emphasize that digital evidence is becoming increasingly important in criminal proceedings, but its assessment requires both special technical knowledge and compliance with legal standards, in particular those arising from the practice of the ECHR. The main conclusion is that effective work with digital evidence requires a combination of technical literacy and legal awareness. The significance of this study for improving education in the field of criminal law and forensics is that it demonstrates the need to train lawyers to work with the latest types of evidence, which becomes possible

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

thanks to the use of ICT in the educational process and at the same time contributes to the formation of skills in the application of international standards of admissibility of evidence.

The relevance of integrating modern information and communication technologies into the field of legal education is confirmed by a number of recent studies by Ukrainian scholars. Thus, Matvienko & Tsyvin (2024) in their article consider OSINT technologies. The authors justify the pedagogical goal-setting in teaching OSINT, emphasizing that the ability to work with open sources of information forms analytical, critical thinking and data verification skills in students. The conclusions of the article indicate that the inclusion of OSINT in the educational process not only improves the quality of training of future specialists in the information sphere, but can also be integrated into the training of lawyers and criminologists, since the methods of collecting, analyzing and systematizing data from open sources are directly related to the criminal process and forensic practice. In the context of the research topic, this work demonstrates the importance of forming in students the competencies of working with information arrays, which allows effectively combining educational ICT with practical tasks of criminal law and taking into account the standards of evidence developed by the ECHR.

Torbas's (2024) monograph "OSINT in the Investigation of Criminal Offenses" focuses on the practical aspect of using open sources of information in criminal investigations. The author systematizes OSINT methods, tools, and algorithms, demonstrating their importance in collecting evidentiary information and verifying data in criminal proceedings. The book pays special attention to the issues of admissibility of evidence obtained using OSINT, which is directly related to the practice of the ECHR in the field of observing the right to a fair trial and the right to privacy. The conclusions of the work indicate that the use of OSINT in forensics contributes to the expansion of the tools of investigators and lawyers, but requires a clear legal and ethical framework. For the topic under study, this work is extremely significant, since it not only illustrates the practical potential of ICT in the field of criminal proceedings, but also emphasizes the need to form competencies in students that meet both technical and international legal requirements.

Moreover, Baadzhi (2023) in his article analyzes the latest tools of legal education in the context of the development of artificial intelligence. The author emphasizes that modern legal training should take into account not only traditional teaching methods, but also the possibilities of using AI technologies that provide personalization of the educational process, automation of analytical tasks and creation of adaptive learning platforms. The main conclusions of the study are that artificial intelligence can serve as a powerful means of increasing the efficiency of training, in particular in the field of criminal law and process, where rapid processing of large volumes of information and the formation of legal analytics skills are required. In the context of the research topic, this article is of great importance, as it justifies the need to combine ICT with innovative technologies based on AI, which creates the prerequisites for the formation of students' skills in working with digital evidence and their assessment taking into account international standards, including the practice of the ECHR.

Yu (2023) in his article analyzes the reform of higher legal education in China in the context of the spread of AI, using the example of the application of technologies represented by ChatGPT. The author emphasizes the dual nature of AI in law: on the one hand, AI opens up opportunities for improving educational processes, developing legal analytics tools, modeling legal processes, and creating interactive

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

learning environments; on the other hand, it has certain limitations related to the lack of full reliability of results, ethical and legal challenges, and the risk of distorting legal conclusions. In the conclusions, the author emphasizes that AI should be used as an auxiliary tool, not as a replacement for professional legal thinking. The significance of this work for the topic under study is that it proves: the introduction of intelligent technologies into the legal training system contributes to the development of critical thinking, but requires combination with international standards, including the practice of the ECHR, to ensure legal correctness and protection of fundamental human rights.

McBride's works (2009, 2021) provide a thorough analysis of the decisions of the ECHR in the field of criminal proceedings. The author systematizes the main areas of influence of the Court's practice on the procedure of pre-trial investigation, trial and application of procedural guarantees, in particular the rights to liberty, protection from torture, the right to defense and a fair trial. The author reveals the doctrines used by the ECHR in the formation of approaches to law enforcement, including the principle of a "living instrument", the doctrine of proportionality, the autonomy of the concepts of the Convention. The work demonstrates that the precedents of the ECHR have become the basis for rethinking many national procedural institutions. In the context of education, this work is extremely valuable: it can serve as a basic resource for teaching disciplines that combine criminal procedure with international human rights standards. The use of digital tools for studying such materials (electronic databases, interactive simulations of trials) allows the learning process to be closer to real legal practice).

Moreover, Donnelly (2012) proposes an innovative approach to understanding forensic science through a human rights lens. The author emphasizes that the use of forensic methods should always be within the limits set by international standards, with respect for the right to privacy, the presumption of innocence, and the right to defense. The study emphasizes that the incorrect application of scientific methods in the criminal process can lead to human rights violations.

Vuille et al. (2017) examine the use of scientific evidence in the context of fair trial guarantees. The authors examine how the quality, reliability and admissibility of forensic evidence are consistent with the standards of Article 6 of the Convention. They highlight the risks associated with misinterpretation or overreliance on scientific methods and outline the criteria by which such evidence should be assessed by the court. This article demonstrates that future lawyers should learn not only to analyze the results of expert opinions, but also to critically evaluate them in the light of European standards.

Dryshliuk et al. (2025) show that integrating ECHR case law is essential for developing professional legal awareness, judicial culture, and human rights-oriented competencies. Further, the article of Lundy & Martínez Sainz (2018) emphasizes that effective human rights education requires integrating legal knowledge and real-world application of rights violations, not just abstract teaching. Lorente et al. (2020) - this paper highlights how ICT became essential to ensure continuity, accessibility, and inclusiveness of education during crises. Strongly supports your argument about distance learning, inclusiveness, and digital transformation (COVID-19 context). Moreover, Muntjewerff (2009) situates ICT within broader European higher education reforms and emphasizes its role in transforming teaching methods and learning environments. The study Nilupu-Moreno et al. (2024) (with a Latin American authorship base) confirms that the integration of legaltech and ICT "has immense potential to revolutionize legal education" and better prepare students for a digital legal profession. Finally, Salazar Chica & Palencia Salas (2025) demonstrate a

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

growing body of research on ICT integration in education, especially in Latin America, emphasizing the importance of teacher competencies and digital transformation. This study directly supports your regulatory dimension (ECHR/case law integration) and pedagogical focus on critical thinking and applied analysis.

The discussion on the modernization of legal education is impossible without taking into account the global trend towards the decolonization of knowledge, which is of particular importance for the fields of criminal law, process and forensic science. The article by Chaussée et al. (2022) explores ways to rethink forensic science curricula in light of decolonization practices. The authors emphasize that modern forensic courses rely on Eurocentric models of knowledge, ignoring the cultural, legal and social contexts of other regions. They propose the integration of more inclusive approaches into the educational process that take into account different epistemologies and the experiences of local communities. The conclusions of the article are that the decolonization of forensic education not only contributes to greater justice and cultural sensitivity, but also improves the quality of training of specialists who will work in a globalized legal space. In the context of improving education in the field of criminal law and process, this work is of particular importance, as it provides grounds to reconsider the methods of teaching criminology through the prism of ECHR standards, where universal human rights play a key role. The use of ICT allows adapting such approaches in teaching through the creation of intercultural educational platforms, interactive courses and virtual simulations, where students have the opportunity to familiarize themselves with different approaches to evidence and law enforcement.

Finally, de Sousa Santos (2021) work reveals a broader theoretical and methodological context in which decolonization processes should be considered. The author introduces the concept of “deep cognitive justice”, which involves recognizing the equality of different systems of knowledge, moving away from the monopoly of Western science, and integrating alternative ways of thinking into the educational process. The essence of the work is to prove that a true university education should reflect the diversity of global epistemologies and not just reproduce dominant European or American models. In general, both works demonstrate that the decolonization of knowledge is not only an ethical or cultural challenge, but also a key factor in improving the quality of legal education. Chaussée et al. (2022) concretize this approach using the example of criminology, showing the need to take into account different cultural contexts in the construction of curricula, while de Sousa Santos (2021) lays down the fundamental methodological principles of cognitive justice. Combined with the use of ICT and the integration of ECHR practice, these works contribute to the formation of an innovative model of legal education capable of providing not only technical and legal competence, but also critical, intercultural and human rights thinking of future professionals.

Based on the analysis of existing scholarly approaches, this study proposes a conceptual framework for modern legal education that integrates information and communication technologies with the normative standards developed in the practice of the European Court of Human Rights. The framework is structured around four interrelated components.

The first component is the technological dimension, which includes digital learning platforms, extended reality technologies (XR), open-source intelligence tools, and artificial intelligence applications used for simulation, data analysis, and interactive learning. These technologies serve as instruments for creating practice-oriented and accessible educational environments.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The second component is the pedagogical dimension, grounded in competency-based and evidence-based education. This dimension focuses on the development of analytical thinking, practical skills, and the ability to work with complex factual and legal material through simulations, case-based learning, and problem-oriented tasks.

The third component is the normative dimension, which encompasses the jurisprudence of the European Court of Human Rights, international human rights standards, and principles of fair trial, admissibility of evidence, and procedural guarantees. This dimension ensures that technological innovation in education remains aligned with the rule of law and human rights obligations.

The fourth component is the outcome dimension, represented by the professional competencies of future lawyers, including digital literacy, procedural reasoning, ethical awareness, and the capacity to apply international human rights standards in criminal proceedings.

The interaction of these components forms an integrated model of legal education in which technological tools are not used in isolation but are normatively guided by ECHR standards and pedagogically structured to enhance professional legal training. This framework constitutes the original conceptual contribution of the study and provides a basis for further empirical validation and curriculum development.

Methodology

This study is conceptual and normative in nature and does not involve the collection of primary empirical data. The methodology is based on qualitative doctrinal legal analysis, comparative legal analysis, policy analysis, and conceptual modeling. Secondary sources, including empirical findings from prior educational and legal studies, were selected based on their relevance to digital legal education, the integration of ECHR jurisprudence, and the use of innovative teaching technologies. Peer-reviewed journals, official legal texts, and authoritative reports were prioritized to ensure the reliability and applicability of the evidence.

The policy analysis method was applied to systematize the regulatory and legal framework governing the integration of international standards into higher legal education. Primary sources included the Convention for the Protection of Human Rights and Fundamental Freedoms, the Law of Ukraine "On International Treaties" and the Law of Ukraine "On the Execution of Decisions and Application of the Practice of the European Court of Human Rights" This analysis demonstrated how ECHR standards create a normative foundation for incorporating human rights principles into educational programs, forming the theoretical and legal basis for the proposed framework.

The comparative legal method enabled the identification and evaluation of best practices in digital and interactive legal education across national and international contexts. Selected studies on AI, extended reality technologies, virtual simulations, and online learning platforms were compared to determine which approaches most effectively develop analytical and procedural competencies in criminal law and forensics. This comparative logic guided the adaptation of international experiences to the Ukrainian higher education context.

The formal-legal method provided a systematic analysis of methodological sources and scientific publications, substantiating the inclusion of ICT tools, OSINT technologies, and forensic modeling techniques in the proposed educational model

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

in compliance with ECHR standards.

Finally, the systemic method integrated all components of the study, linking digital technologies, international human rights standards, and pedagogical objectives. This approach ensured that the conceptual framework reflects a cohesive, practice-oriented, and competency-based model of modern legal education, capable of preparing specialists for effective participation in criminal justice while applying international standards in practice.

Conceptual Analysis and Discussion

For analytical clarity, this section distinguishes between the synthesis of existing scholarly and policy approaches and the author's own conceptual and normative analysis based on the proposed framework.

Synthesis of Existing Approaches to ICT and ECHR Integration in Legal Education

Over the past decade, the educational process in higher education has undergone significant changes, largely due to the integration of interactive learning environments and digital technologies. Moving away from traditional lectures and laboratory workshops brings numerous benefits to both teachers and students. The COVID-19 pandemic and full-scale invasion have forced higher education institutions to transform the learning process, while simultaneously demonstrating both the advantages and limitations of using online and virtual educational tools. In particular today in Ukraine, distance and blended learning platforms are actively used: moodle, Google Classroom, OpenEdX, Zoom, Meet.

The European Union has developed a Digital Education Action Plan for 2021-2027, which aims to promote high-quality and inclusive digital learning. The plan includes strategies for adapting national education systems to the digital age, in particular through the integration of digital tools, technologies and content to support learning, teaching and assessment and also emphasizes the importance of developing digital skills in students and supports teachers in implementing innovative teaching methods. In particular, the plan envisages the creation of a European digital education platform, the development of a European digital education content framework and the provision of recommendations on the ethical use of artificial intelligence in education (European Education Area, 2025).

The integration of the case law of the European Court of Human Rights into the curricula is an important aspect of modern legal education. First, the decisions of the ECHR establish international human rights standards that are binding on States Parties to the Convention for the Protection of Human Rights and Fundamental Freedoms of 4 November 1950 (Council of Europe, 1950). Ukraine, as a State Party to the Convention, is obliged to take into account the case law of the ECHR in accordance with the Law of Ukraine "On the Execution of Judgments and Application of the Case Law of the European Court of Human Rights" (Law 3477-IV, 2006), which means that national courts and law enforcement agencies must take into account the findings and decisions of the ECHR when conducting criminal proceedings, which makes knowledge of the case law of the Court critically important for the training of future professionals. Additionally, it is worth considering the provisions of the Law of Ukraine "On International Treaties of Ukraine" (Law 1906-IV, 2004), which determines the procedure for applying international treaties, which include the Convention and the practice of the ECHR, which

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

emphasizes the legitimacy and relevance of using the Court's decisions in the training of future lawyers. Secondly, the integration of ECHR decisions contributes to the development of critical thinking and skills in analyzing legal situations, taking into account the legality of international norms, which is especially relevant in the field of criminal law and criminology, where compliance with human rights and the principles of fair trial are key. Thus, to increase the effectiveness of education in the field of criminal law and criminology, it is necessary to combine traditional teaching methods with digital technologies and the integration of ECHR practice. This provides more interactive, practically oriented and inclusive training that meets the requirements of modern society and guarantees the training of specialists capable of applying international human rights standards in the national context.

Digital technologies, including virtual and augmented reality (VR/AR/XR) and educational electronic games, are becoming an important tool in the training of forensic science and criminal justice professionals. They allow for the simulation of crime scenes, the practice of evidence collection and processing techniques, and the development of independent learning and critical thinking skills. The use of such environments also increases the inclusiveness of the educational process, ensuring access to education for students with physical, mental, or family limitations at a time convenient for them.

The following table demonstrates examples of XR technologies and their application in the training of forensic scientists and specialists in related disciplines, highlighting the essence of each technology and ways to integrate it into the educational process.

Table 1.
Examples of the use of augmented reality technologies in teaching criminal law, process and forensics

Technology name	Essence	Method of application
XR (extended Reality)	A general term covering various immersive technologies: virtual reality (VR), augmented reality (AR), and mixed reality (MR). Allows you to create environments ranging from fully virtual to real with technological additions.	Used to recreate crime scenes in 3D, simulate trials, train evidence collection skills, simulate forensic procedures without being physically present on site. Available 24/7, allows for repetitive skill acquisition.
Thinglink	An educational platform for creating interactive XR environments based on images, videos, and 360° content. You can add "hotspots" with text, audio, and links to documents.	Creating interactive learning materials, virtual fieldwork, and laboratory research in forensics. Increases accessibility and inclusiveness of learning, allows for remote, self-paced learning.
Virtual Reality (VR)	Complete immersion in a virtual environment, recreating realistic scenes and situations.	Crime scene modeling, training investigators in evidence collection and analysis, simulation of procedural actions in criminal justice, development of practical skills without risk to students.
Augmented Reality (AR)	Overlaying digital content on the real world via tablets, smartphones or AR glasses.	Using AR for crime scene evidence analysis, visualization of forensic procedures, interactive learning cases for students with real objects and evidence.
Mixed Reality (MR)	The combination of the real and virtual world with interactive interaction of objects.	Simulations of court hearings, training of procedural actions, combined training based on real and virtual materials, creation of scenarios for a comprehensive criminal investigation.
XR field equipment for	Specialized XR equipment for data collection and visualization in the field.	Use in forensics for scene investigation, landscape and evidence analysis, crime

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

geophysics and forensics		scenario modeling, and increasing accuracy and effectiveness of field training.
XR educational electronic game: Forensic Geophysical Search	Fully interactive laboratory environments created using equipment photos, diagrams, text and graphics. Includes sections: introduction, theory, safety, instrument design, calibration, sample analysis.	Students can perform simulated operations with laboratory instruments, analyze data and samples, and navigate through sequential and non-sequential XR materials. The resources were used during the COVID-19 pandemic to provide access to distance learning, which allowed for increased flexibility and accessibility of education. Student and faculty surveys showed high effectiveness and positive perception of such resources (97–100% positive feedback).

Source: (Pringle et al., 2022)

The table demonstrates the pedagogical potential of XR technologies in forensic and legal education, illustrating how immersive and interactive tools can support practical, competency-based learning. In the proposed conceptual model, these technologies are integrated as core components of a digitally mediated educational environment that aligns with European Court of Human Rights standards. For example, VR and AR simulations of crime scenes and procedural actions allow students to practice evidence collection, procedural decision-making, and case analysis in conditions that replicate real-world complexity while minimizing risk. Platforms such as Thinglink and XR educational games provide interactive, self-paced learning environments that reinforce analytical skills, critical thinking, and the ability to apply legal norms in practical scenarios.

By systematically embedding XR technologies within the framework alongside electronic case banks of ECHR decisions, OSINT exercises, and virtual laboratories, the model ensures that students not only acquire theoretical knowledge but also develop the procedural and analytical competencies required in modern criminal justice practice. This integration facilitates continuous, flexible, and inclusive learning while fostering professional skills in legal analysis, investigative reasoning, and the application of international human rights standards. Thus, XR technologies are not standalone tools but functional elements of a structured, competency-oriented educational system that operationalizes the proposed conceptual model.

Augmented reality (XR) environments demonstrate significant potential for effective learning and teaching in forensic science, serving as a useful complement to traditional lectures, practical classes, and field methods. They are particularly valuable due to the possibility of 24/7 continuous access, asynchronous use, and multiple revisions to reinforce knowledge. Students can experiment with different approaches without having to spend time in physical fieldwork or laboratory classes, which are often dependent on weather conditions, equipment availability, or the quality of the course.

However, creating XR learning environments is a labor-intensive process. In particular, the development of educational electronic games requires a high level of programming, thoughtful user experience design, scientific support, and significant time for product development, evaluation, and improvement. For students with limited access to the Internet, low levels of digital literacy, certain physical or mental limitations, or those who are less actively engaged with online learning, such environments can pose serious challenges that should be considered when using them in formal assessment of knowledge.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

In developing countries, the system of training personnel in the field of criminal law, process and forensics faces a number of objective difficulties: limited financial resources, outdated material and technical base and the lack of unified training programs. At the same time, the demand for qualified specialists in this field is universal, and overcoming these barriers is critically important for the effective functioning of the justice system (Nilendu, 2024). One of the promising areas for improving the quality of training of lawyers and forensic scientists is the implementation of a system of evidence-based education, which involves the integration of modern scientific research, technological innovations and the practice of the European Court of Human Rights into training programs. In this learning model, students master not only traditional methods of evidence analysis and procedural tools, but also acquire skills in applying the latest information and communication technologies, digital forensics, and international standards for the protection of human rights, which allows future specialists to combine theoretical knowledge with practice, based on current legal and scientific approaches.

Author's Conceptual Analysis of ICT-Based Criminal Law Education

For example, in a situation of investigation of intentional murder, a graduate trained according to the principles of evidence-based education will be able not only to apply classical forensic methods, but also to use modern digital technologies for collecting and analyzing evidence, as well as to take into account the practice of the ECHR on the admissibility of evidence and compliance with procedural guarantees, which ensures more informed decision-making and improves the quality of the trial. The introduction of evidence-based educational strategies in combination with ICT will contribute to the development of critical thinking, analytical skills and the ability to interdisciplinary problem solving. At the same time, the integration of ECHR practice ensures the unification of training with international standards, which allows students to develop the competencies necessary for working in a globalized legal environment.

Therefore, the implementation of an evidence-based education model in the field of criminal law, process and forensics using ICT and integrating the practice of the ECHR has the potential to significantly improve the quality of training of future specialists. Such an approach will contribute to the combination of classical scientific and legal principles with modern technological solutions and international standards for the protection of human rights, ensuring the effectiveness and fairness of criminal justice in a global dimension.

In addition, OSINT technologies are becoming increasingly important, providing access to open sources of information and its analytical processing. The use of OSINT in the training of lawyers and criminologists allows students to develop practical skills in collecting, verifying and interpreting data from open sources, which is extremely important in criminal investigations and litigation. In the educational context, OSINT technologies act not only as a tool for digital forensics, but also as a methodology for developing critical thinking and the ability to work with large amounts of information. The study by Matvienko & Tsyvin (2024) emphasizes that the integration of OSINT into educational programs creates interdisciplinary opportunities, allowing for the combination of legal, information and technological competencies. OSINT is of particular importance in the field of criminal proceedings, as its use can help not only in collecting evidence, but also in ensuring the ECHR standards on access to justice and fair trial. For example, open source data can confirm or refute the claims of the parties, help the lawyer in protecting the rights of the client, or ensure the transparency of procedural actions. In a practical sense, as Torbas (2024) notes, OSINT opens up wide opportunities for the investigation of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

criminal offenses, in particular cybercrime, fraud or crimes against the person. The ability of students to apply such tools in simulated learning environments allows them to combine theory with practice.

From the perspective of the development of legal education, the implementation of OSINT contributes to innovation and compliance with modern challenges of the digital age. As Baadzhi (2023) rightly notes, the latest tools, in particular artificial intelligence and OSINT, are becoming integral elements of the training of lawyers of the future, as they allow the formation of skills in data analysis, evidence and information security.

Thus, the integration of OSINT into curricula in criminal law, process, and forensics, combined with ICT and the practice of the ECHR, contributes to the formation of highly qualified specialists capable of operating effectively in the conditions of a modern information society and ensuring the implementation of the principles of fair trial.

Normative Implications for Legal Education and Professional Training

In this context, it is also important to integrate practical guarantees of the right to a defence, such as guaranteed access to a lawyer from the moment of detention, a standard set out in the FRA 2019 report, as well as in the Handbook on European Law on Access to Justice (FRA, 2019). These documents highlight the importance of the practical implementation of the right to a defence in criminal proceedings, which meets the standards of the ECHR, and which should be integrated into curricula. Therefore, the integration of evidence-based education together with ICT and the practice of the ECHR is the foundation for the formation of modern, effective, innovative and human rights-oriented legal education, capable of preparing specialists for the challenges of international criminal justice.

The approach that promotes the integration of information and communication technologies into the process of studying the case law of the European Court of Human Rights opens up new opportunities for the formation of high-quality legal education and allows combining traditional teaching methods with innovative digital tools, ensuring accessibility, interactivity, and practical orientation of the educational process.

At this stage, promising areas include: the creation of electronic case banks of ECHR decisions with scientific and practical comments, which will contribute to the development of analytical skills of students and practitioners, allowing them to combine the analysis of decisions with their critical reflection; the use of interactive maps and visualizations, for example, a "map" of human rights violations in cases against individual states, which makes it possible to trace the dynamics and geography of systemic problems in the field of human rights; online modeling of processes with reference to ECHR precedents, which simulates judicial debates, procedural actions and legal analysis, ensuring the formation of practical skills in the application of international standards in the national context.

At the same time, despite significant potential, the implementation of ICT and the practice of the ECHR in the legal education system is accompanied by a number of challenges. Among them: insufficient funding for educational and scientific projects aimed at the digitalization of legal education; technical barriers associated with the lack of proper infrastructure, software or stable access to electronic resources; lack of training of teachers, which limits the possibilities of effective use of digital

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.

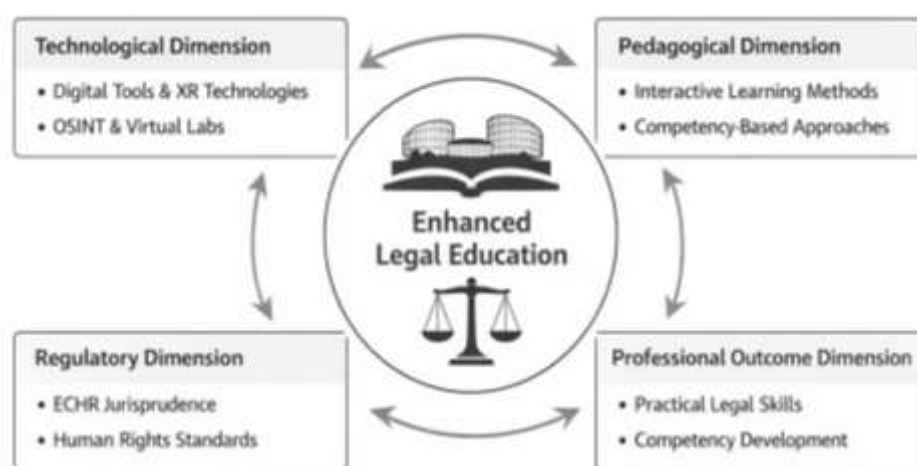


Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

technologies in the educational process.

Moreover, the development of this direction opens up new prospects: the formation and development of legal clinics in an online format, which will allow students to provide legal assistance remotely, while simultaneously increasing their own professional competence; cooperation with international institutions and educational platforms, which ensures the exchange of best practices and increases academic mobility; expanding access to open data, including databases of decisions of the ECHR and other international bodies, which creates a more transparent and inclusive environment for legal education.

Thus, despite the existing difficulties, the integration of ICT and ECHR practice into legal education is a promising direction that can qualitatively change the training of lawyers, making it more modern, adaptive, and focused on international human rights standards.



Conceptual Framework for the Integration of ICT and ECHR Jurisprudence in Legal Education

Figure 1. Conceptual Framework for the Integration of ICT and ECHR Jurisprudence in Legal Education.

The conceptual framework for integrating ICT and the jurisprudence of the European Court of Human Rights (ECHR) into legal education (Figure 1) is structured around four interrelated dimensions—technological, pedagogical, regulatory, and professional outcomes—which together form a coherent, system-oriented model of enhanced legal education. The technological dimension encompasses digital platforms (e.g., Moodle, OpenEdX, Zoom) and advanced tools such as XR environments, virtual laboratories, and OSINT technologies that enable simulation-based and data-driven learning. These tools support the pedagogical dimension, which is based on interactive, competency-oriented approaches, including case-based learning, simulations, and the integration of ECHR jurisprudence to develop critical thinking and analytical skills. As demonstrated in the text, the shift toward blended and distance learning—accelerated by the COVID-19 pandemic and wartime conditions in Ukraine—highlights both the necessity and effectiveness of such digitally mediated educational models.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

The regulatory dimension ensures that the content and structure of legal education are aligned with international human rights standards, particularly the Convention for the Protection of Human Rights and Fundamental Freedoms and the case law of the ECHR. National legal frameworks, including the Laws of Ukraine on the execution of ECHR judgments and on international treaties, further reinforce the obligation to integrate these standards into legal training. This normative layer interacts dynamically with technological and pedagogical components, for example through the use of XR simulations of crime scenes or procedural actions that incorporate ECHR principles of fair trial and admissibility of evidence. At the same time, the framework acknowledges existing challenges, such as limited funding, technical barriers, and insufficient digital competencies among educators, which may affect the implementation of ICT-based approaches.

The professional outcomes dimension reflects the ultimate objective of the model—the formation of highly qualified legal professionals capable of applying both technological tools and international human rights standards in practice. Through the integration of ICT, ECHR case law, and evidence-based education, students develop practical skills in evidence analysis, procedural decision-making, and legal reasoning in complex, digitally mediated environments. As illustrated in the text, tools such as OSINT and XR not only enhance accessibility and inclusiveness but also create opportunities for interdisciplinary and practice-oriented learning. Thus, the framework conceptualizes legal education as a dynamic and adaptive system in which technological innovation, pedagogical transformation, and normative alignment jointly contribute to the development of professional competencies required in modern criminal justice systems.

Conclusions

Analysis of the current state of teaching criminal law, process and forensics in Ukrainian universities indicates the presence of a number of systemic problems associated with the dominance of theoretically oriented courses and an insufficient level of practice-oriented training. The use of innovative educational technologies, in particular electronic platforms, virtual simulations of court proceedings and digital forensic laboratories, is currently fragmentary and not always methodologically justified. Among the main obstacles, the obsolescence of educational and methodological materials, the lack of unified digital solutions for teaching special disciplines, as well as insufficient training of teachers to work with the latest information technologies should be highlighted. Although universities are actively implementing interactive educational environments based on the Moodle, Prometheus or OpenEdX platforms, the systematic development of specialized courses using digital forensic laboratories, as well as the improvement of the digital competence of scientific and pedagogical workers is not observed.

The practical integration of ECHR decisions into training allows students to practice specific skills in case law analysis. For example, the creation of electronic case banks with comments makes it possible to simulate various scenarios: for example, assessing the lawfulness of detention under the European Convention on Human Rights or considering cases on the rights of defense in criminal proceedings. The use of interactive maps of human rights violations allows for the visualization of geographical and typological patterns of violations in national systems, and online simulation of trials allows students to practice procedural decisions in a safe environment. In addition, digital forensic laboratories and XR technologies (augmented reality) allow for the reproduction of crime scenes and laboratory processes. For example, the Thinglink platform is used to simulate the operation of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

a polarizing microscope, an XRF spectrometer, an ion chromatography system, and a laser particle size analyzer. Each XR tool includes a theoretical block, safety instructions, a sample calibration and analysis module, as well as interactive “hot spots” with additional data and images. Students can analyze real datasets, practicing evidence collection and processing techniques without leaving the classroom or their own home, which is especially relevant for students with disabilities or during pandemic restrictions. An important tool in modern legal education is OSINT technologies, which are used both in student training and in the practical activities of investigators. The use of open sources of information allows you to simulate crime investigations, collect data for forensic analysis, and practice practical skills in working with information resources. For example, students can analyze digital traces in social networks or open databases, integrating the information obtained into virtual forensic cases. Thus, the combination of interactive digital platforms, XR technologies, case banks of ECHR decisions, and OSINT allows you to create a modern educational environment that combines theory and practice. This contributes to the formation of students' professional competencies, the development of critical thinking and skills in analyzing real-world situations, while increasing the inclusiveness of learning and providing access to modern methods of criminal science even in conditions of limited resources.

The use of electronic resources, such as databases of ECHR decisions (for example, HUDOC) and legal search engines (Google Scholar, the website of the Verkhovna Rada of Ukraine, etc.), is a key tool for the formation of modern professional competencies in law students. These resources provide access to a large amount of relevant legal information and practice of the ECHR, which allows students to work on real cases, analyze court decisions and compare them with national legislation. At the same time, the created and translated electronic case banks of ECHR decisions with comments and interactive diagrams allow students not only to familiarize themselves with theoretical provisions, but also to practice legal analysis algorithms. The integration of ICT into curricula will ensure the creation of a comprehensive educational environment that combines distance platforms (Moodle, OpenEdX), virtual laboratories (XR-simulations of forensic processes) and electronic cases of ECHR decisions. Such synergy allows students to form both theoretical knowledge and practical skills that meet the modern requirements of professional activity.

This study has demonstrated that the modernization of legal education in the fields of criminal law, criminal procedure, and forensic sciences requires not only the introduction of digital technologies, but also their systematic alignment with international human rights standards developed in the practice of the European Court of Human Rights. The proposed conceptual framework integrates technological, pedagogical, normative, and outcome-oriented components and offers a structured approach to ICT-based legal education grounded in the principles of the rule of law and fair trial.

The main contribution of this research lies in the formalization of a comprehensive conceptual model that unifies dispersed strands of literature on educational technologies, criminal justice training, and ECHR jurisprudence. By articulating the interaction between ICT tools, competency-based pedagogy, and human rights norms, the study advances the theoretical foundations of technology-mediated legal education and provides guidance for curriculum design and methodological development.

At the same time, the study has certain limitations. It is based on doctrinal and conceptual analysis and does not include empirical testing of the proposed

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

framework in specific educational settings. In addition, the normative focus on ECHR standards reflects the European legal context and may require adaptation when applied to other regional human rights systems.

Future research should focus on the empirical validation of the proposed framework through pilot educational programs, comparative studies across jurisdictions, and assessment of learning outcomes associated with ICT-based legal training. Further investigation into the ethical and regulatory implications of artificial intelligence and digital evidence in legal education also represents a promising direction for interdisciplinary research.

Bibliographic references

- Baadzhi, N. P. (2023). The latest tools of legal education in the age of artificial intelligence. *Legal Scientific Electronic Journal*, (12), 233–239. Retrieved from http://lsej.org.ua/12_2023/57.pdf
- Council of Europe. (1950, November 4). *Convention for the Protection of Human Rights and Fundamental Freedoms of November 4, 1950*. European Convention on Human Rights (E.T.S. No. 5; 213 U.N.T.S. 221). Retrieved from <https://www.echr.coe.int/european-convention-on-human-rights>
- Chaussée, A. S., Winter, J., & Ayres, P. (2022). Approaches to decolonising forensic curricula. *Science & Justice*, 62(6), 795–804. <https://doi.org/10.1016/j.scijus.2022.06.003>
- Custers, B., & Stevens, L. (2024). *Data as Evidence in Criminal Courts*. Cambridge University Press. Retrieved from <https://doi.org/10.1017/9781009431453.014>
- de Sousa Santos, B. (2021). *Decolonising the University: The Challenge of Deep Cognitive Justice*. Cambridge: Cambridge Scholars.
- Donnelly, S. (2012). Forensic Science in a Human Rights Framework. *Australian Journal of Forensic Sciences*, 44(1), 93–103. <https://doi.org/10.1080/00450618.2011.610822>
- Dryshliuk, V., Chanysheva, A., Borychenko, K., Kravchenko, S., & Hotsuliak, Y. (2025). Application of the practice of the ECHR in legal education: impact on the formation of judicial culture and the protection of human rights. *Revista Eduweb*, 19(2), 107-121. <https://doi.org/10.46502/issn.1856-7576/2025.19.02.8>
- European Education Area. (2025). *Digital Education Action Plan: Policy background*. <https://education.ec.europa.eu/focus-topics/digital-education/plan>
- FRA. (2019). *Rights in practice: access to a lawyer and procedural rights in criminal and European arrest warrant proceedings*. Retrieved from <https://acortar.link/dlqP2A>
- Jeffery, A. J., Rogers, S. L., & Jeffery, K. L. A., & Hobson, L. (2021). A flexible, open, and interactive digital platform to support online and blended experiential learning environments: Thinglink and thin sections. *Geosci. Commun*, 4, 95–110. <https://doi.org/10.5194/gc-4-95-2021>
- Lorente, L. M. L., Arrabal, A. A., & Pulido-Montes, C. (2020). The Right to Education and ICT during COVID-19: An International Perspective. *Sustainability*, 12(21), 9091. <https://doi.org/10.3390/su12219091>
- Lundy, L., & Martínez Sainz, G. (2018). The Role of Law and Legal Knowledge for a Transformative Human Rights Education: Addressing Violations of Children's Rights in Formal Education. *Human Rights Education Review*, 1(2), 04–24. <https://doi.org/10.7577/hrer.2560>
- Matvienko, O., & Tsyvin, M. (2024). "OSINT technologies" as an educational component of the specialty "Information, library and archival studies": pedagogical goal-setting. *Ukrainian Journal of Library and Information Sciences*, (13), 145–156. <https://doi.org/10.31866/2616-7654.13.2024.307136>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- Mayne, R., & Green, H. (2020). Virtual reality for teaching and learning in crime scene investigation. *Science & Justice*, 60(5), 466–472. <https://doi.org/10.1016/j.scijus.2020.07.006>
- McBride, J. (2009). *Human rights and criminal procedure*. Case law of the European Court of Human Rights. Council of Europe. Retrieved from https://www.echr.coe.int/documents/d/echr/pub_coe_criminal_procedure_2009_eng
- McBride, J. (2021). *The doctrines and methodology of interpretation of the European Convention of Human Rights by the European Court of human rights*. Council of Europe Publishing. Retrieved from <https://rm.coe.int/echr-eng-the-doctrines-and-methodology-of-interpretation-of-the-europe/1680a20aee>
- Muntjewerff, A. J. (2009). ICT in Legal Education. *German Law Journal*, 10(6–7), 669–716. <https://doi.org/10.1017/S2071832200001292>
- Nilendu, D. (2024). Enhancing forensic education: exploring the importance and implementation of evidence-based education system. *Egyptian Journal of Forensic Sciences*, 14. <https://doi.org/10.1186/s41935-023-00375-w>
- Nilupu-Moreno, K., Riega-Virú, Y., Puga-Ayala, E. M., & Salas-Riega, J. L. (2024). *Legaltech in legal education: A systematic review of the training of technological competencies*. IEEE. DOI: <https://doi.org/10.1109/ICALTER65499.2024.10819225>
- Law of Ukraine No. 1906-IV. *On International Treaties of Ukraine*. (2004, June 29). Retrieved from <https://zakon.rada.gov.ua/laws/show/1906-15>
- Law of Ukraine No. 3477-IV. *On the Execution of Decisions and Application of the Practice of the European Court of Human Rights*. (2006, February 23). Retrieved from <https://zakon.rada.gov.ua/laws/show/3477-15/ed20121202>
- Pringle, J., Stimpson, I., Jeffery, A., Wisniewski, K., Grossey, T., Hobson, L., Heaton, V., Zholobenko, V., & Rogers, S. (2022). Extended reality (XR) virtual practical and educational eGaming to provide effective immersive environments for learning and teaching in forensic science. *Science & Justice*, 62(6), 696–707. <https://doi.org/10.1016/j.scijus.2022.04.004>
- Selwyn, N. (2007). The use of computer technology in university teaching and learning: a critical perspective. *Journal of Computer Assisted Learning*, 23(2), 83–94. <https://doi.org/10.1111/j.1365-2729.2006.00204.x>
- Salazar Chica, M. A., & Palencia Salas, V. (2025). Teacher training in ICT and learning technologies: A bibliometric analysis. *Contemporary Readings in Law and Social Justice*, 17(1), 571–583. <https://doi.org/10.52783/crlsj.542>
- Torbias, O. O. (2024). *OSINT in the investigation of criminal offenses*. Odesa, Ukraine: Jurydika. <https://doi.org/10.32837/11300.27740>
- Vuille, J., Lupària, L., & Taroni, F. (2017). Scientific evidence and the right to a fair trial under Article 6 ECHR. *Law, Probability & Risk*, 16(1), 55–68. <https://doi.org/10.1093/lpr/mgx001>
- Yu, Y. (2023). Discussion on the Reform of Higher Legal Education in China Based on the Application and Limitation of Artificial Intelligence in Law Represented by ChatGPT. *Journal of Education, Humanities and Social Sciences*, 14, 220–228. <https://doi.org/10.54097/ehss.v14i.8840>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Enfoques innovadores potenciados por la tecnología digital en la formación de futuros profesores de lenguas extranjeras

Digital technology-enhanced innovative approaches in future foreign language teacher education

Oleksandra Shynkaruk¹  Yuliia Liakhovska²  Victoria Kylyvnyk³  Ivanna Zaremska⁴  Oksana Doichyk⁵ 

Afiliación autor:

¹ Candidate of Legal Sciences, Associate Professor, Associate Professor of the Department of Philosophy and International Communication, National University of Life and Environmental Sciences of Ukraine, Ukraine. aleksandra.shyn5@gmail.com

² Doctor of Philosophy, Military Institute, Taras Shevchenko National University of Kyiv, Ukraine. lyrebird26@ukr.net

³ Candidate of Pedagogical Science, Teacher of English, Communal Higher Education Institution «Vinnytsia Humanities Pedagogical College», Ukraine. vicakiliivnik1982@gmail.com

⁴ Candidate of Philological Sciences, Senior Lecturer at the Department of Foreign Languages and Teaching Methods, Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Ukraine. zaremska@gnpu.edu.ua

⁵ PhD in Philology, Associate Professor, Associate Professor at the Department of English Philology, Vasyl Stefanyk Carpathian National University, Ukraine. oksana.doichyk@cnu.edu.ua

Recibido: 13/02/26
Aceptado: 16/05/26

Cómo citar:

Shynkaruk, O., Liakhovska, Y., Kylyvnyk, V., Zaremska, I., & Doichyk, O. (2026). Digital technology-enhanced innovative approaches in future foreign language teacher education. *Revista Eduweb*, 20(2), 208-228. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.13>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Resumen

El artículo examina la importancia y las características clave de las tecnologías digitales y los enfoques innovadores en la formación de futuros profesores de lenguas extranjeras. Aunque las tecnologías digitales son ampliamente utilizadas en la enseñanza de idiomas, los estudios existentes se centran principalmente en herramientas individuales y plataformas en línea, en lugar de sistemas pedagógicos integrados que fomenten de manera sistemática la competencia digital en los programas de formación docente. El objetivo de este estudio fue investigar la eficacia de un sistema innovador de formación apoyado en tecnologías digitales e identificar las condiciones pedagógicas que contribuyen al desarrollo de la competencia digital en futuros profesores de lenguas extranjeras. El estudio empleó un diseño cuantitativo cuasi experimental con grupo control y grupo experimental. El análisis estadístico se realizó mediante la prueba de chi-cuadrado de Pearson. Los participantes fueron estudiantes de maestría matriculados en programas de formación de profesores de lenguas extranjeras. Los resultados demostraron mejoras estadísticamente significativas en los componentes motivacional, cognitivo, de actividad y comunicativo de la competencia digital entre los estudiantes del grupo experimental. Los hallazgos confirman la eficacia del sistema innovador propuesto, que integra plataformas digitales, gamificación, aprendizaje móvil y herramientas colaborativas en línea para fortalecer la competencia digital en la formación docente.

Palabras clave: tecnologías digitales, futuros profesores de lenguas extranjeras, enfoques innovadores, competencia digital, formación docente.

Abstract

The article examines the importance and key characteristics of digital technologies and innovative approaches in the training of future foreign language teachers. Although digital technologies are widely used in language education, existing studies mainly focus on individual tools and online platforms rather than on integrated pedagogical systems that systematically foster digital competence in teacher education programs. The purpose of this study was to investigate the effectiveness of an innovative training system supported by digital technologies and to identify the pedagogical conditions that contribute to the development of digital competence among future foreign language teachers. The study employed a quantitative quasi-experimental design with a control group and an experimental group. Statistical analysis was conducted using Pearson's chi-square test. The participants were master's students enrolled in foreign language teacher education programs. The results demonstrated statistically significant improvements in the motivational, cognitive, activity, and communicative components of digital competence among students in the experimental group. The findings confirm the effectiveness of the proposed

innovative system integrating digital platforms, gamification, mobile learning, and collaborative online tools for strengthening digital competence in teacher education.

Keywords: digital technologies, future foreign language teachers, innovative approaches, digital competence, teacher education.

Introduction

Despite the increasing attention devoted to the integration of digital technologies into foreign language education, the existing body of research mainly focuses on the application of individual digital tools, platforms, or isolated teaching techniques. Many studies analyze the motivational potential of gamification, the role of artificial intelligence in language learning, or the advantages of online learning environments (Wozniak et al., 2018). However, these studies rarely address the systemic integration of digital technologies into the professional training of future foreign language teachers within higher education programs (Tai et al., 2022).

Furthermore, previous research often emphasizes technological innovation itself rather than examining the pedagogical conditions and structured educational models that ensure the effective development of digital competence among future teachers (Markauskaite et al., 2023). As a result, the issue of designing and empirically validating a comprehensive innovative system that combines digital technologies with pedagogically grounded training approaches remains insufficiently explored in contemporary educational research (Videnovik et al., 2023).

Therefore, the research gap lies in the lack of empirically tested models that integrate digital technologies, innovative pedagogical approaches, and specific pedagogical conditions aimed at the systematic development of digital competence among future foreign language teachers.

In this context, the research problem of the present study is to determine how the implementation of an integrated innovative system and pedagogical conditions supported by digital technologies influences the development of digital competence in future foreign language teachers in higher education institutions (Zhang & Zou, 2020).

Literature Review

Researchers increasingly emphasize the importance of integrating digital technologies into foreign language education and teacher training. According to Galante et al. (2023), digital plurilingual pedagogies create favorable conditions for improving oral communication in foreign language classes and encourage students to actively use the target language. The authors argue that such approaches mobilize learners' entire linguistic repertoire through cross-linguistic comparisons, translanguaging, and multimodal interaction in digital environments. Their study also demonstrated that synchronous digital platforms contribute to the development of plurilingual and pluricultural awareness among students.

Schaefer et al. (2019) consider digital technologies an essential component of modern foreign language learning. The researchers state that tools such as web conferencing, digital games, digital storytelling, and telecollaboration expand opportunities for language acquisition and allow students to experience more flexible and interactive forms of learning. In their opinion, digital resources contribute to the

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

development of learners' autonomy, communication skills, and engagement in the educational process.

Harvey Arce & Cuadros Valdivia (2020) focus on the motivational potential of gamification in foreign language learning. The authors developed a digital platform based on competitiveness and gamified activities and concluded that gamification elements, including rankings, medals, and progress indicators, significantly increase students' motivation to learn foreign languages. According to their findings, most participants preferred gamified digital tools and demonstrated greater interest in language learning through interactive educational environments.

Jacome Paredes et al. (2025) investigate the role of artificial intelligence in vocabulary retention among foreign language students. The researchers argue that AI-powered tools, including intelligent tutoring systems and augmented reality applications, improve long-term vocabulary retention, writing accuracy, and learner motivation. At the same time, the authors point out certain limitations of AI technologies, such as occasional inaccuracies and insufficient opportunities for authentic conversational practice, emphasizing the necessity of further improvement of adaptive digital learning environments.

Finocchiaro & Leto (2018) underline the importance of combining digital learning with foreign language education in innovative laboratory settings. According to the authors, the use of multimedia tools, virtual platforms, and flipped classroom approaches promotes students' autonomy, teamwork, and creativity. They emphasize that digital technologies allow students not only to learn a foreign language but also to use it practically while creating their own educational products and participating in collaborative activities.

Moisés & Borges (2021) analyze the process of technological appropriation by teachers of Portuguese as a foreign language during the COVID-19 pandemic. The researchers stress that the rapid transition to online education revealed the crucial role of teachers' digital competence and professional training. In their view, effective integration of digital technologies depends on teachers' ability to adapt pedagogical practices to new digital environments and to apply innovative teaching approaches in everyday educational activities.

Thus, the analyzed studies demonstrate that digital technologies significantly influence the development of foreign language education and teacher preparation. Researchers highlight the positive effects of digital platforms, gamification, artificial intelligence, telecollaboration, and multimedia environments on students' motivation, communication, autonomy, and digital competence. However, despite the considerable attention devoted to digital technologies in language education, the issue of developing a comprehensive innovative system and pedagogical conditions for training future foreign language teachers using digital technologies remains insufficiently researched. Therefore, further studies are needed to investigate the integrated formation of digital competence among future foreign language teachers in higher education institutions.

Research purpose: to analyze the effect of implementing pedagogical strategies supported by digital technologies on the development of digital competence in future foreign language teachers.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Methodology

This study employed a quantitative quasi-experimental research design to evaluate the effectiveness of an innovative system supported by digital technologies in the development of digital competence among future foreign language teachers. The methodological framework was based on the comparison of a control group and an experimental group before and after the implementation of the pedagogical intervention.

Research Design

The study was conducted during 2023–2025 and included two main stages: an ascertaining stage and a formative stage. During the ascertaining stage, the initial level of digital competence among participants was identified in order to determine the homogeneity of the control and experimental groups. During the formative stage, the innovative system and the pedagogical conditions supported by digital technologies were implemented with the experimental group, while the control group continued its training through traditional instructional approaches.

The research followed a pre-test and post-test logic. The initial diagnosis allowed the researchers to establish the baseline levels of digital competence, while the final diagnosis made it possible to compare the changes achieved after the intervention.

Participants

The study involved 122 master's students enrolled in foreign language teacher education programs. The participants were divided into two independent groups: 60 students in the control group and 62 students in the experimental group. At the beginning of the experiment, both groups demonstrated approximately equivalent levels of digital competence, which allowed the researchers to compare the effects of the intervention.

Pedagogical Intervention

The experimental group participated in an innovative training system focused on the pedagogical use of digital technologies in foreign language teacher education. This system included the use of digital educational platforms, cloud technologies, multimedia resources, gamification strategies, mobile applications, virtual learning environments, collaborative online tools, and digital content creation activities.

Students in the experimental group worked with resources such as Google Classroom, Moodle, Zoom, YouTube, blogs, social networks, and Wiki technologies. They also participated in project-based activities, online collaboration, interactive tasks, and the creation of digital educational products.

A special course entitled "Foreign Language Teacher in the Conditions of Digital Transformation of Education" was implemented as part of the intervention. This course included the use of AR/VR applications, Google Workspace for Education, gamification platforms, and the development of educational products such as chatbots, interactive quests, and mobile applications.

The pedagogical conditions implemented during the intervention were:

- Creation of an innovative digital educational environment.
- Integration of online platforms and cloud services into the educational process.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Modeling of communicative pedagogical situations through debates, master classes, and business games.
- Practice-oriented professional training using digital technologies.

Criteria and Indicators

The development of digital competence was assessed through four components:

- Motivational component: related to students' awareness of the value of digitalization and their motivation to develop digital competence.
- Cognitive component: related to knowledge of digital technologies and understanding of their pedagogical application in foreign language education.
- Activity component: related to the ability to use digital technologies for learning and teaching foreign languages.
- Communicative component: related to the ability to organize and participate in foreign language communication through digital technologies.

For each component, three levels of development were established: low, average, and high.

Data Collection

Data were collected through diagnostic assessments applied at the beginning and at the end of the pedagogical experiment. These assessments made it possible to identify the distribution of students across the low, average, and high levels of digital competence in both the control and experimental groups.

The comparison between the initial and final results allowed the researchers to determine the degree of progress achieved by each group and to evaluate the effectiveness of the innovative system implemented in the experimental group.

Data Analysis

The quantitative data were analyzed using Pearson's chi-square test. This statistical test was applied to compare the distribution of students across the three levels of digital competence in the control and experimental groups.

The null hypothesis stated that there were no statistically significant differences between the control and experimental groups. The alternative hypothesis stated that there were statistically significant differences between both groups after the implementation of the innovative system.

The level of statistical significance was set at $\alpha = 0.05$. When the empirical chi-square value exceeded the critical value, the null hypothesis was rejected and the alternative hypothesis was accepted.

Ethical Considerations

The study was conducted with respect for the principles of voluntary participation, confidentiality, and responsible use of the information collected. The data were analyzed in aggregate form, without identifying individual participants.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Results and Discussion

The importance and key features of digital technologies and innovative approaches in training future foreign language teachers. The content of the main concepts of the study. Modern platforms for innovative teacher training.

In the educational process of higher education, digitalization, which directly depends on the level of each student's mastery of digital technologies, is aimed at lifelong learning, i.e., lifelong learning – a continuous learning process. In the conditions of digitalization, the priority tasks of the development of higher education should include the training of future foreign language teachers using digital technologies, using innovative approaches to their training, resource filling of the educational environment with modern digital learning tools, and ways of effective use of digital technologies by teachers and higher education students (Lisborg et al., 2021).

Particularly high demands are placed on innovative changes in education regarding the level of practical training and theoretical knowledge of future foreign language teachers. The readiness of future foreign language teachers to use digital technologies in their professional activities ensures the ability to use digital technologies, which creates the basis for the formation of competence and digital literacy in them, which the EU recognizes as one of the key competencies of a person for a full life and activity (Seiler et al., 2017).

Future foreign language teachers must be able to tailor the educational process to each student's personality and enhance their professional practice, guiding each student toward a multitude of opportunities for highly effective, independent development. This is in a fundamentally new context, focusing on the need to create modern pedagogical systems aimed at innovative activity, to determine the content and issues of personal and professional training for teachers, and to ensure the search for future specialists using new approaches to learning.

The possibilities of working with information have changed the intensive development of digital technologies. A characteristic feature of digital technologies is their ability to provide unlimited opportunities for creative joint and independent activity of students and teachers. The introduction of digital technologies into the educational process provides new opportunities for students' development, facilitates the acquisition of skills, increases interest in professional activity, and contributes to better assimilation of the material, making students' lives less stressful and more interesting (Alvarez-Flores, 2021).

Continuous improvement of pedagogical activity determines the dynamism of the introduction of innovative technologies into all spheres of life. In pedagogy, the terms "innovative" and "innovation" refer to innovations that concern the modern aspects of the higher education process. In innovative technologies, non-standard approaches are used to organize students' educational activities, thereby developing original educational goals, methods, and forms of learning.

The communicative space of innovative learning offers modern platforms for future teachers to learn: Google Meet, Google Classroom, Moodle, Microsoft Teams, Zoom, Kahoot, Google Hangouts, Cisco Webex, etc. The future teacher can use any resource (YouTube, podcasts, blogs, Twitter, educational websites, mobile applications, bookmarks, etc.) that is at the same time a means of development and a means of learning to contribute to students' motivation. During the training, students present the studied material as a "mind map", a scribe presentation, a PowerPoint presentation, a "brainstorming", a role-playing game, a "case method",

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

an "open microphone", a competition with practical tasks with subsequent discussion, etc. (Petri & Gresse von Wangenheim, 2017).

In the context of information abundance, digital competence acquires special significance; it is currently defined as an educational key competence and provides students with the skills to act in relation to information across educational areas, subjects, and the world around them. In modern universities, students use various forms of working with information, but this is often perceived by students as part of subject information and occurs spontaneously. The availability of information and its significant amount create the illusion for students that it is easy to obtain knowledge about anything. Therefore, the teacher must actively involve students in the educational process and create a relaxed learning atmosphere in the lesson. Modern students are a generation of the digital age. Therefore, they confidently use smartphones, computers, and the Internet, tablets, and other mobile devices in everyday life (Guerrero-Quíñonez et al., 2023).

Main approaches to groups of innovative technologies in the context of professional foreign language training of future foreign language teachers.

In the context of professional foreign language training of future foreign language teachers, several main approaches to groups of innovative technologies can be conditionally distinguished:

- Information and communication technologies (ICT), which include the use of interactive platforms, virtual rooms, electronic resources, video content, distance learning systems (Moodle, Google Classroom, etc.), form the digital competence of higher education students, ensure individualization of learning, and allow creating a dynamic, interactive environment of the educational space (Ngandu et al., 2023).
- Distance and blended learning ensure accessibility and flexibility in the higher education process. Thanks to such approaches, future foreign language teachers have the opportunity to master professional material in a convenient mode, combining traditional classes with online activity (Martynets et al., 2020).
- Gamification for learning a foreign language is a powerful means of increasing students' motivation (Zainuddin et al., 2020). The introduction of game elements, such as role-playing scenarios, quests, quizzes, and competitions, reduces the psychological barrier to communication and enables future foreign language teachers to engage in active language interaction (Elshiekh & Butgerit, 2017).
- The project approach in education creates conditions for the practical application of professional knowledge in simulated or real situations. During project implementation, future foreign language teachers learn to argue for their positions, engage in dialogue, search for information in a foreign language, work in a team, and present their results, thereby developing communicative, linguistic, and organizational skills.
- Mobile learning creates conditions in higher education for the use of social networks, online platforms, and mobile applications for language learning, both autonomous and group, allowing you to adapt the educational process to the individual pace and style of learning and ensure continuity of education.
- A problem-based and contextual approach to learning aims to create educational situations that closely resemble real pedagogical activity, allowing students to use a foreign language as a tool for solving problems and communicating to model professional situations they may encounter in future practice. In general, each of the analyzed innovative approaches in higher

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

education performs certain functions: cognitive, communicative, motivational, and organizational.

Moreover, the combination of such approaches in the context of professional foreign language training for future foreign language teachers ensures the integrity of the training, contributes to the formation of the future teacher's general professional readiness to work in an innovative educational environment, and to the formation of professional foreign language competence.

Experimental verification of the effectiveness of the innovative system and pedagogical conditions for training future foreign language teachers using digital technologies.

During 2023-2025, an experimental study was conducted to evaluate the effectiveness of the developed innovative system and the pedagogical conditions for training future foreign language teachers to develop their digital competence using digital technologies.

Students of the second (master's) level were involved in the experimental study. The purpose of the research and experimental work was to verify the effectiveness of the developed innovative system and the pedagogical conditions for training future foreign language teachers to develop their digital competence using digital technologies.

At the study's ascertaining stage, the initial level of digital competence formation among future foreign language teachers was established. To determine whether statistically significant differences exist between the experimental and control groups, the data obtained were analyzed using statistical methods.

At the formative stage, the developed innovative system and pedagogical conditions for training future foreign language teachers to develop their digital competence were implemented in the experimental group. CG students studied according to the usual methodology.

The educational web resources developed for the EG were used and placed in the system's web space for training future foreign language teachers using digital technologies of the global or local network in various formats (audio and video, graphics, text, archive formats). Wiki sites formed a special category. Their use in the educational activities of EG students opened up wide opportunities for organizing research, implementing freedom in learning, and for the independent accumulation and assimilation of knowledge. Using wiki technology, EG students had the opportunity to exchange ideas, quickly and effortlessly place various educational web resources, create a powerful source of educational web resources, and reuse posted web resources. EG students worked with the WikiWiki service, a convenient platform for organizing educational projects and presenting creative developments jointly.

To prepare future foreign language teachers using digital technologies, various services played an important role in EG: YouTube, virtual sites, blogs, webcasts, social networks, and special bookmarks. Let us note the most effective tools and innovative approaches for the development of the digital environment of education in higher education that were proposed for EG students: mobile devices, mobile web applications for any devices and platforms, a collection of mobile, universal HTML5 applications for website development, "cloud" applications, Personal Cloud

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

(provides access to data and applications), "Internet of Things", Strategic Big Data – processing of large data sets, Hybrid IT & Cloud Computing – cloud" calculations.

The use of the Smart Board has fundamentally changed the teaching methodology for EG students and helped the teacher ensure each student's active participation in the lesson. Thanks to the Smart Board – an interactive board, students began to understand complex ideas as a result of an effective, clear, and dynamic presentation of professional material. This allowed teachers, turning to innovative modern resources, to adapt to specific needs and use different learning styles, because the Smart Board gallery contains a variety of tools and interactive tools for students to work on mastering meta-subject methods of activity.

Among the interesting innovative approaches using digital technologies to train future foreign language teachers in EG was the rapid adaptation of online learning, which manifested itself in the active use of online courses, for example, open international online courses on the Coursera platform or others, and in the development of blended learning.

Digital libraries at higher education institutions provided significant support for the application of digital technologies in education in EG. Thanks to digitalization, each student of higher education gains access to information that was previously available only to experts and scientists.

The implementation of the stage of training future foreign language teachers using digital technologies in the EG took place through specially organized pedagogical conditions, digital tools, and interactive approaches that contribute to increasing professional interest and awareness of the significance of innovations.

A special course was developed and implemented in the EG: "Foreign language teacher in the conditions of digital transformation of education". Future foreign language teachers were involved in testing lesson fragments and designing using modern digital tools (AR/VR applications, Google Workspace for Education, gamification platforms), and in creating educational products – interactive quests, mobile applications, chatbots.

The system-forming factor was the pedagogical conditions:

- Creation of an innovative educational and developmental digital environment that integrates modern innovative pedagogical approaches, digital technologies, and the infrastructure of an educational institution to provide students with innovation, interactivity, adaptability, support, and openness of personalized learning.
- Innovative approaches to combining online platforms, cloud services, digital simulators, and virtual laboratories that promote flexibility and personalization of learning.
- Modeling of pedagogical communicative situations, master classes, educational debates, and business games, mastering innovative tools that will contribute to the formation of the ability to predict the results of communicative actions, will allow students to gain experience in managing communication processes and adapting interaction strategies to the specific conditions of the educational process.
- Practice-oriented training of future foreign language teachers.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Providing separate conditions for training future foreign language teachers using digital technologies in higher education contributes to improving and raising the awareness of future specialists of their own communicative strategies through self-assessment of speech activity, analysis of pedagogical interaction, and correction of professional communication.

In the control and experimental groups, a systematic summary and current diagnosis and assessment of the development of digital competence were conducted. At the end of the formative stage, the results obtained were summarized, the data were processed using statistical methods, and statistical conclusions were formulated.

To diagnose the development of digital competence in future foreign language teachers, components, indicators, and levels were outlined in a pedagogical experiment.

Motivational component.

Indicators of the effectiveness of the implementation of the developed innovative system and pedagogical conditions for training future foreign language teachers using digital technologies to form digital competence in them:

- Awareness of the value of digitalization.
- The formation of motives for studying problems and methods of forming digital competence.

Cognitive component.

Indicators of the effectiveness of the implementation of the developed innovative system and pedagogical conditions for training future foreign language teachers using digital technologies to form their digital competence:

- Possession of foreign language vocabulary through the effective implementation of digital technologies.
- Completeness of knowledge acquisition and understanding of the theoretical aspects of the outlined phenomenon.

Activity component

Indicators of the effectiveness of the implementation of the developed innovative system and pedagogical conditions for training future foreign language teachers using digital technologies to form their digital competence:

- The formation of the ability to use digital technologies to study a foreign language.
- The formation of the ability to use the content and methods of teaching a foreign language.

Communicative component.

Indicators of the effectiveness of the implementation of the developed innovative system and pedagogical conditions for training future foreign language teachers using digital technologies to form their digital competence:

- The formation of the ability to organize and communicate in a foreign language using digital technologies.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

To assess the formation of the components of the phenomenon's effectiveness, an ordinal scale of levels was chosen: low, average, and high.

Methods of statistical processing of empirical data. To select methods for formulating substantiated conclusions and obtaining reliable results in the experiment, an analysis of literary sources on the practice and theory of research, as well as of statistical data processing, was conducted.

The study's general population comprises future foreign language teachers. We will use open data sources to determine its volume, in particular, the Unified Electronic Database on Education.

To participate in the experimental study, the required number of respondents was calculated using the formula:

$$n = \frac{\frac{t_{n,\alpha}^2 \sigma^2}{d^2}}{1 + \frac{1}{N} \left(\frac{t_{n,\alpha}^2 \sigma^2}{d^2} - 1 \right)}$$

N – population size.

$t_{n,\alpha}$ – for the significance level α and the number of steps n , the critical value of the Student distribution – since n is not exactly known, for n and $\alpha = 0.95$ we choose the tabular value $t_{n,\alpha} = 1,96$.

d – in determining the value ($d = 0,5$) – absolute maximum permissible error.
 σ – standard deviation ($\sigma = 2$).

Therefore, to ensure reliability in the control and experimental groups, the number of respondents should be at least 69. As follows from the formula, the representativeness of a sample from a smaller general population can be ensured by a smaller number of people, and the larger its volume relative to the general population of respondents, the more representative the sample will be.

Within the sample population – 122 respondents who participated in the experiment – control (60 respondents) and experimental (62 respondents) groups of future foreign language teachers were selected, independent of each other.

According to the results of the survey of the sample population, we needed to compare the formation of digital competence of respondents through the effectiveness of the implementation of the developed innovative system and pedagogical conditions, among the participants of the pedagogical experiment, and formulate conclusions about their probability and existing differences, and the possibility of extending the obtained effect to the general population of respondents. For this purpose, the method of testing statistical hypotheses (null hypothesis H_0 and alternative hypothesis H_1) was applied.

In our study, a hypothesis was formulated: the implementation of the developed innovative system and the pedagogical conditions for training future foreign language teachers using digital technologies contribute to increasing the effectiveness of the formation of their digital competence.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
 Internacional (CC BY 4.0)

To analyze (coincidences or differences in the characteristics of the control group and the experimental group), the data obtained in the empirical study, two statistical hypotheses were formulated:

- Null hypothesis H_0 – hypothesis about the absence of differences between the control group and the experimental group.
- Alternative hypothesis H_1 – hypothesis about the significance of the differences between the experimental group and the control group.

The methodology for testing hypotheses was as follows:

Based on the indicators of CG and EG – data on the results of observations – the value – empirical – of the criterion was calculated χ_{emp}^2 , which was compared with that given in the table of critical values, with the known χ_{α}^2 reference number – critical value of the criterion χ_{cr}^2 , with a given probability (significance level 0.05) of error.

A 5% possibility of error is allowed; that is, in the study, we have chosen a probability level of error of 0.05, with a reliability of 95%.

According to the table, for the significance level $\alpha = 0.05$, the value is determined by χ_{cr}^2 . It equals 4, the number of degrees of freedom. Therefore, $\chi_{cr}^2 = 9.49$.

Calculated by the formula empirical value χ^2 -criterion:

$$\chi_{emp}^2 = N \cdot M \cdot \sum_{i=1}^L \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)^2}{\frac{n_i}{N} + \frac{m_i}{M}}$$

N – total number of students in the experimental group.

M – total number of students in the control group.

n_i – number of students in the experimental group with the appropriate graduation level.

m_i – number of control group students with the appropriate graduation level.

L – number of gradation levels.

According to the results of comparing the empirical and critical values of the criterion χ^2 , the following conclusions were drawn:

- If the empirical value of the criterion $\chi_{emp}^2 \leq \chi_{cr}^2$ is less than or equal to the critical value, the null hypothesis is accepted, meaning that the qualitative characteristics of the students in the experimental group (EG) and the control group (CG) coincide with a probability of 95%.
- If the empirical value of the criterion $\chi_{emp}^2 > \chi_{cr}^2$ is greater than the critical value, the null hypothesis is rejected, and the alternative hypothesis is accepted — the qualitative characteristics are considered significantly different with 95% confidence among the students of the control group (CG) and the experimental group (EG).

Results of the ascertaining stage of the pedagogical experiment.

At the ascertaining stage of the experiment, we obtained data that provided grounds for concluding about the preliminary assumptions regarding the formation of the outlined competence of future foreign language teachers through the implementation of the developed innovative system and pedagogical conditions.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

1. Respondents who entered the sample population showed an insufficient level of formation of the outlined components.
2. Respondents in the experimental and control groups revealed approximately the same levels of formation of the components of digital competence. The average difference in respondents' shares did not exceed 1.7% at the levels, allowing us to consider the sample population homogeneous.

Let us show this in tabular form.

Table 1.

Formation of the motivational component (ascertaining stage)

Levels	Control Group	Experimental Group
Low	49,5%	48,6%
Average	41,3%	42,3%
High	9,2%	9,1%

Diagnosis of the formation of the motivational component of future foreign language teachers revealed: 49.5% of higher education applicants CG and 48.6% EG had a low level; 41.3% CG and 48.6% EG had an average level, 9.2% of higher education applicants CG and 9.1% EG had a high level (Table 1). Thus, at the beginning of the experiment, the overwhelming majority of respondents had poorly formed motivational attitudes towards developing the outlined competence of future foreign language teachers.

Let us compare the experimental and control groups in terms of the level of formation of the motivational component and assess the reliability of the data obtained. To do this, we formulate two hypotheses.

Hypothesis H_0 : the control and experimental groups of respondents do not differ significantly in the level of formation of the motivational component.

Hypothesis H_1 : The control and experimental groups of respondents differ significantly in the level of formation of the motivational component.

Let us calculate the Pearson criterion.

Calculated $\chi^2_{emp} < \chi^2_{cr}$, accordingly, the hypothesis H_0 is accepted: the control and experimental groups of respondents do not differ significantly in terms of the level of formation of the motivational component.

Table 2.

Formation of the cognitive component (ascertaining stage)

Levels	Control Group	Experimental Group
Low	50,6%	50,8%
Average	37,8%	38,1%
High	11,8%	11,1%

Diagnosis of the formation of the cognitive component among future foreign language teachers revealed that 50.6% of higher education applicants in the control group (CG) and 50.8% in the experimental group (EG) demonstrated a low level; 37.8% in the CG and 38.1% in the EG showed an average level, while 11.8% in the CG and 11.1% in the EG demonstrated a high level (Table 2). Thus, at the beginning

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

of the experiment, the vast majority of respondents lacked sufficient knowledge regarding the outlined problem and demonstrated an insufficient level of foreign-language vocabulary related to digital technologies. Let us compare the experimental and control groups in terms of the level of formation of the cognitive component and assess the reliability of the data obtained. To do this, we formulate two hypotheses.

Hypothesis H_0 : the control and experimental groups of respondents do not differ significantly in the level of formation of the cognitive component.

Hypothesis H_1 : The control and experimental groups of respondents differ significantly in the level of development of the cognitive component.

Let us calculate the Pearson criterion.

Calculated $\chi^2_{emp} < \chi^2_{cr}$, accordingly, the hypothesis H_0 is accepted: the control and experimental respondents do not differ significantly in the level of formation of the cognitive component.

Table 3.

Formation of the activity component (ascertaining stage)

Levels	Control Group	Experimental Group
Low	52,2%	53,7%
Average	37,9%	37,2%
High	9,9%	9,1%

Diagnosis of the formation of the activity component of future foreign language teachers revealed: 52.2% of higher education applicants CG and 53.7% of EG had a low level; 37.9% of CG and 39.2% of EG had an average level, 9.9% of higher education applicants CG and 9.1% of EG had a high level (Table 3). Thus, at the beginning of the experiment, the vast majority of respondents had insufficiently developed abilities to use digital technologies to learn a foreign language and had not yet developed the ability to use the content and methods of foreign-language teaching.

Let us compare the experimental and control groups in terms of the level of formation of the activity component and check the reliability of the data obtained. To do this, we formulate two hypotheses.

Hypothesis H_0 : the control and experimental groups of respondents do not differ significantly in terms of the level of formation of the activity component.

Hypothesis H_1 : The control and experimental groups of respondents differ significantly in the level of development of the activity component.

Let us calculate the Pearson criterion.

Calculated $\chi^2_{emp} < \chi^2_{cr}$, accordingly, the hypothesis H_0 is accepted: the control and experimental groups of respondents do not differ significantly in the level of development of the activity component.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 4.

Development of the communicative component (ascertaining stage)

Levels	Control Group	Experimental Group
Low	51,9%	51,9%
Average	29,3%	29,2%
High	18,8%	18,9%

Diagnosis of the formation of the communicative component of future foreign language teachers revealed: 51.9% of higher education applicants CG and 51.9 EG had a low level; 29.3% CG and 29.2% EG had an average level, 18.8% of higher education applicants CG and 18.9% EG had a high level (Table 4). Thus, at the beginning of the experiment, the vast majority of respondents had not sufficiently developed the ability to organize and communicate in a foreign language using digital technologies.

Let us compare the experimental and control groups in terms of the level of formation of the communicative component and check the reliability of the data obtained. To do this, we formulate two hypotheses.

Hypothesis H_0 : the control and experimental groups of respondents do not differ significantly in terms of the level of formation of the communicative component.

Hypothesis H_1 : The control and experimental groups of respondents differ significantly in the level of development of the communicative component.

Let us calculate the Pearson criterion.

Calculated $\chi_{emp}^2 < \chi_{cr}^2$, accordingly, the hypothesis H_0 is accepted: the control and experimental groups of respondents do not differ significantly in terms of the level of formation of the communicative component.

Therefore, it can be concluded that, according to the results of the ascertaining stage of the experiment:

1. Respondents who entered the sample population showed an insufficient level of formation of the outlined components.
2. Respondents of the experimental and control groups revealed approximately the same levels of formation of the components of digital competence.

Results of the formative stage of the pedagogical experiment. Empirical data were obtained at the end of the formative stage of the study, which gave grounds to confirm the assumptions regarding the formation of digital competence among higher education students of the experimental group by implementing the developed innovative system and pedagogical conditions for training future foreign language teachers using digital technologies:

1. In both groups, the shares of respondents with average and high levels of the outlined phenomenon increased. However, in the experimental group, the relative indicators are much higher, indicating that growth is more pronounced.
2. There are significant differences between the shares of respondents with sufficient and high levels regarding the described phenomenon in the control and experimental groups. Therefore, it can be assumed that, in general, digital competence is higher among future foreign language teachers in the experimental group than in the control group.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

3. In the experimental group, the specified effect was achieved due to the implementation of the developed innovative system and pedagogical conditions for training future foreign language teachers using digital technologies, which contributes to increasing the efficiency of forming digital competence in them. In the CG, we observe a slight increase in performance.

Let us show this in tabular form.

Table 5.

Formation of the motivational component (formative stage)

Levels	Control Group	Experimental Group
Low	47,7%	8,4%
Average	41,5%	40,7%
High	10,8%	50,9%

Diagnosis of the formation of the motivational component of future foreign language teachers at the formative stage of the experiment revealed: 47.7% of higher education applicants CG and 8.4% EG had a low level; 41.5% CG and 40.7% EG had an average level, 10.8% of higher education applicants CG and 50.9% EG had a high level (Table 5). Thus, at the end of the experiment, the vast majority of EG respondents clearly formed motivational attitudes towards developing the outlined competence of future foreign language teachers. In contrast, CG respondents did not show significant positive changes.

Let us compare the experimental and control groups in terms of the level of motivational component formation and assess the reliability of the data obtained. To do this, we formulate two hypotheses.

Hypothesis H_0 : the control and experimental groups of respondents do not differ significantly in terms of the level of formation of the motivational component.

Hypothesis H_1 : The control and experimental groups of respondents differ significantly in the level of formation of the motivational component.

Let us calculate the Pearson criterion.

Calculated $\chi^2_{emp} > \chi^2_{cr}$, accordingly, hypothesis H_1 is accepted: the control and experimental groups of respondents differ significantly in the level of formation of the motivational component.

Table 6.

Formation of the cognitive component (formative stage)

Levels	Control Group	Experimental Group
Low	47,8%	5,7%
Average	38,9%	36,3%
High	13,3%	57,8%

Diagnosis of the formation of the cognitive component of future foreign language teachers at the formative stage of the study revealed: 47.8% of higher education applicants in the CG and 5.7% in the EG had a low level; 38.9% in the CG and 36.3% in the EG had an average level, 13.3% of higher education applicants in the CG and 57.8% in the EG had a high level (Table 6). Thus, at the end of the experiment, the vast majority of EG respondents demonstrated deep knowledge of the outlined

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

problem and a predominantly high level of foreign-language vocabulary. The results in the CG remained practically at the ascertaining level.

Let us compare the experimental and control groups in terms of the level of formation of the cognitive component and assess the reliability of the data obtained. To do this, we formulate two hypotheses.

Hypothesis H_0 : The control and experimental groups of respondents do not differ significantly in the level of development of the cognitive component.

Hypothesis H_1 : The control and experimental groups of respondents differ significantly in the level of development of the cognitive component.

Let us calculate the Pearson criterion.

Calculated $\chi^2_{emp} > \chi^2_{cr}$, accordingly, hypothesis H_1 is accepted: the control and experimental respondents differ significantly in the level of formation of the cognitive component.

Table 7.

Formation of the activity component (formative stage)

Levels	Control Group	Experimental Group
Low	43,3%	11,1%
Average	41,9%	37,2%
High	14,8%	39,1%

Diagnosis of the formation of the activity component of future foreign language teachers at the formative stage of the study revealed: 43.33% of higher education applicants CG and 11.1 EG had a low level; 41.9% CG and 37.2% EG had an average level, 14.8% of higher education applicants CG and 39.1% EG had a high level (Table 7). Thus, by the end of the experiment, the vast majority of EG respondents had significantly developed their ability to use digital technologies for learning a foreign language and to apply the content and methods of foreign-language teaching. The results of the control group respondents did not differ significantly from those of the ascertaining section.

Let us compare the experimental and control groups by the level of formation of the activity component and check the reliability of the data obtained. To do this, we formulate two hypotheses.

Hypothesis H_0 : The control and experimental groups of respondents do not differ significantly in the level of development of the activity component.

Hypothesis H_1 : The control and experimental groups of respondents differ significantly in the level of development of the activity component.

Let us calculate the Pearson criterion.

Calculated $\chi^2_{emp} > \chi^2_{cr}$, accordingly, hypothesis H_1 is accepted: the control and experimental groups of respondents differ significantly in the level of development of the activity component.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 8.

Development of the communicative component (formative stage)

Levels	Control Group	Experimental Group
Low	42,0%	5,8%
Average	36,9%	33,1%
High	21,1%	61,1%

Diagnosis of the development of the communicative component of future foreign language teachers at the formative stage of the experiment revealed: 42.0% of higher education applicants CG and 5.8 EG had a low level; 36.9% CG and 33.1% EG had an average level, 21.1% of higher education applicants CG and 61.1% EG had a high level (Table 8). Thus, at the end of the experiment, the vast majority of EG respondents clearly developed the ability to organize and communicate in a foreign language using digital technologies. The results of the control group respondents did not differ significantly from those of the ascertaining section.

Let us compare the experimental and control groups in terms of the level of development of the communicative component and check the reliability of the data obtained. To do this, we formulate two hypotheses.

Hypothesis H_0 : The control and experimental groups of respondents do not differ significantly in terms of the level of development of the communicative component.

Hypothesis H_1 : The control and experimental groups of respondents differ significantly in the level of development of the communicative component.

Let us calculate the Pearson criterion.

Calculated $\chi^2_{emp} > \chi^2_{cr}$, accordingly, hypothesis H_1 is accepted: the control and experimental groups of respondents differ significantly in terms of the level of development of the communicative component.

Therefore, it can be concluded that according to the results of the formative stage of the experiment, the experimental group, in which the developed innovative system and pedagogical conditions for training future foreign language teachers using digital technologies were implemented, which contribute to increasing the effectiveness of the formation of digital competence in them, exceeds the control group in terms of the level of development of all the identified components in higher education applicants.

Analysis of the development dynamics for the outlined components indicates that, in the experimental group, positive changes were more pronounced than in the control group.

Therefore, based on the results of the formative stage of the experiment, it can be concluded that, among higher education applicants, there are statistically significant differences between the control and experimental groups in the level of development of both individual components and the overall. More significant positive changes were recorded in the experimental group than in the control group. The above is a strong basis for asserting the effectiveness of the developed innovative system and pedagogical conditions.

Conclusions

The study confirmed that the integration of pedagogical strategies supported by digital technologies positively influences the development of digital competence

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

among future foreign language teachers. The implementation of the innovative educational system in the experimental group generated statistically significant improvements in the motivational, cognitive, activity, and communicative components when compared with the control group, demonstrating the pedagogical value of structured digital interventions in teacher education.

The findings indicate that the use of digital educational platforms, collaborative online tools, gamification strategies, mobile learning resources, and practice-oriented activities can strengthen not only technological skills but also professional readiness for teaching in digitally mediated educational environments. These results reinforce the importance of moving beyond the isolated use of digital tools toward integrated pedagogical models that systematically foster digital competence development in teacher education.

From an educational perspective, the study highlights the relevance of designing innovative teacher training programs that combine technological resources with active, communicative, and practice-oriented pedagogical approaches. Preparing future foreign language teachers for digital transformation requires not only access to technology, but also intentional pedagogical planning that promotes interaction, learner autonomy, critical use of digital resources, and professional application in authentic teaching contexts.

This study has some limitations. The research was conducted with a specific sample of master's students enrolled in foreign language teacher education programs, which may limit the generalizability of the findings to other educational contexts or academic disciplines. In addition, the quasi-experimental design focused primarily on short-term changes in digital competence development; therefore, the long-term sustainability of the observed effects remains uncertain.

Future research should explore the long-term development of digital competence, compare the effectiveness of specific digital pedagogical interventions, and examine how similar innovative training models can be adapted to other teacher education programs and educational levels.

Bibliographic references

- Alvarez-Flores, E. P. (2021). Uso crítico y seguro de tecnologías digitales de profesores universitarios. *Formación Universitaria*, 14(1), 33–44. <https://doi.org/10.4067/S0718-50062021000100033>
- Elshiekh, R., & Butgerit, L. (2017). Using Gamification to Teach Students Programming Concepts. *Open Access Library Journal*, 4, 1-7. <https://doi.org/10.4236/oalib.1103803>
- Finocchiaro, G., & Leto, E. (2018). Digital foreign language learning in the "Intercultura" lab. In *Proceedings of the 11th Innovation in Language Learning International Conference* (pp. 99–102). Pixel. <https://conference.pixel-online.net/ICT4LL/files/ict4ll/ed0011/FP/1834-ICL3446-FP-ICT4LL11.pdf>
- Galante, A., Zeaiter, L. F., de la Cruz, J. W. N., Massoud, N., Lee, L., Aronson, J., de Oliveira, D. S. A., & Teodoro-Torres, J. A. (2023). Digital plurilingual pedagogies in foreign language classes: Empowering language learners to speak in the target language. *The Language Learning Journal*, 51(4), 523–543. <https://doi.org/10.1080/09571736.2023.2179654>
- Guerrero-Quiñonez, A. J., Bedoya-Flores, M. C., Mosquera-Quiñonez, E. F., Mesías-Simisterra, Á. E., & Bautista-Sánchez, J. V. (2023). Educational platforms: Digital tools for the teaching-learning process in education.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- Ibero-American Journal of Education & Society Research*, 3(1), 259–263.
<https://doi.org/10.56183/iberoeds.v3i1.626>
- Harvey Arce, N. P., & Cuadros Valdivia, A. M. (2020). Adapting competitiveness and gamification to a digital platform for foreign language learning. *International Journal of Emerging Technologies in Learning (IJET)*, 15(20), 194–209.
<https://doi.org/10.3991/ijet.v15i20.16135>
- Jacome Paredes, V., Espinoza Romero, S. M., & Andraus Quintero, C. E. (2025). Herramientas digitales impulsadas por inteligencia artificial para la retención de vocabulario en estudiantes de lenguas extranjeras: Un estudio basado en percepciones. *Revista San Gregorio*, 1(62), 79-84.
<https://doi.org/10.36097/rsan.v1i62.3579>
- Lisborg, S., Handel, W., Schroeder, V., & Rehder, M. (2021). Digital competences in Nordic teacher education: An expanding agenda. *Nordic Journal of Comparative and International Education*, 5(4), 53–69.
<https://doi.org/10.7577/njcie.4295>
- Markauskaite, L., Carvalho, L., & Fawns, T. (2023). The role of teachers in a sustainable university: From digital competencies to postdigital capabilities. *Educational Technology Research and Development*, 71, 181–198.
<https://doi.org/10.1007/s11423-023-10199-z>
- Martynets, L., Stepanchenko, N., Ustymenko-Kosorich, O., Yashchuk, S., Yelisieieva, I., Groshovenko, O., Torichnyi, O., Zharovska, O., Kademiya, M., Buchatska, S., Matsuk, L., Stoliarenko, O., Stoliarenko, O., & Zarichna, O. (2020). Developing business skills in high school students using project activities. *Revista Românească pentru Educație Multidimensională*, 12(4), 222–239.
<https://doi.org/10.18662/rrem/12.4/343>
- Moisés, C., & Borges, F. G. B. (2021). Apropriação tecnológica de professores de Português Língua Estrangeira em tempos pandêmicos: Uma reflexão sobre formação. *Revista EntreLinguas*, 7(esp. 6), e021033.
<https://doi.org/10.29051/el.v7i00.15516>
- Ngandu, M. R., Risinamhodzi, D., Dzvapatsva, G. P., & Matobobo, C. (2023). Capturing student interest in software engineering through gamification: A systematic literature review. *Discover Education*, 2(47), 1–15.
<https://doi.org/10.1007/s44217-023-00069-4>
- Petri, G., & Gresse von Wangenheim, C. (2017). How games for computing education are evaluated? A systematic literature review. *Computers & Education*, 107, 68–90. <https://doi.org/10.1016/j.compedu.2017.01.004>
- Schaefer, R., Salbego, N., & Lorenset, C. C. (2019). Foreign language learning development: Reflections on the contribution of digital technology. *Revista de Letras Norte@mentos*, 12(29), 143–157.
<https://doi.org/10.30681/rln.v12i29.7460>
- Seiler, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior*, 69, 371–380.
<https://doi.org/10.1016/j.chb.2016.12.033>
- Tai, T.-Y., Chen, H. H.-J., & Todd, G. (2022). The impact of a virtual reality app on adolescent EFL learners' vocabulary learning. *Computer Assisted Language Learning*, 35(4), 892–917. <https://doi.org/10.1080/09588221.2020.1752735>
- Videnovik, M., Vold, T., Kionig, L., & Madevska Bogdanova, A. (2023). Game-based learning in computer science education: A scoping literature review. *International Journal of STEM Education*, 10(54), 1–23. <https://doi.org/10.1186/s40594-023-00447-2>
- Wozniak, H., Ellaway, R. H., & de Jong, P. G. M. (2018). What have we learnt about using digital technologies in health professional education? *The Medical Journal of Australia*, 209(10), 431–433.e1. <https://doi.org/10.5694/mja18.00152>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- Zainuddin, Z., Chu, S. K. W., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review*, 30, 100326.
<https://doi.org/10.1016/j.edurev.2020.100326>
- Zhang, R., & Zou, D. (2020). Types, purposes, and effectiveness of state-of-the-art technologies for second and foreign language learning. *Computer Assisted Language Learning*, 35(4), 696–742.
<https://doi.org/10.1080/09588221.2020.1744666>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Pedagogical innovation in science teacher education: Integrating FizziQ to develop TPACK-21

Innovación pedagógica en la formación de profesores de ciencias: Integrando FizziQ para desarrollar TPACK-21

Serhat Çoban¹  Mustafa Ergun² 

Afiliación autor:

¹ M.Sc. in Science Education, Ondokuz Mayıs University, Science Education, Graduate School of Education, Türkiye.
kuantumfizigi@hotmail.com

² PhD in Science Education, Ondokuz Mayıs University, Associate Professor, Faculty of Education, Samsun, Türkiye.
(Corresponding author) mergun@omu.edu.tr

Recibido: 02/11/25
Aceptado: 25/01/26

Cómo citar:

Çoban, S., & Ergun, M. (2026). Pedagogical innovation in science teacher education: Integrating FizziQ to develop TPACK-21. *Revista Eduweb*, 20(2), 229-252.
<https://doi.org/10.46502/issn.1856-7576/2026.20.02.14>

Abstract

This study explores how integrating the FizziQ mobile application into lesson planning processes influences the development of preservice science teachers' (PSTs) TPACK-21 competencies. This inquiry relied on a mixed-methods approach, where a single-group pre- and post-test design was complemented by qualitative data derived from both individual interviews and focus group sessions. The sample comprised 46 PSTs enrolled in a science education program at a public university in Türkiye. Following an initial assessment, PSTs were introduced to the 5E instructional model and the FizziQ application, and subsequently engaged in designing and implementing lesson plans supported by mobile technologies. The findings show a clear increase in TPACK-21 scores after working with FizziQ. In addition, qualitative data suggest that the use of FizziQ encouraged more inquiry oriented and student centered instructional approaches, while also revealing certain challenges related to usability and curriculum alignment. These results suggest that smartphone based learning tools such as FizziQ can support the development of integrated technological and pedagogical competencies in science teacher education, particularly when embedded within structured instructional frameworks.

Keywords: Educational technology, FizziQ, mobile application, preservice science teachers, TPACK-21.

Resumen

Este estudio analiza cómo la integración de la aplicación móvil FizziQ en los procesos de planificación de clases influye en el desarrollo de las competencias TPACK-21 de los futuros docentes de ciencias. Para ello, se adoptó un enfoque de métodos mixtos, combinando un diseño de grupo único con pretest y posttest con datos cualitativos obtenidos mediante entrevistas y un grupo focal. Los participantes fueron 46 futuros docentes de ciencias matriculados en un programa de educación científica en una universidad pública de Türkiye. Tras una evaluación inicial, se presentó a los participantes el modelo instruccional 5E y la aplicación FizziQ; posteriormente, diseñaron e implementaron planes de clase apoyados en tecnologías móviles. Los resultados muestran un aumento claro en las puntuaciones TPACK-21 después del trabajo con FizziQ. Además, los datos cualitativos sugieren que el uso de FizziQ favoreció enfoques de enseñanza más orientados a la indagación y centrados en el estudiante, aunque también puso de manifiesto ciertos desafíos relacionados con la usabilidad y la alineación curricular. En conjunto, estos resultados indican que



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



herramientas de aprendizaje basadas en teléfonos inteligentes, como FizziQ, pueden apoyar el desarrollo de competencias tecnológicas y pedagógicas integradas en la formación inicial del profesorado de ciencias, especialmente cuando se incorporan dentro de marcos instruccionales estructurados.

Palabras clave: Aplicación móvil, FizziQ, formación inicial del profesorado de ciencias, tecnología educativa, TPACK-21.

Introduction

In recent years, digital technologies have increasingly reshaped how teaching and learning take place across educational contexts. In today's knowledge driven society, education must cultivate students' 21st-century skills cognitive, metacognitive, social, and technological competencies that promote creativity, collaboration, self regulation, and problem solving (Voogt & Roblin, 2012). Science teachers play a key role in developing all competencies by designing student-centered, inquiry-based, and technology-enriched learning environments. It is not easy to fully integrate 21st-century skills into science classes. While critical thinking stands out in particular, students' proficiency in technology use, collaboration, and problem-solving remains at a more limited level (Uğur & Sungur, 2021). Within the context of current trends, the use of artificial intelligence tools alone is not sufficient to develop 21st-century skills (Gökçe & Nacaroğlu, 2026). Recent OECD (2018, 2025) reports further highlight that digital and mobile technologies enable teachers to personalize instruction, enhance engagement, and strengthen digital pedagogical competence. These reports emphasize that mobile supported teaching not only enhances instructional quality but also fosters lifelong learning skills, key components of 21st-century education.

Theoretical Framework: TPACK and TPACK-21

The Technological Pedagogical Content Knowledge (TPACK) framework proposed by Mishra & Koehler (2006) provides a conceptual model for understanding how teachers integrate technology with pedagogy and subject matter. This integration is considered a key factor in effective teaching performance (Alemán-Saravia et al., 2023). Building on this foundation, the expanded TPACK-21 framework integrates 21st-century learning dimensions that encompass skills such as collaboration, innovation, self-regulation, and digital literacy (Valtonen et al., 2017). Recent studies show a clear increase in global TPACK research, with growing attention to technology integration, digital competence, and teacher professional development (Ergun & Uzuner, 2026). The TPACK-21 model has been shown to have a positive impact on student learning outcomes across various educational stages and disciplines (Hu et al., 2025), while enhancing teachers' ability to design technology rich and student centered instruction (Nanola et al., 2024; Teknowijoyo et al., 2024). However, scholars emphasize that successful implementation of TPACK-21 requires consideration of contextual factors, including subject nature, teaching method, duration, and cultural context (Alawadh et al., 2019; Diamah et al., 2022; Ergun & Uzuner, 2026; Hu et al., 2025). Technology use does not necessarily improve instructional outcomes unless it is supported by teachers' PCK and integrated TPACK competencies (Ng et al., 2025). Recent studies suggest that TPACK-21 can support teachers in developing organizational capacity and adaptability, while also encouraging more innovative teaching practices and digital learning ecosystems (Guo, 2021; Karaduman & Akman, 2024). While Chai et al. (2013) noted that a lack of technological knowledge directly affects

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

TPACK-21 levels, Albayrak Sari et al. (2016) found a positive relationship between TPACK competencies and attitudes toward information and communication technologies (ICT) among teachers in various fields. Taken together, these studies point to the increasing role of TPACK-21 in teacher education. In particular, it helps teachers integrate technology into their teaching, support inquiry-based learning, and respond to changing technological demands (Dzakia et al., 2023; Miguel-Revilla et al., 2020).

Although the number of studies on TPACK and mobile learning is steadily increasing, important gaps remain in the literature. Existing studies have largely focused on student learning outcomes or teachers' self-perceived digital competencies, rather than examining how preservice teachers transform their pedagogical practices during authentic lesson design processes (Aslan et al., 2025; Kaya Yatar & Ergun, 2024; Valtonen et al., 2017; Voogt & Roblin, 2012). In particular, empirical studies that investigate the integration of mobile experimentation tools within the TPACK-21 framework in the context of lesson planning are still limited. This gap highlights the need for research that explores how emerging mobile technologies can support preservice science teachers (PST) in developing integrated technological, pedagogical, and content knowledge through practice based experiences.

Mobile Applications in Science Education

In science education, mobile applications have gained increasing importance due to their potential to transform traditional instruction into inquiry based, data driven, and interactive experiences. Applications such as FizziQ (Chazot & Delabre, 2025) allow both teachers and students to collect, visualize, and analyze real time data using smartphones' built-in sensors (accelerometer, gyroscope, light, and sound detectors). Such tools promote conceptual understanding by bridging the gap between abstract theories and concrete experimentation (Crompton et al., 2016; Zydney & Warner, 2016). Meta analytic findings have revealed that the use of mobile applications significantly enhances student achievement and engagement in science, particularly in physics education, where they foster intellectual development and sustained interest (Zharylgapova et al., 2025). Similarly, integrating mobile technologies into laboratory activities has been shown to strengthen students' digital literacy and attitudes toward technology use, contributing to more effective and inclusive learning environments (Ürek, 2024). Studies also demonstrate that mobile learning environments enhance students' scientific process skills, motivation, and contextualized understanding (Widowati & Tyas, 2024). Furthermore, mobile applications democratize access to experimentation, making them particularly valuable in schools with limited laboratory facilities (Başaran, 2020). Within this context, FizziQ stands out as an innovative tool that supports the design of student centered, inquiry-based, and technology integrated lessons in alignment with 21st-century learning goals.

Despite the growing interest in mobile applications in science education, several limitations can be identified in the existing literature. Many studies primarily focus on student outcomes such as achievement, motivation, or engagement, while offering limited insight into how teachers integrate these technologies into pedagogical design processes. Moreover, research often examines the use of mobile applications in isolated instructional activities rather than within comprehensive frameworks such as TPACK-21. As a result, there remains a need for studies that explore how mobile technologies can support the development of integrated TPACK in authentic teaching contexts.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The Purpose of the Study

The primary aim of this study is to explore how the integration of the FizziQ mobile application into the lesson planning processes influences the development of PSTs TPACK levels within the framework of 21st-century skills (TPACK-21). To address this aim, the study is guided by the two following research questions:

RQ1. How does the use of the FizziQ mobile application in lesson plan design affect PSTs' TPACK-21 levels?

RQ2. What are the PSTs' perceptions of the FizziQ mobile application?

Methodology

Research Design

This study employed a mixed methods research design. The quantitative strand explored changes in PSTs' TPACK-21 levels before and after the intervention. On the other hand, the qualitative strand focused on understanding PSTs' perceptions, experiences, and reflections about using FizziQ during lesson plan development. A mixed-methods design was considered appropriate for this study, as it allows for combining quantitative results with in-depth qualitative insights (Creswell & Clark, 2016).

The quantitative strand followed a pre and post-test single group design, which is considered a weak experimental design due to the absence of a control group. Although this design limits the ability to make strong causal inferences, it is appropriate for exploring changes within a specific group over time and is commonly used in educational intervention studies where random assignment is not feasible. Given the absence of a control group, the quantitative findings are better understood as indicative rather than causal. The observed changes may reflect not only the influence of the intervention but also other factors such as practice effects, increased familiarity with the measurement instrument, or concurrent learning experiences during the course. This approach ensures a comprehensive examination of mobile technology's role in advancing science education within contemporary teacher preparation programs.

Context and Participants

The study group consisted of 46 PSTs enrolled in the last year of a science education program at a public university in Türkiye. Participants were selected through purposeful sampling, as they had already completed foundational courses in science teaching methods and were concurrently enrolled in a course focusing on technology integration in science education. This ensured that participants possessed a sufficient background in both content and pedagogy to meaningfully engage with the FizziQ mobile application during the lesson planning process. Prior to data collection, all participants were informed about the purpose and procedures of the study, and their voluntary participation was ensured through informed consent. Ethical approval was obtained from the university's ethics committee before the commencement of data collection.

Quantitative Data Collection

In order to measure PSTs' TPACK within the scope of 21st-century skills, the TPACK-21 scale was employed. The scale was originally developed by

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Valtonen et al. (2017) and comprises 38 items spread out in seven sub factors (PK21, TK, CK, PCK21, TPK21, TCK, and TPACK). Each item was measured on a six point Likert scale from “I have very good knowledge” to “I am in great need of additional knowledge”. The original validation study reported a high reliability coefficient (Cronbach’s Alpha = .974), with factor loadings ranging between .71 and .88, indicating strong internal consistency and construct validity. The scale was later adapted into Turkish by Alpaslan et al. (2021), who confirmed the psychometric soundness of the instrument in the Turkish cultural context. Rasch analysis produced person and item reliability coefficients of .90 and .91, both exceeding the recommended threshold of .70. Factor loadings ranged from .71 to .86, demonstrating strong correlations between items and their respective latent constructs. These results collectively confirm that both the original and adapted versions of the TPACK-21 scale are reliable and valid tools for assessing preservice teachers’ knowledge of technology integration within the framework of 21st-century skills.

Qualitative Data Collection

The qualitative data collection phase of the study was conducted in two complementary stages. In the first stage, individual interviews were carried out using a semi structured interview form consisting of 12 open ended questions. Details of the interview questions are available in Appendix 1. These questions were designed to elicit PSTs’ views on the advantages and disadvantages of using the FizziQ application, its impact on the use of assessment techniques, and its contribution to their TPACK-21 levels. In the second stage, a focus group interview was organized to explore three critical themes in greater depth: experiences in preparing lesson plans, the professional contributions of the application, and the benefits it provides in terms of assessment and teaching methods (Appendix 2). During this session, participants were asked questions regarding the process of creating their individually prepared lesson plans, the benefits and challenges of using the application as PST, and its contributions to assessment practices. This approach increased the validity and reliability of the findings by triangulating the data, while adding a more holistic perspective to the research question.

FizziQ Mobil Application

In this research, we used the new mobile application FizziQ. This is a mobile application that converts students’ and teachers’ smartphones as well as tablet computers into transportable science labs. Its compatibility in 20 languages and being offered for free make it appropriate for use among physics and science education mobile applications (Chazot & Delabre, 2025). FizziQ is a data collection, visualization, and analysis tool specifically for physics and science education. It utilizes the in-device sensors, such as a tablet or smartphone, as a data collection device (Delabre, 2022). It, for instance, utilizes sensors such as gyroscopes, accelerometers, a microphone, and light sensors utilized in physics lessons to access real time data as well as make graphical displays from this data (Figure 1). It also possesses an interactive learning environment in case the user wants to design as well as share their own experiment (Ergun & Delabre, 2026). Through these functionalities, the FizziQ mobile application emerges as a pedagogical application that enhances inquiry based as well as experimental methods in science education.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

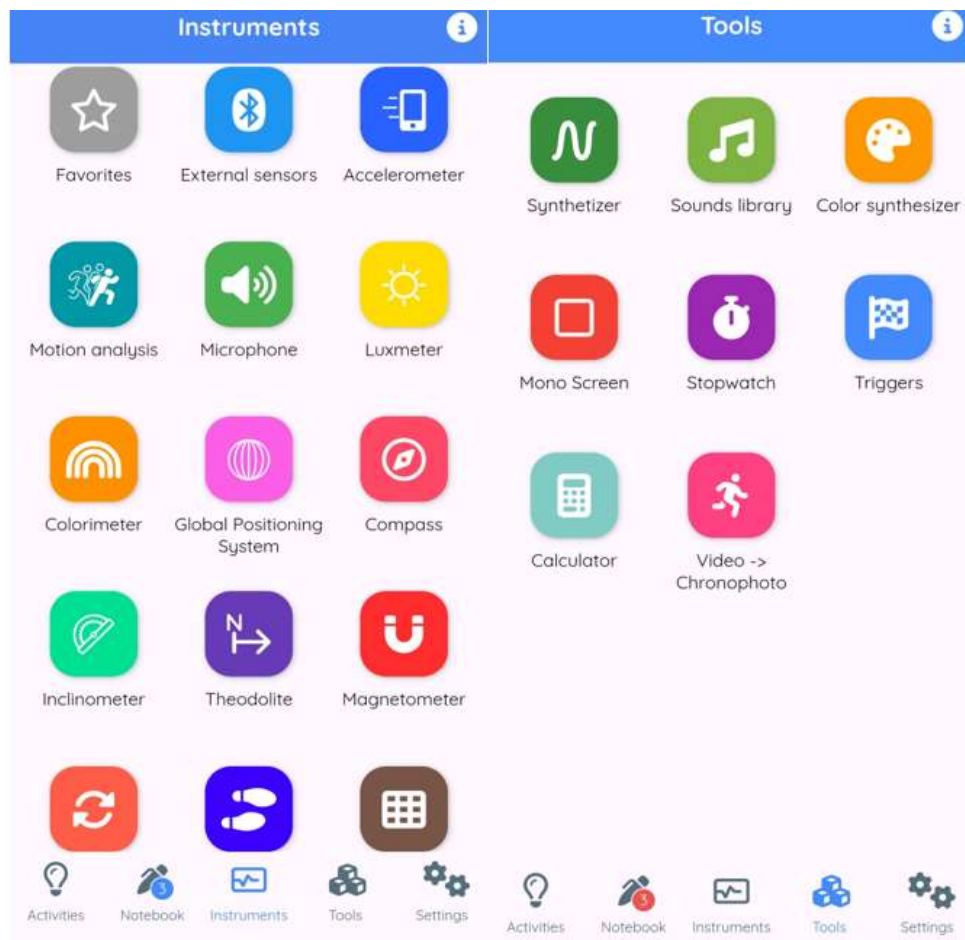


Figure 1. FizziQ application's main screen shows available instruments and tools

Procedure

The implementation process spanned nine weeks. In the first week, the TPACK-21 scale was administered as a pre-test, followed in the second week by an introduction to the 5E learning cycle model and the FizziQ mobile application. Between weeks three and six, PSTs designed lesson plans integrating the FizziQ app within the 5E framework in alignment with current science curriculum learning outcomes. They implemented these lesson plans in middle school science classes where they were serving as preservice teachers during their teaching practicum (Appendix 3). In the seventh week, the TPACK-21 scale was administered again as a post-test. Finally, qualitative data were collected through semi-structured interviews in week eight and a focus group interview in week nine.

Data Analysis TPACK-21 Scale

To examine the suitability of the TPACK-21 scale for factor analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were conducted. As shown in Table 1, the KMO value was .642, exceeding the .60 threshold, and Bartlett's test yielded a significant chi-square value ($\chi^2(703)=1885.03$, $p<.001$), confirming the appropriateness of the data for factor analysis.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 1.
KMO and Bartlett's test results

Test	Value
KMO Measure of Sampling Adequacy	.642
Bartlett's Test of Sphericity χ^2 (df = 703), p	1885.03, p < .001

Exploratory factor analysis revealed a seven factor structure that accounted for 78.63% of the total variance, which is well above the 50% threshold typically considered acceptable for construct validity. The factor loadings met the recommended .45 criterion (Field, 2009; Tabachnick & Fidell, 2013), and the differences across factors were greater than .10, indicating a clear and distinct factor structure (Hair et al., 2019).

Table 2.
Reliability coefficients of TPACK-21

Subscale	Pre-test	Post-test
PK21	.894	.908
TK	.899	.907
CK	.871	.856
PCK21	.913	.909
TCK	.901	.945
TPK21	.897	.918
TPACK	.925	.947

Table 2 shows that the reliability coefficients of the scale's sub factors ranged from .871 to .925 in the pre-test and from .856 to .947 in the post-test. This results demonstrate that the sub factors are composed of items that reliably measure the same construct. Item total correlation analysis further supported this finding, with all items showing coefficients above .30, demonstrating strong discrimination and confirming that participants interpreted and responded to the items as intended. Overall, these findings confirm that the TPACK-21 scale is both valid and reliable in the context of this study. In the quantitative phase, a paired samples t-test was applied to compare pre and post-test scores on the TPACK-21 scale. In addition to statistical significance, effect sizes were calculated using Cohen's d to determine the magnitude of the observed differences between pre-test and post-test scores. Effect size interpretation followed Cohen's (1988) criteria, where 0.20 is considered small, 0.50 medium, and 0.80 large. This test, appropriate for repeated measurements on the same group, assumes normality of the data, which was examined prior to the analysis (Pallant, 2020).

Qualitative Data Analysis

In the analysis of the qualitative data, the responses to the semi structured interview questions were examined through thematic coding and organized into themes, categories, and codes. For the analysis of the focus group data, responses obtained through the questions included in the focus group form were systematically examined. In the first stage, audio recordings of the approximately 60 minute session with PST were transcribed. The transcripts were then analyzed collaboratively by the researcher, a graduate student in science education, and a field expert, resulting in the identification of themes, categories, and codes. To ensure reliability, inter coder agreement was calculated (Miles & Huberman, 1994). In this study, 36 codes were agreed upon and 6 were disputed, yielding an inter coder reliability coefficient of 86%. These procedures ensured that the coding

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

process was both systematic and trustworthy, thereby enhancing the credibility of the qualitative findings.

Findings

Quantitative Results on the TPACK-21 Scale

Table 3 displays the results of the paired-samples t-test conducted to examine differences between pre and post-test scores across the sub-factors of the TPACK-21 scale, providing evidence of changes in PSTs' TPACK.

Table 3.
t-test results of TPACK-21 sub factors

Sub-factor	Pre-test M (SD)	Post-test M (SD)	t	df	p	Effect size (d)
PK	27.00 (6.16)	33.04 (4.40)	-7.91	45	.000	1.08
TK	14.70 (4.05)	17.24 (3.50)	-4.73	45	.000	0.64
CK	12.52 (4.08)	15.74 (3.47)	-5.43	45	.000	0.83
PCK	21.76 (5.38)	27.00 (4.12)	-7.39	45	.000	1.06
TPK	19.50 (4.99)	27.17 (4.98)	-10.16	45	.000	1.54
TCK	12.72 (3.85)	17.30 (3.46)	-9.27	45	.000	1.26
TPACK	21.76 (5.97)	30.74 (5.26)	-10.22	45	.000	1.60

The results of the paired-samples t-test show clear improvements across all sub factors of the TPACK-21 scale. Specifically, mean scores increased from pre to post-test in PK (M = 27.00 to 33.04), TK (M = 14.70 to 17.24), CK (M = 12.52 to 15.74), PCK (M = 21.76 to 27.00), TPK (M = 19.50 to 27.17), TCK (M = 12.72 to 17.30), and overall TPACK (M = 21.76 to 30.74). In all cases, the paired samples t-test revealed statistically significant differences ($p < .001$). These findings suggest that the intervention was associated with improvements in PSTs' TPACK levels. However, these improvements need to be interpreted with caution, as the study design does not allow for isolating the specific effect of the intervention. One possible explanation for this improvement is that the integration of FizziQ within the 5E instructional model provided PST with structured opportunities to actively engage in technology supported lesson design. This hands-on and inquiry based experience may have facilitated the meaningful integration of TPACK. In addition, Cohen's effect size values presented in Table 3 show that the observed differences range from medium to very large, suggesting that the use of the application has a significant practical effect. This suggests that the integration of the FizziQ mobile application not only resulted in statistically significant improvements but also had a strong practical impact on PST's TPACK. These results should therefore be understood as reflecting a strong association between the intervention context and the observed outcomes, rather than direct causal evidence.

Qualitative Findings on the FizziQ Application

The qualitative findings, obtained from the semi-structured interviews conducted with PST, were grouped into three themes derived from the twelve interview questions. The first theme, informed by seven questions, highlights the perceived advantages and challenges of using FizziQ in lesson planning. The second theme, based on two questions, focuses on the theme's influence on assessment practices. The third theme, drawn from three questions, explores the contribution to the development of PST's TPACK.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Advantages and Challenges of Using FizziQ

The first theme focuses on PSTs' perceptions of the advantages and challenges associated with using the FizziQ mobile application during lesson plan preparation. Their responses highlight both the pedagogical benefits and the limitations encountered in practice. Based on the qualitative findings presented in Table 4, two main categories of advantages emerged from the PSTs' views: lesson preparation and delivery, and physical environment.

Within the first category, PST emphasized that using the FizziQ encouraged more student centered and participatory learning, enhanced motivation, and facilitated game based and inquiry oriented teaching practices. They also reported that FizziQ helped them better understand learning stages, promoted scientific literacy through the interpretation of data in tables and graphs, and supported the integration of various instructional methods and techniques. Furthermore, PSTs noted that FizziQ contributed to lowering cognitive load by enabling students to experiment and learn through practice. The second category, physical environment, focused on the practical benefits of the application. PSTs asserted that FizziQ could be used directly without additional tools, allowed for more efficient lesson time management, and was especially useful when material preparation posed challenges. In addition, they stated that the FizziQ helped create portable, laboratory like environments, particularly in settings with limited resources.

Table 4.
Advantages of using FizziQ

Theme	Category	Code	Illustrative Quote
Advantages	Lesson preparation and delivery	Student centered activities	PST2: "By using the application, I was able to organize student-centered activities in my lesson plan to increase retention."
		Participation	PST7: "It can be used for methods that enhance student participation and develop observation skills."
		Motivation	PST29: "Since it is an application where students can use technology in the digital age, their motivation increases."
		Game based learning	PST17: "By gamifying situations we can relate to daily life with a good scenario, it may help us create game-based learning environments."
		Learning stages	PST40: "By deciding at which stage of the 5E model the application can be used, it helps students understand the importance of these stages in the learning process."
		Literacy	PST42: "It can be said to enhance scientific literacy in terms of using tables and graphing tools."
		Data set analysis	PST2: "It enables students to conceptualize data sets at a cognitive level and visualize them in their minds."
		Different methods and techniques	PST28: "It is open to collaborative learning and diverse techniques such as brainstorming."
		Cognitive load	PST31: "Allowing students to practice through trial-and-error reduces cognitive load."
	Physical Environment	Direct usability	PST38: "Being able to take measurements from abstract to concrete and use the app directly without extra tools creates effective learning opportunities."
		Lesson time	PST7: "Varying lesson delivery and using time efficiently can boost productivity and reduce the limits of traditional teaching methods."
		Material preparation	PST11: "It's helpful when preparing materials is difficult or when testing pre-made ones."
		Portable laboratory	PST25: "In schools without laboratories or with insufficient laboratory equipment, it can serve as an effective support for teachers."

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

In relation to the disadvantages, two main categories were identified, similar to those in the advantages. Within the first category, PST reported several limitations

regarding the use of FizziQ in lesson planning. They mentioned reduced usability, particularly having to repeat measurements that required navigating multiple menus, as well as the limited availability of measurement tools such as stopwatches and thermometers. Additionally, some participants noted difficulties in aligning the application with the middle school science curriculum, as its functions were perceived to be overly detailed for that level. The second category, physical environment, referred to contextual challenges specifically, how environmental conditions, such as room brightness, could interfere with sensor accuracy and require additional adjustments during experiments. These findings are summarized in Table 5.

Table 5.
Disadvantages of using the FizziQ

Theme	Category	Code	Illustrative Quote
Disadvantages	Lesson preparation and delivery	Usability	PST46: <i>"Using a sensor with graphical output required re-entering the menu for each measurement, which reduced usability and wasted time."</i>
		Measurement tools	PST2: <i>"Sensors such as a chronometer, thermometer, or speedometer are missing."</i>
		Science curriculum	PST7: <i>"The application felt too detailed for middle school, so I struggled to align it with the science curriculum."</i>
	Physical environment	Environmental factors	PST10: <i>"During the activity, I noticed that environmental factors like room brightness affected the measurements and adjusting them took extra time."</i>

FizziQ and Assessment Practices

The second theme explores PST's views on how the use of FizziQ influenced their assessment and evaluation practices. As presented in Table 6, three main categories were identified: variety of tools, individualized assessment, and efficiency. PSTs articulated that the application encourages the use of various assessment methods and supports flexibility in measuring learning outcomes. They also praised that FizziQ offers valuable opportunities for personalized assessment. Through the application, students could design their own experiments, analyze data, and make the process more meaningful and lasting. Furthermore, the application was found to improve assessment efficiency. As pupils understood the lessons better, they could recall information more easily, which made the evaluation process smoother and faster. These results together highlight FizziQ's potential as a flexible tool for facilitating both formative and summative assessment.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 6.
Assessment Practices with FizziQ

Theme	Category	Code	Illustrative Quote
Assessment practices	Different assessment tools	Variety of tools	PST11: <i>"This application encourages teachers to use different methods at the assessment and evaluation stage."</i>
	Personalized assessment	Individualized assessment	PST40: <i>"Allowing pupils to design their own experiments and interpret data instead of doing traditional homework makes learning more engaging, lasting, and meaningful."</i>
	Efficiency	Effectiveness	PST3: <i>"When students understand the lesson better, they recall information more easily during assessment, making the evaluation process more efficient."</i>

FizziQ's Contribution to TPACK

The third theme focuses on the impact of using FizziQ on PST's TPACK development. As shown in Table 7, the application contributed to five impacts of TPACK: content knowledge, technological pedagogical knowledge, mobile learning environments, interactive tools, and curriculum integration. PSTs reported that features such as motion video analysis enhanced their ability to collect and analyze data, supporting content knowledge development. They also noted that FizziQ's portability as a mobile laboratory facilitated more effective lesson delivery and provided an accessible environment for technology supported teaching. Furthermore, the use of multiple sensors and real life connections helped make abstract concepts more concrete, thereby strengthening the interaction between TPK. Finally, several participants emphasized that integrating FizziQ into lesson delivery expanded their understanding of curriculum design and implementation, enhancing their pedagogical knowledge.

Table 7.
Effects of FizziQ on PST's TPACK

Theme	Code	Illustrative Quote
Impact on TPACK levels	Content knowledge	PST15: <i>"The motion video analysis feature makes it easier to collect and analyze data. As a preservice teacher, I think this convenience helps improve my content knowledge."</i>
	Mobile learning environments	PST5: <i>"Having the application as a portable lab always available supports me in delivering lessons more effectively."</i>
	Technological pedagogical knowledge	PST3: <i>"It helped me make abstract concepts concrete and strengthened the interaction between my technological and pedagogical knowledge."</i>
	Interactive tools	PST4: <i>"Using multiple sensors in one app helped me show how science connects to daily life, which improved my technological pedagogical knowledge."</i>
	Curriculum integration	PST1: <i>"I had never used a mobile app in lesson delivery before, and this experience enhanced my pedagogical knowledge about curriculum integration."</i>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Focus Group Findings on FizziQ

Through thematic analysis, three main themes were identified (Figure 2): Teaching learning process, technology integration, and 21st-century skills. These themes represent PSTs' shared perspectives on how FizziQ supported instructional design, enhanced technology based teaching practices, and contributed to the development of competencies aligned with 21st-century science education.



Figure 2. Focus group interview themes

Teaching Learning Process

Findings from the focus group analysis revealed that the use of FizziQ positively shaped PSTs' views on the teaching learning process. As shown in Figure 3, participants emphasized that the app supported effective lesson planning and fostered innovative pedagogical design. It was reported to enhance creativity and innovation by encouraging experimentation and the integration of interactive, sensor based, and game like activities. Moreover, FizziQ was seen to connect scientific concepts to everyday life, promote cultural literacy, and motivate teachers to design lessons suitable for both classroom and outdoor settings. Collectively, these findings suggest that the application strengthened PSTs' ability to plan and implement student centered, technology enhanced science lessons.

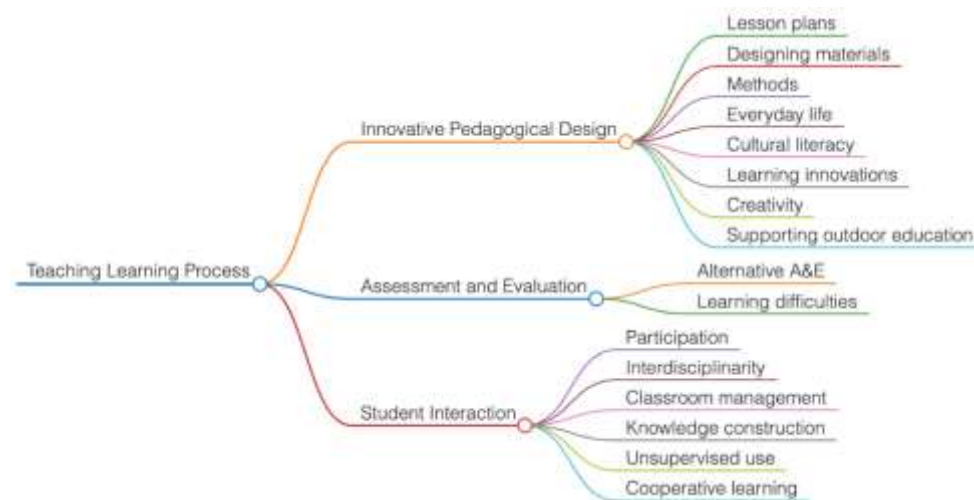


Figure 3. Teaching learning process theme

The second theme, assessment and evaluation, reflects PSTs' views on how FizziQ contributed to both formative and summative assessment practices. As presented in Figure 3, the app facilitated alternative assessment techniques, enabling users to design diverse tools such as data diagrams, lab reports, and performance based tasks. These methods supported a more authentic evaluation of pupils' scientific reasoning and inquiry skills. In addition, FizziQ was found to make assessment processes more inclusive by allowing adaptations for pupils with learning difficulties.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Overall, the integration of FizziQ was perceived to enhance assessment literacy and promote evidence based, student centered evaluation.

The third theme, student interaction, centers on how the FizziQ application influenced participation, collaboration, and communication in classroom contexts. As illustrated in Figure 3, the app increased engagement, enabling students to interact actively with both peers and scientific content during experiments. The inclusion of interdisciplinary connections such as linking physics to traffic safety made lessons more meaningful and relatable. PST also reported that FizziQ improved classroom management by maintaining pupil attention through hands-on, real time measurements. Moreover, the FizziQ fostered collaborative learning and knowledge construction, encouraging teamwork even among pupils who typically struggled with focus or participation. While some PSTs mentioned minor challenges, such as potential distractions during unsupervised use, the overall perception was that FizziQ effectively promotes interactive, cooperative, and student centered learning environments in science education.

Technology Integration

The theme technology integration examines how PST implemented the FizziQ mobile application within their lesson design and teaching practice. As illustrated in Figure 4, the app enriched their instructional experience by enhancing problem solving, experiential learning, and curriculum alignment with the 5E model. Some noted challenges, such as the effect of environmental brightness on measurement accuracy, led them to develop practical solutions, like repeating experiments under controlled lighting conditions. Additionally, FizziQ was described as a valuable technological tool for promoting scientific literacy, facilitating data visualization, and simulating virtual laboratories. PST emphasized its effectiveness in improving lesson efficiency and helping students understand abstract scientific concepts through hands-on experimentation. Importantly, the app provided meaningful learning opportunities even in schools with limited laboratory resources, enhancing material diversity and accessibility. Overall, these findings suggest that integrating FizziQ strengthened PST's technological and pedagogical competencies while supporting the creation of inclusive, efficient, and resource aware learning environments in science education.



Figure 4. Technology integration theme

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

21st-Century Skills

The final theme, 21st-century skills, explores how the use of the FizziQ mobile application supported both pedagogical approaches and teacher professional growth in science education. As illustrated in Figure 5, the app encouraged lesson designs suitable for middle school students, emphasizing student centered, long term, and gamified learning experiences. They explained that FizziQ helped bridge abstract and real world concepts through interactive activities and strengthened students' scientific process skills through data collection and analysis. Regarding teacher development, PST highlighted that integrating FizziQ enhanced their sense of competence, effectiveness, and technological pedagogical knowledge. The app was also viewed as a tool that fostered professional confidence in designing and delivering technology enhanced lessons. Moreover, many noted that its integration helped connect more closely with digital native learners, reducing the generational gap between teachers and pupils. Overall, these findings demonstrate how integration of FizziQ harmonizes with the broader goal of cultivating 21st-century learning competencies in science education while simultaneously bolstering teachers' pedagogical and technological capacities to create more inclusive and efficient learning environments.

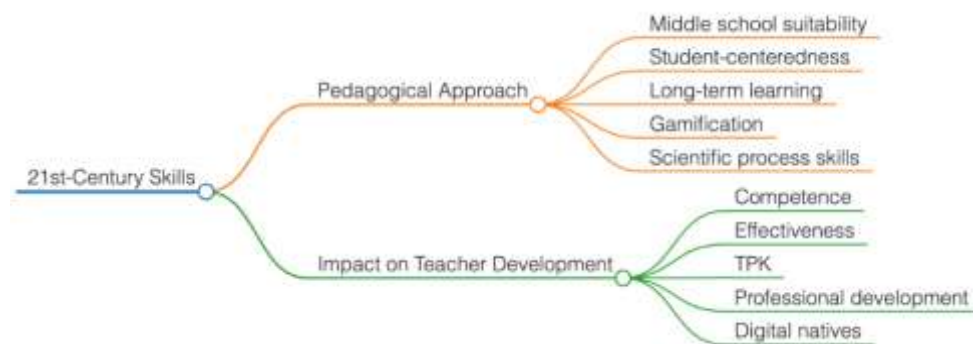


Figure 5. 21st-Century Skills Theme

Discussion and Conclusion

The present study examined how integrating the FizziQ mobile application into PSTs lesson plan design processes affected their TPACK-21. Quantitative results showed a statistically significant increase across all TPACK-21 sub dimensions between pre and post-tests. These findings are consistent with those of Valtonen et al. (2017) and Başaran (2020), both of whom reported strong interrelations among TCK, TPK21, and PCK21 as predictors of overall TPACK-21 performance. Likewise Alemán-Saravia et al. (2023) confirmed the structural validity and reliability of the TPACK-21 framework in culturally distinct contexts, emphasizing its robustness for measuring teachers' technology integrated competencies worldwide. These results directly address the first research question, indicating that the integration of the FizziQ mobile application into lesson planning significantly enhanced PSTs' TPACK-21 levels by strengthening their technological, pedagogical, and content knowledge integration. At the same time, it is important to consider that this increase is likely to be influenced by multiple interacting factors beyond the use of the FizziQ application alone. As Ng et al. (2025) have highlighted the using technology alone does not directly improve teaching outcomes, but works through teachers' PK and PCK. Peñaojas & Palomar (2025) posit that TPACK alone may not fully explain teaching related outcomes, as it works in combination with factors such as self-efficacy and experiential learning. Rotary-Saban & Shonfeld (2025) also suggest that TPACK

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

does not operate on its own, but works through other factors such as teachers' beliefs. Moreover, the effect sizes observed across all sub-dimensions lend support to the notion that the impact of the smartphone based task may be not only statistically significant but also educationally meaningful.

The qualitative findings further reinforced these quantitative outcomes by revealing three major themes: teaching and learning process, technology integration, and 21st-century skills. Under the first theme, PSTs described FizziQ as a facilitator of creative instructional design, to prepare student centered and inquiry based lessons. Mobile sensors and visualization tools helped connect abstract scientific concepts with real life physical phenomena. This observation is consistent with Başaran (2020), who emphasizes that ICT based pedagogical designs can support contextual learning and student motivation. Similar to the assertions of Aslan et al. (2025), the use of digital tools encouraged PSTs to integrate pedagogical innovations with digital literacy, thereby cultivating reflective teaching practices based on experimentation and collaboration. Similar to the findings highlight by Ateş & Garzón (2022) that teachers' positive attitudes and perceived usefulness of mobile applications play a critical role in fostering their intention and confidence to integrate such technologies into science teaching. Consistent with the findings of Crompton et al. (2016) and Widowati & Tyas (2024), this study reinforces the growing consensus that mobile inquiry based learning environments effectively bridge theory and practice by fostering inquiry, contextualized learning, and the development of teachers' TPACK-21 competencies within science education. A possible explanation lies in the affordances of mobile technologies, such as real time data collection and visualization, which support experiential learning and contribute to deeper conceptual understanding. Although previous studies have reported an increase in students' interest and curiosity (Salhab & Daher, 2023), there are also studies that have observed a similar improvement in learning outcomes in physics education (Hochberg et al., 2018).

Within the technology integration theme, PSTs acknowledged FizziQ's effectiveness in enhancing lesson efficiency and engagement within the 5E instructional framework. These observations correspond to Alemán-Saravia et al. (2023), who highlighted that validated TPACK-21 constructs are essential for evaluating teachers' capacity to integrate digital resources into culturally responsive pedagogy. The PSTs in this study also reported developing adaptive strategies to address environmental factors affecting sensor readings, reflecting Mishra & Koehler's (2006) notion that pedagogical reasoning and contextual decision making are central to pedagogically grounded technology use. However, these findings should be interpreted with caution, as contextual factors such as classroom environment and technological infrastructure may influence the effectiveness of mobile applications in different educational settings. Moreover, FizziQ served as a mobile laboratory, enabling experimentation in schools with limited physical resources, echoing findings from Başaran (2020), Voogt & Roblin (2012) that digital technologies can broaden access to scientific inquiry. In line with Zydney & Warner (2016), the findings suggest that FizziQ supports inquiry-based, technology-integrated, and student-centered learning among preservice teachers. As Oliveira et al. (2019) note, in a technology integrated science classroom, teachers are not simply users of technology. They play a key role in guiding how students engage with it from an epistemological perspective.

The 21st-century skills theme underscored that FizziQ not only strengthened PSTs' technological and pedagogical capacities but also enhanced creativity, problem solving, collaboration, and communication skills as core competencies for modern education (González-Pérez & Ramírez-Montoya, 2022; Wang, 2022). PST reflected

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

that the app fostered inquiry, critical thinking, and digital fluency among students, thereby also improving their own confidence and reflective practice as future educators. These outcomes parallel those reported by Aslan et al. (2025) and Alemán-Saravia et al. (2023), who argued that digital literacy mediates the relationship between TPACK competence and effective 21st-century teaching. In line with Li (2024), this study highlights that integrating mobile technologies like FizziQ within the TPACK-21 framework fosters preservice teachers' digital competence and critical thinking in contemporary digital learning environments. These findings directly respond to the second research question, revealing that PSTs perceived FizziQ as an innovative, motivating, and pedagogically valuable tool that enhances lesson design, assessment, and student engagement in science education. These findings also suggest that integrating emerging technologies into teacher education programs can play a critical role in preparing future teachers for digitally enriched and student-centered learning environments.

In conclusion, this study finds that mobile sensor based learning environments, such as FizziQ, can serve as a genuine bridge between theoretical teacher education frameworks and practical classroom applications.

The observed increase in PSTs' TPACK-21 levels suggests that technology enhanced lesson promotes both conceptual understanding and professional development. Similar points are raised by OECD (2025) and Voogt & Roblin (2012), who emphasize the importance of integrating technology within pedagogically grounded frameworks to prepare teachers for guiding learners in complex, digitally rich environments. The integration of digital and mobile technologies allows teachers to enhance instructional quality and enrich learning processes (OECD, 2025). Most teachers feel confident using digital tools to foster student engagement, personalize instruction, and provide real-time feedback. These technological applications not only help teachers develop their digital pedagogical competencies but also foster the design of student-centered learning environments (OECD, 2025). This finding is in line with previous research showing that TPACK-21 is a key factor associated with teachers' competencies in technology-supported instructional practices and assessment processes (Yilmaz & Isbulan, 2026). But Luik et al. (2024) caution that the relationship between TPACK components and teaching related outcomes may vary depending on context and may not always be direct. Conclusively, the findings of this study contribute to the growing body of research emphasizing the importance of aligning emerging learning technologies with pedagogically grounded frameworks such as TPACK-21 in order to support sustainable and effective teacher development.

Implications and Limitations

This research contributes to the expanding literature validating the pedagogical potential of TPACK-21 aligned digital tools in teacher education. Embedding mobile applications like FizziQ into science methods courses or practicum experiences can help PSTs develop evidence based, inclusive, and inquiry oriented teaching strategies. Future studies could build on these results by conducting longitudinal or cross cultural analyses comparing PSTs' TPACK-21 development in different educational systems. Additionally, comparative investigations of different mobile applications could further illuminate how tools like FizziQ shape inquiry-based teaching and foster 21st-century competencies in varied learning contexts. Further exploration into artificial intelligence supported mobile laboratories and mixed reality applications could also extend the TPACK-21 framework, offering deeper insights into how digital technologies transform science learning in both formal and informal settings.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

This study has several limitations that should be considered when interpreting the results. First, the relatively small and context specific sample of PSTs from a single university in Türkiye limits the generalizability of the findings. Future research could include larger and more diverse cohorts across different institutions and cultural settings to enhance external validity. Second, the short duration of the intervention restricted the examination of long-term effects on PSTs sustained TPACK-21 development. Longitudinal designs would allow researchers to investigate how such competencies evolve over time.

Statements and Declarations

This study was approved by the Ethics Committee of University Ondokuz Mayıs, Approval No: 2024-238, Date: 29.03.2024, and all procedures were carried out in accordance with institutional and international ethical standards. The authors declare that no financial support was received for the conduct or publication of this research. The study was conducted independently, without any external funding or sponsorship. AI tools as language editing resources were used solely to improve clarity and grammar. All intellectual content, analysis, and interpretation belong to the authors. This study was conducted as part of the first author's master's thesis research, supervised by the second author.

Bibliographic references

- Alawadh, S., Ali, H., Almutairi, M., & Alhuzimi, T. E. (2019). Pre-service teachers' perceptions of their abilities to teach students with special needs by integrating technology in their classrooms. *Journal of Education and Practice*, 10(35), 84-92. <https://doi.org/10.7176/JEP/10-35-12>
- Albayrak Sarı, A., Canbazoğlu Bilici, S., Baran, E., & Özbay, U. (2016). Investigating the relationship between teachers' technological pedagogical content knowledge (TPACK) competencies and attitudes towards information and communication technologies. *Educational Technology Theory and Practice*, 6(1), 1-21. <https://doi.org/10.17943/etku.11643>
- Alemán-Saravia, A. C., Deroncele-Acosta, A., & Robles-Mori, H. (2023). Translation, cultural adaptation and validation of the tpack-21 questionnaire in teachers' in-service. *Revista de Ciencias Sociales*, 29(3), 453-469. <https://doi.org/10.31876/rcs.v29i3.40730>
- Alpaslan, M. M., Ulubey, Ö., & Ata, R. (2021). Adaptation of technological pedagogical content knowledge scale into turkish culture within the scope of 21st century skills. *Psycho-Educational Research Reviews*, 10(1), 77-91. Recuperado de <https://www.perrjournal.com/index.php/perrjournal/article/view/93>
- Aslan, S., Alanoğlu, M., & Karabatak, S. (2025). Enhancing 21st-century teaching competencies: The key role of digital literacy in connecting pre-service teachers' TPACK. *Information Development*. <https://doi.org/10.1177/02666669251315841>
- Ateş, H., & Garzón, J. (2022). Drivers of teachers' intentions to use mobile applications to teach science. *Education and Information Technologies*, 27(2), 2521-2542. <https://doi.org/10.1007/s10639-021-10671-4>
- Başaran, B. (2020). Investigating science and mathematics teacher candidate's perceptions of TPACK-21 based on 21st century skills. *Elementary Education Online*, 19(4), 2212-2226. Retrieved from <https://ilkogretim-online.org/index.php/pub/article/view/6504>
- Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Journal of Educational Technology & Society*, 16(2), 31-51. <https://www.jstor.org/stable/jeductechsoci.16.2.31>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Chazot, C., & Delabre, U. (2025). Using smartphones to perform kinematic analysis in sports with the FizziQ App: Example of the pole vault. *The Physics Teacher*, 63(9), 791-793. <https://doi.org/10.1119/5.0174195>
- Cohen, S. (1988). Psychosocial models of the role of social support in the etiology of physical disease. *Health psychology*, 7(3), 269. <https://doi.org/10.1037/0278-6133.7.3.269>
- Creswell, J. W., & Clark, V. L. P. (2016). *Designing and conducting mixed methods research*. Sage publications.
- Crompton, H., Burke, D., Gregory, K. H., & Gräbe, C. (2016). The use of mobile learning in science: a systematic review. *Journal of Science Education and Technology*, 25(2), 149-160. <https://doi.org/10.1007/s10956-015-9597-x>
- Delabre, U. (2022). *Smartphonique: Faites de votre smartphone un labo de physique*. Dunod. <https://acortar.link/II7Nmh>
- Diamah, A., Rahmawati, Y., Paristiowati, M., Fitriani, E., Irwanto, I., Dobson, S., & Sevilla, D. (2022). Evaluating the effectiveness of technological pedagogical content knowledge-based training program in enhancing pre-service teachers' perceptions of technological pedagogical content knowledge. *Frontiers in Education*, 7, 897447. <https://doi.org/10.3389/feduc.2022.897447>
- Dzakia, J. R., Sulaeman, N. F., & Subagiyo, L. (2023). Analisis pemahaman guru fisika sma terhadap tpack (technolgical, pedagogical, and content, knowledge) dalam media pembelajaran berbasis teknologi. *INKUIRI: Jurnal Pendidikan IPA*, 12(3), 160-163. <https://doi.org/10.20961/inkuiri.v12i3.79313>
- Ergun, M., & Uzuner, M. N. (2026). Systematic review of science curriculum concepts within TPACK studies from Türkiye. *Discover Education*, 5(476), 1-23. <https://doi.org/10.1007/s44217-026-01522-w>
- Ergun, M., & Delabre, U. (2026). The FizziQ ecosystem as a pocket laboratory in physics education. *Physics Education*, 61(3), 033009.
- Field, A. (2009). *Discovering statistics using SPSS: Book plus code for E version of text* (Vol. 896). London, UK: SAGE Publications Limited.
- González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of education 4.0 In 21st century skills frameworks: Systematic review. *Sustainability*, 14(3), 1493. <https://doi.org/10.3390/su14031493>
- Gökçe, H., & Nacaroğlu, O. (2026). The effect of the use of artificial intelligence tools in science education on secondary school students' 21st century skills competency perceptions and digital literacy. *Educ Inf Technol*, 31, 1059–1077. <https://doi.org/10.1007/s10639-025-13853-6>
- Guo, P. (2021). Integrated practice effect analysis of teaching design pattern on TPACK. *Computer Applications in Engineering Education*, 29(2), 385-393. <https://doi.org/10.1002/cae.22207>
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate Data Analysis (8th ed.)*. New York, NY: Pearson.
- Hochberg, K., Kuhn, J., & Müller, A. (2018). Using smartphones as experimental tolos - Effects on interest, curiosity, and learning in physics education. *Journal of Science Education and Technology*, 27(5), 385–403. <https://doi.org/10.1007/s10956-018-9731-7>
- Hu, L., Zhang, W., & Lin, P. (2025). Can the utilization of technology-enhanced learning spaces lead to improved learning outcomes? A meta-analysis based on 39 experimental and quasi-experimental studies. *Interactive Learning Environments*, 33(4), 3052-3072. <https://doi.org/10.1080/10494820.2024.2436943>
- Karaduman, T., & Akman, B. (2024). A comprehensive review of technological pedagogical content knowledge (TPACK). *e-Kafkas Journal of Educational Research*, 11(1), 141-159. <https://doi.org/10.30900/kafkasegt.1282126>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- Li, H. (2024). Education challenges in developing digital competence and critical thinking skills in a post-information age. *Culture and Education*, 36(2), 419-445. <https://doi.org/10.1177/113564052412598>
- Luik, P., Taimalu, M., Naruskov, K., & Kalk, K. (2024). Does knowledge according to the TPACK framework have an impact on student teachers' beliefs? A path analysis. *Education and Information Technologies*, 29(17), 23027-23048. <https://doi.org/10.1007/s10639-024-12767-z>
- Kaya Yatar, G. & Ergun, M. (2024). Investigation of factors influencing technological pedagogical content knowledge of prospective science teachers. *International Journal of Eurasian Education & Culture*, 9(28), 511-537. <http://dx.doi.org/10.35826/ijoecc.2851>
- Miguel-Revilla, D., Martínez-Ferreira, J. M., & Sánchez-Agustí, M. (2020). Assessing the digital competence of educators in social studies: An analysis in initial teacher training using the TPACK-21 model. *Australasian Journal of Educational Technology*, 36(2), 1-12. <https://doi.org/10.14742/ajet.5281>
- Miles, M. B., & Huberman, A.M. (1994). *Qualitative data analysis (2nd edition)*. Thousand Oaks, CA: Sage.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record: The Voice of Scholarship in Education*, 108(6), 1017-1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
- Nanola, N., Maftuh, B., Burhanudin, B., Wulida, Y., & Siregar, S. W. (2024). TPACK learning in improving teacher skills in elementary school: a systematic literature review. *Mimbar Sekolah Dasar*, 11(2), 422-440. <https://doi.org/10.53400/mimbar-sd.v11i2.71832>
- Ng, K., Venckuniene, K., Klavina, A., Labecka, M., Ostaseviciene, V., Pozeriene, J., Strazdina, N., Reklaitiene, D., & Morgulec-Adamowicz, N. (2025). Associations between technology use, knowledge and inclusive physical education teacher-efficacy among European primary school teachers. *Physical Culture and Sport. Studies and Research*, 108(1), 71-83. <https://doi.org/10.2478/pcssr-2025-0013>
- Peñaojas, J. I., & Palomar, B. C. (2025). A multiple regression analysis on pre-service science teachers' TPACK, efficacy belief, experiential learning and blended teaching readiness. *Discover Education*, 4, 418. <https://doi.org/10.1007/s44217-025-00846-3>
- Rotary-Saban, M., & Shonfeld, M. (2025). Examining the Predictors of Teachers' Self-Efficacy in Digital Science Teaching: the Roles of TPACK, Openness, and School Support. *Research in Science Education*. <https://doi.org/10.1007/s11165-025-10302-9>
- OECD. (2018). *The future of education and skills: Education 2030/2040*. Paris, France: OECD Publishing. <https://www.oecd.org/education/2030-project/>
- OECD. (2025). *Results from TALIS 2024: The state of teaching*. Paris, France: OECD Publishing. https://www.oecd.org/en/publications/results-from-talis-2024_90df6235-en.html
- Oliveira, A., Feyzi Behnagh, R., Ni, L., Mohsinah, A. A., Burgess, K. J., & Guo, L. (2019). Emerging technologies as pedagogical tools for teaching and learning science: A literature review. *Human Behavior and Emerging Technologies*, 1(2), 149-160. <https://doi.org/10.1002/hbe2.141>
- Pallant, J. (2020). *SPSS Survival Manual: A step by step guide to data analysis using IBM SPSS (7th ed.)*. London, UK: Routledge. <https://doi.org/10.4324/9781003117452>
- Salhab, R., & Daher, W. (2023). University students' engagement in mobile learning. *European Journal of Investigation in Health, Psychology and Education*, 13(1), 202-216. <https://doi.org/10.3390/ejihpe13010016>
- Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics*. Boston, MA: Pearson.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

- Teknowijoyo, F., Budiyo, B., Gunarhadi, U., & Sukarmin, A. (2024). *Exploring the role of TPACK in promoting inquiry-based learning in 21st-century science learning*. In The 3rd International Conference on Humanities Education, Law and Social Sciences (Vol. 2024, pp. 1088-1100). KnE Social Sciences. <https://doi.org/10.18502/kss.v9i2.14925>
- Uğur, Ü. E., & Sungur, S. (2021). Middle school students' perceptions about twenty-first-century learning practices in science classes: A multidimensional approach. *Hacettepe University Journal of Education*, 36(1), 186–200. <https://doi.org/10.16986/HUJE.2020058877>
- Ürek, H. (2024). The impact of a mobile phone and mobile application-supported science laboratory on the digital literacy of preservice teachers and their disposition toward using technology in class. *Journal of Science Education and Technology*, 33(6), 983-997. <https://doi.org/10.1007/s10956-024-10138-4>
- Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology*, 33(3), 15-31. <https://doi.org/10.14742/ajet.3518>
- Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: implications for national curriculum policies. *Journal of Curriculum Studies*, 44(3), 299-321. <https://doi.org/10.1080/00220272.2012.668938>
- Wang, A. Y. (2022). Understanding levels of technology integration: A TPACK scale for EFL teachers to promote 21st-century learning. *Education and Information Technologies*, 27(7), 9935-9952. <https://doi.org/10.1007/s10639-022-11033-4>
- Widowati, A., & Tyas, R. A. (2024). Mobile-Based learning in science trends: a systematic review (2015–2023). *Cogent Education*, 11(1), 2303563. <https://doi.org/10.1080/2331186X.2024.2303563>
- Yilmaz, B., & Isbulan, O. (2026). Examining the relationship between teachers' technological pedagogical content knowledge (TPACK) and their self-efficacy for online assessment and evaluation within the scope of 21 st century skills. *Education and Information Technologies*, 1-22. <https://doi.org/10.1007/s10639-026-13974-6>
- Zharylgapova, D. M., Abdikarimov, B. Z., Kaliev, B. K., Almagambetova, A. A., Khodjaev, B. K., & Khujamkulov, A. P. (2025). Meta-Analysis of mobile applications and their impact on student outcomes: enhancing interest and intellectual abilities in physics learning. *Eurasia Journal of Mathematics, Science and Technology Education*, 21(8), em2674. <https://doi.org/10.29333/ejmste/16653>
- Zydney, J. M., & Warner, Z. (2016). Mobile apps for science learning: review of research. *Computers & Education*, 94, 1-17. <https://doi.org/10.1016/j.compedu.2015.11.001>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Appendix 1. Interview Questions

1. Did you experience any difficulties while using the FizziQ application during the lesson preparation process? If yes, were you able to develop any solutions to overcome these difficulties?
2. Do you think that using FizziQ during lesson preparation contributed to your Technological Pedagogical and Content Knowledge? How? Could you give an example?
3. Do you believe that using FizziQ during lesson preparation contributes to the effectiveness of lesson delivery? Why?
4. What are your thoughts on how using FizziQ in lesson preparation influences your choice of teaching methods, techniques, and strategies for lesson delivery? Why?
5. How does using FizziQ in lesson preparation affect your use of assessment and evaluation techniques?
6. Which assessment and evaluation techniques did you employ when evaluating the teaching learning process using FizziQ? Why?
7. Do you think you were able to conduct a lesson consistent with the lesson plan you prepared using FizziQ?
8. Would you like to use the FizziQ application in your future science classes as a teacher? If not, why?
9. What possible benefits could the FizziQ application offer when used in science classes?
10. Do you think there are any limitations to using the FizziQ application in science classes? If so, what are they, and why?
11. Do you believe that technological pedagogical and content knowledge is important for teaching competencies? Why? How? Could you provide examples?
12. Has the use of the FizziQ application contributed to your technology use competencies? If so, how?

Appendix 2. Focus Group Interview Questions

1. How did you prepare your lesson plans using the FizziQ mobile application? What challenges or difficulties did you experience during the planning process?
2. As a preservice science teacher, what are your opinions about using the FizziQ mobile application in the lesson planning process? (Consider professional contributions, advantages, learning gains, and challenges.)
3. In the lesson plan you prepared using the FizziQ mobile application, what contributions did the application provide in terms of selecting instructional strategies, methods, and techniques, identifying students' prior knowledge, and supporting assessment and evaluation processes?

Appendix 3. Lesson Plan

Dersin Adı	Fen Bilimleri
Sınıf	8
Ünitenin Numarası ve Adı	6. Ünite Elektriğin Yolculuğu
Konu Alan Adı	Fiziksel Olaylar
Ünitenin Sırası ve Başlığı	F.B.8.6.1.1. Ampullerin bağlanma durumunun ampul parlaklığına etkisine yönelik deney yapabilme
Konu ve Kavramlar	Ampul, parlaklık, elektrik enerjisi, seri ve paralel bağlama
Tarih	30 Mayıs- 7 Haziran 2024
Önerilen Süre	2 ders saati
Öğrenci Kazanımları	F.B.8.6.1.1. Ampullerin bağlanma durumunun ampul parlaklığına etkisine yönelik deney yapabilme

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Ünite Kavramları ve Sembolleri	Ampul, Parlaklık, Elektrik enerjisi, Seri ve paralel bağlama
Öğrenme Yöntem ve Teknikleri	Soru- cevap, gösterip yaptırma, küçük grup çalışması
Kullanılan Eğitim Araç, Gereçler ve Kaynakça	Maket ev, elektrik devreleri, https://youtu.be/9nC8lrremnE?si=YrQtfeEpqjxYnDB4 https://wordwall.net/resource/15792129

Sokakta bulunan aydınlatmaların sokaktaki insan yoğunluğuna göre ışık şiddetinin değişimini gösteren YouTube üzerinden video bulunarak öğrencilere izletilir. <https://youtu.be/9nC8lrremnE?si=YrQtfeEpqjxYnDB4> Ardından öğrencilerin meraklarını arttırmak ve derse olan hazır bulunuşluklarını ölçebilmek adına aşağıdaki sorular sorulur.

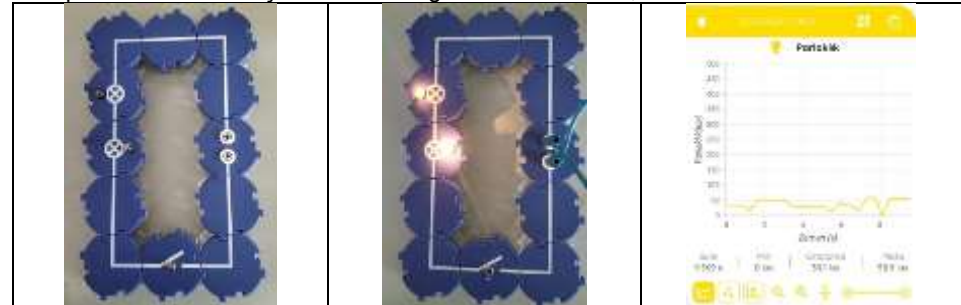
1. Videoda ilk dikkatinizi çeken ne oldu?
2. Sokak lambalarında ne gibi değişiklikler fark ettiniz?
3. Lambaların bu özelliğinin sizce ne gibi avantajları olabilir?

Keşfetme Aşaması: Kazanım kapsamında farklı devrelerde ampul parlaklığını gözlemleyebilmek amacıyla sınıfa farklı özelliklere sahip devreler getirilir. Öğrencilerin bu devreleri gözlemlmeleri sağlanır. Gözlemler yapılırken FizziQ uygulamasında bulunan ışık ölçer kullanarak teorik bilgilerin somut bir kanıtının oluşturulması sağlanır. Öğrenciler gözlemlerini tamamladıktan sonra devre elemanları sınıfta öğrenci grupları oluşturularak öğrencilere dağıtılır ve grupla birlikte kendi devrelerini kurarak uygulamayı kendi kendilerine deneyimlemeleri sağlanır. Bu durumda da öğrencilere sorumluluk verme eğilimi kullanılmış olur. Aynı zamanda kendileri konuyu keşfederler, bu sayede gerçeği arama eğilimi de bu basamakta aktif olarak kullanılır.

1 ampul kullanılarak oluşturulan seri bağlı devrenin verileri;



2 ampul kullanılarak oluşturulan seri bağlı devrenin verileri;



2 ampul kullanılarak oluşturulan paralel bağlı devrenin verileri;

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)



Yapılan deney doğrultusunda öğrencilere aşağıdaki sorular sorulur;

1. Grafiklere bakıldığında ampul parlaklıkları hakkında ne gibi yorumlar yapabilirsiniz?
2. Sizce grafiğin şekli neden bu şekilde oluşmuştur?

Açıklama Aşaması: Keşfetme basamağında yapılan gözlemlerin teorik bilgisi öğrencilere bu basamakta anlatılır. Konu hakkında öğrencilerin bilgi yoğunluğu arttıkça kafalarında oluşan soruları soru sorma eğilimi temelinde sormaları sağlanır.

Derinleşme Aşaması: Öğrencilere konu detaylı bir şekilde anlatıldıktan sonra öğrencilerin konu hakkındaki bilgilerini pekiştirmeleri ve konuya farklı bakış açılarından bakmalarını sağlamak amacıyla sınıfa öğretmenin oluşturduğu maket getirilir. Bu maket öğrencilerin derste öğrendiklerinden farklı olarak yeni devre elamanlarıyla kurulmuş bir devre içermektedir. Maket öğrencilere anlatılır, devreyi incelemeleri sağlanır. İncelemeleri sayesinde odaklanma eğilimi bu basamakta aktif bir şekilde kullanılır. İncelemeler sonucunda öğrencilere elektrik tasarrufu sağlamak amacıyla başka ne gibi devreler kurulabileceğini ve bunu günlük hayatta nerelerde kullanabilecekleri sorulur. Böylece öğrenciler konu üzerinde uzmanlaşmaya başlarlar ve bu eğilimi kullanırlar. Ayrıca öğrencilerde tasarruf bilinci oluşturarak çevreye karşı duyarlılığını arttırıp çevre okur yazarlığı becerisi kazandırılmak amaçlanmıştır. Son olarak hazırlanan maketeki devrede ampulün farklı ışık şiddetleri FizziQ uygulamasında ölçülür. Böylece farklı ışık şiddetlerinin elektrik enerjisi üzerindeki etkisinin tartışılması sağlanır.

Maketin FizziQ uygulaması kullanılarak yapılan ölçümler ve maketin görseli aşağıda verilmiştir.

Ampul parlaklığı en yüksek değerindeyken uygulamada elde edilen ölçüm;

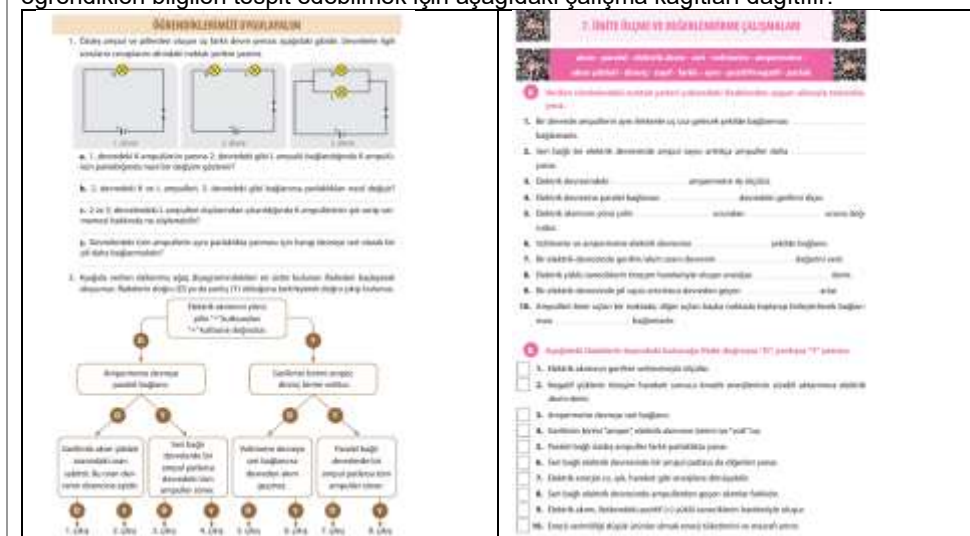


Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Değerlendirme Aşaması: Derinleşme aşaması tamamlandıktan sonra öğrencilere öğrendikleri bilgileri tespit edebilmek için aşağıdaki çalışma kağıtları dağıtılır.



Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Entornos de aprendizaje inmersivos: Realidad virtual para el desarrollo de habilidades de toma de decisiones en ocupaciones de alto estrés

Immersive learning environments: Virtual reality for developing decision-making skills in high-stress occupations

Ruslan Sich¹  Oleh Reznik²  Oleksandr Olytskyi³  Andrii Biliavets⁴  Petro Horpynych⁵ 

Afiliación autor:

¹ PhD, Bogdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine, Khmelnytskyi, Ukraine. r.sich75@gmail.com

² PhD, Bogdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine, Khmelnytskyi, Ukraine. aleg05021982@gmail.com

³ PhD, Bogdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine, Khmelnytskyi, Ukraine. olytskiyo@ukr.net

⁴ PhD, Bogdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine, Khmelnytskyi, Ukraine. biliavets1986@gmail.com

⁵ Senior lecturer, Bogdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine, Khmelnytskyi, Ukraine. gorpynychpetro@gmail.com

Recibido: 20/03/26

Aceptado: 30/05/26

Cómo citar:

Sich, R., Reznik, O., Olytskyi, O., Biliavets, A., & Horpynych, P. (2026). Immersive learning environments: Virtual reality for developing decision-making skills in high-stress occupations. *Revista Eduweb*, 20(2), 253-271. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.15>

Resumen

Los entornos de aprendizaje inmersivos basados en tecnologías de realidad virtual (RV) han abierto nuevas oportunidades para la formación de profesionales cuyas actividades se desarrollan en condiciones complejas y dinámicas. El objetivo de este estudio fue evaluar la eficacia del entrenamiento en RV para desarrollar habilidades de toma de decisiones en situaciones profesionales complejas e identificar los factores psicológicos que influyen en la eficacia de las actividades en dichos entornos. El estudio incluyó a 300 personas, divididas en un grupo experimental (entrenamiento en RV) y un grupo de control (entrenamiento tradicional con escenarios). El análisis de los resultados mostró diferencias estadísticamente significativas entre los grupos. Los participantes que recibieron entrenamiento en un entorno de RV obtuvieron mejores resultados en cuanto a conciencia situacional, velocidad de análisis de situaciones, precisión en la toma de decisiones y autorregulación emocional. Los resultados del análisis de regresión indicaron que la intensidad del uso de la RV ($\beta = 0,34$, $p < 0,001$), la resiliencia psicológica ($\beta = 0,30$, $p < 0,001$) y la autorregulación emocional ($\beta = 0,26$, $p < 0,001$) tuvieron el mayor impacto. Esto subraya la importancia tanto de las condiciones pedagógicas de aprendizaje como de los recursos psicológicos individuales de los participantes. Los hallazgos destacan que la combinación de tecnologías inmersivas y los recursos psicológicos de los participantes contribuyó a la formación de estrategias cognitivas más eficaces para el análisis de situaciones.

Palabras clave: entornos de aprendizaje inmersivos, aprendizaje en realidad virtual, toma de decisiones, conciencia situacional, formación profesional, tecnologías educativas.

Abstract

Immersive learning environments based on virtual reality (VR) technologies have opened up new opportunities for training professionals whose activities are related to work in complex and dynamic conditions. The purpose of the study was to assess the effectiveness of using VR training to develop decision-making skills in complex professional situations, to identify psychological factors that influenced the effectiveness of activities in such environments. The study involved 300 people who were divided into an experimental group (VR training) and a control group (traditional scenario training). Analysis of the results showed the presence of significant differences between the groups. Participants who underwent training in a



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

VR environment had better indicators of situational awareness, speed of situation analysis, accuracy of decision-making. Additionally, analysis of variance indicated that the effectiveness of scenario tasks increased in accordance with the intensity of VR scenario use in the learning process. The results of regression analysis indicated that the intensity of VR use ($\beta = 0.34$, $p < 0.001$), psychological resilience ($\beta = 0.30$, $p < 0.001$) and emotional self-regulation ($\beta = 0.26$, $p < 0.001$) had the greatest impact. This indicates the important role of both pedagogical learning conditions and individual psychological resources of participants. The findings emphasize that the combination of immersive technologies and participants' psychological resources contributed to the formation of more effective cognitive strategies for analyzing situations.

Keywords: immersive learning environments, VR learning, decision-making, situational awareness, professional training, educational technologies.

Introduction

The rapid development of digital technologies has significantly influenced the formation of modern educational practices, including in the field of professional training of specialists in high-responsibility fields. In many emergency professions, the effectiveness of activities depended on the ability of specialists to quickly analyze the situation, make informed decisions in limited time conditions and control their own emotional reactions. Traditional educational models, which were based on lecture and seminar forms of training, did not always provide a sufficient level of practical training for such situations, which led to the need to find new pedagogical approaches.

One of the promising areas was the use of immersive learning environments, in particular virtual reality technologies (Virtual Reality, VR). Immersive technologies made it possible to create interactive learning spaces in which students could interact with dynamic simulated scenarios.

In modern scientific literature, interest has been formed in researching the potential of immersive technologies in the education system (Zechner et al., 2023). Studies have shown that VR has increased the engagement of learners, contributed to a deeper understanding of complex processes, and created conditions for practice-oriented learning (Clifford et al., 2019; Dubreucq et al., 2025). In particular, immersive simulations have made it possible to integrate cognitive, behavioral, and emotional components of learning. At the same time, many available studies have focused on the technical aspects of VR or on general indicators of the effectiveness of digital educational tools (Hurrell & Baker, 2020; Kleygrewe et al., 2022). However, the problems of pedagogical design of immersive learning environments and their impact on the development of decision-making skills in complex situations have remained insufficiently studied (Llanos-Ruiz et al., 2025). The latest educational models have taken into account the technological capabilities of VR, pedagogical principles of organizing the educational process, and the features of user interaction with the digital environment. At the same time, an important but under-researched aspect is the economic and organizational feasibility of implementing VR in the educational process (Tsymbol-Slatvinska et al., 2022). Despite the high initial costs of equipment and development, VR technologies can reduce long-term costs due to scalability, repeatability of scenarios, and a reduction in the need for costly practical training.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

In such circumstances, the study of the possibilities of using immersive learning environments to develop decision-making skills in professions with a high level of stress has become relevant in the future.

The purpose of the study is to analyze the potential of immersive learning environments based on virtual reality technologies for the development of decision-making skills in professions with a high level of stress. To achieve the goal, the following research objectives were defined:

1. To analyze modern approaches to the use of immersive technologies in professional training.
2. To identify pedagogical principles for designing training scenarios in a virtual reality environment.
3. To investigate the impact of an immersive training environment on the development of decision-making skills in complex situations.
4. To determine the relationship between the psychological characteristics of training participants and the effectiveness of performing scenario tasks in a VR environment.

The study proposed the following hypotheses:

1. The use of immersive training environments based on virtual reality technologies will contribute to an increase in the level of formation of decision-making skills in complex situations.
2. Participants who underwent training in a VR environment demonstrated a higher level of situational awareness and speed of decision-making compared to traditional forms of training.
3. Psychological characteristics, in particular the level of stress resistance and the ability to self-regulate, are positively correlated with the effectiveness of performing scenario tasks in an immersive learning environment.

Literature Review

At the current stage of development of research in the field of vocational education, significant attention has been paid to the issue of finding effective pedagogical approaches for training specialists whose activities take place in conditions of increased risk and uncertainty. Since approximately 2020, there has been a noticeable increase in interest in research in the scientific literature that combined pedagogical, psychological and technological approaches to training specialists in complex and stressful situations. Researchers have paid particular attention to the use of digital simulations, immersive learning environments and professional scenario modeling technologies as tools for developing decision-making skills (Vieira et al., 2025; Steingraber et al., 2021; Semenova et al., 2023).

In this context, an important area of research has been the study of psychological and cognitive factors that influenced the effectiveness of professional activity in complex conditions. In particular, recent review studies have shown that the ability to be psychologically resilient and emotionally self-regulating was an important part of decision-making in situations of increased workload (Moreno et al., 2024). In pedagogical practice, training programs aimed at developing these competencies were increasingly used, in particular, trainings that integrated cognitive-behavioral approaches, mindfulness techniques, and emotion management strategies (Filipenko et al., 2024). Researchers have emphasized the effectiveness of such programs, noting the dependence on the possibility of individualizing learning and adapting educational trajectories to the characteristics of participants in the

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

educational process. At the same time, the development of digital educational technologies has significantly expanded the possibilities of pedagogical modeling of complex professional situations (Reale et al., 2023; Vittadello et al., 2025). One of the most promising areas in this context was the use of scenario-based and simulation-based learning, which allowed for the reproduction of realistic work situations in a controlled educational environment. Immersive technologies (such as virtual reality) created conditions for interactive interaction of users with educational scenarios and allowed the formation of practical skills in a safe digital environment.

However, one of the key issues in the study of immersive technologies has become the problem of transferring learning outcomes from a virtual environment to real professional activity. Modern pedagogical research has determined that the effectiveness of VR training cannot be assessed solely through the level of involvement or realism of the simulation. The category of effectiveness should be described based on the ability to form stable cognitive and behavioral patterns that are reproduced in real conditions of activity.

From this point of view, the integration of immersive technologies with psychological and pedagogical approaches to learning is of particular importance (Ocaña-Zuñiga et al., 2023; Ramdani & Kotsou, 2025). For example, the formation of stress resistance, emotional self-regulation and situational awareness has become an important factor that ensured the effective transfer of the formed skills into practical activities. Immersive environments also make it possible to model conditions of uncertainty, limited time and a high level of responsibility.

In addition, the issue of harmonizing individual and socio-organizational factors of learning has become important. Studies have shown that the effectiveness of training in difficult conditions depends on individual characteristics (level of self-regulation, cognitive flexibility) and on the learning space. In particular, the factors of team interaction, organizational culture and after-action review practices have become important. Accordingly, VR environments play the role of an integrative platform that combines individual and collective learning (Ramdani & Kotsou, 2025). Therefore, immersive technologies should be considered as a visualization tool and as a pedagogical environment that provides conditions for the formation, consolidation and transfer of professional competencies.

Several studies have shown that the combination of immersive technologies with pedagogical learning models that were focused on the development of stress resistance significantly increased the effectiveness of specialist training (Andersen et al., 2024; Caudillo-Melgoza & Caudillo Melgoza, 2025). In particular, an increase in attention concentration and a decrease in the number of errors when performing complex tasks in simulated scenarios were confirmed (Gamito et al., 2024). European research projects have also proposed comprehensive training models that combine psychoeducational modules, self-regulation training, situational scenario analysis, and group interaction in digital simulation environments (Steingraber et al., 2021). Such approaches have integrated individual learning, team interaction, and dynamic assessment of professional competencies. A separate area of research has been related to the consolidation of the role of socio-organizational factors in shaping readiness for activity in conditions of increased risk. In particular, studies have shown that organizational climate, management style, safety culture, and the level of collegial support could significantly affect professional resilience and effectiveness in complex situations (Dubiel et al., 2025). Organizations that implemented team incident analysis, after-action review, and horizontal communication practices

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

showed significantly better adaptability and psychological preparedness for unforeseen situations (Fedorenko et al., 2023; Jongbloed et al., 2024). These results confirmed the need for further training programs with special modules aimed at developing team interaction, communication, and collective resilience in complex work environments. At the same time, despite the significant amount of research in this area, a number of significant research gaps remained in the scientific literature. First of all, this concerned a limited number of empirical studies aimed at comprehensively assessing the effectiveness of immersive learning environments for developing decision-making skills in complex situations. Existing training programs differed significantly from the existing standardized criteria for assessing the formation of relevant competencies. Therefore, it remains relevant to conduct further research aimed at empirically verifying pedagogical models of using immersive technologies in the professional training of specialists whose activities are related to work in stressful conditions.

Methodology

Research Design

The study was conducted using a mixed-methods design. It combined quantitative and qualitative approaches to analyze the effectiveness of immersive learning environments based on virtual reality (VR) technologies in developing decision-making skills in situations of increased complexity. This design made it possible to combine statistical measurement of changes in learning outcomes with a deeper analysis of participants' behavioral responses while performing scenario tasks in a virtual environment.

The study was quasi-experimental in nature and included a comparison of two training models: traditional training and training using an immersive VR environment. In general, the study was implemented in three stages.

The first stage involved a quantitative study to determine the initial level of psychological characteristics related to decision-making in stressful situations (stress tolerance, emotional self-regulation, coping strategies).

In the second stage, participants participated in scenario training tasks. For the experimental group, these scenarios were implemented in VR environments. Participants from the control group performed similar tasks in the traditional format of training simulations. The scenarios consisted of modeling complex professional situations that required rapid response, information analysis, and risk assessment.

The VR scenarios used were to:

- Respond to sudden crisis situations in a complex environment;
- Make decisions in complex situations of information uncertainty;
- Perform tasks in an environment with an increased level of sensory load (noise, limited visibility, dynamic changes in the situation);
- Participants demonstrated team interaction in complex scenarios.

The assessment was carried out using standardized observation cards that were filled out by instructors after each scenario.

The VR environment was used with stand-alone VR headsets, which allowed users to immerse themselves in simulated scenarios without the need to connect to external computing systems. The devices are equipped with built-in displays with a

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

resolution of 1832×1920 pixels per eye, a refresh rate of 72–90 Hz, and real-time head and hand movement tracking systems.

Hand-held controllers were also used to interact with the virtual environment, allowing for navigation, selection of actions, and manipulation of objects in the scenarios. Audio support was based on integrated spatial audio systems, which increased the level of sensory load and realism of situations.

The VR scenario software was developed taking into account the principles of interactivity, dynamic situations, and variability of events. This ensured the adaptation of the learning environment to the actions of the participants.

The final stage involved qualitative research in the form of semi-structured interviews with participants and instructors to delve deeper into the experience of using the immersive learning environment and assess its impact on the learning process.

Participants

The study involved 300 people who had undergone professional training or worked in areas of activity associated with a high level of responsibility and the need to make decisions in difficult situations.

The sample structure was as follows:

students and cadets of professional educational programs - 150 people
professionals with practical experience in the relevant professional fields - 150 people

Participants were divided into two groups:

experimental group (VR training) - 150 people
control group (traditional training) - 150 people

Inclusion and exclusion criteria were applied to those wishing to participate in the experiment (See Table 1).

Table 1.
Inclusion and Exclusion criteria

Inclusion Criteria	Exclusion Criteria
age from 18 to 45 years	presence of diagnosed mental disorders
experience in participating in professional or educational programs that provide preparation for work in difficult situations	refusal to participate in VR scenarios
regular participation in training or simulation training tasks	participation in parallel intensive psychological rehabilitation programs
voluntary consent to participate in the study	

Source: Author's development

It is worth noting that the average age of the participants was 27.4 years (SD = 5.8). The proportion of women in the sample was approximately 20%.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Instruments and Procedure

A range of research tools was used to assess the impact of an immersive learning environment on the development of decision-making skills. It included standardized psychodiagnostic techniques, author's questionnaires, behavioral observation maps in VR scenarios, and semi-structured interviews. In particular, the Connor–Davidson Resilience Scale (CD-RISC-25) was used to assess psychological resilience, which allowed us to measure the ability to adapt, emotional self-regulation, and recovery from stress. Psychological resilience was also assessed using the Hardiness Survey, which consisted of three main components: commitment, control, and challenge. The level of anxiety was measured using the State–Trait Anxiety Inventory (STAI), which allowed us to assess situational and personal anxiety in the process of performing complex tasks. To determine the dominant coping strategies, the Coping Inventory for Stressful Situations (CISS) was used, which differentiated problem-oriented, emotion-oriented, and unique coping strategies.

The author's Decision-Making under Pressure Questionnaire was used to assess decision-making skills. This questionnaire consisted of 12 scenario situations with time constraints and information uncertainty.

An important tool was the behavioral observation map during the execution of VR scenarios. Instructors assessed the participants on a five-point scale according to the following indicators:

- Speed of situation analysis;
- Rationality of decision-making;
- Emotional self-regulation;
- Effectiveness of team interaction;
- Overall effectiveness of task performance.

Semi-structured interviews with study participants were aimed at analyzing their experience of interacting with the VR environment, their perception of the realism of the scenarios, and assessing the impact of immersive learning on the formation of professional skills.

Research procedure

The study took place over a period of four months. In particular, during the first stage, the organizers conducted initial psychodiagnostic testing of the participants. The survey was conducted in both group and individual formats. The average time to complete all instruments was 55–70 minutes.

During the second stage, the participants implemented training scenarios. The experimental group completed tasks in a VR environment using immersive simulations, while the control group worked with traditional training scenarios. Each scenario was evaluated by two independent instructors.

At the third stage, qualitative interviews were conducted with the participants and instructors. The sample for the interview was formed according to the principle of maximum variability. The duration of the interview was from 25 to 40 minutes.

Data analysis

Quantitative data were analyzed using the SPSS 28 statistical package.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

At the first stage, data cleaning, checking for omissions, detecting outliers, and testing for normal distribution (Shapiro–Wilk test) were organized. To assess the reliability of the scales, Cronbach's α coefficients were calculated (critical value $\alpha \geq 0.70$).

Subsequently, descriptive statistics were calculated. Therefore, the Pearson correlation coefficient was used to analyze the relationships between variables. With its help, the relationships between:

- Psychological stability and the effectiveness of VR scenario execution;
- Emotional self-regulation and the quality of decision-making;
- Coping strategies and the results of scenario tasks were analyzed.

Independent samples t-tests were used to compare experimental and control groups. Regression analysis was also conducted to determine the main predictors of decision-making effectiveness in the VR environment.

Qualitative interview data were analyzed using the thematic analysis method, which consisted of coding significant fragments of text, forming thematic categories, and summarizing the results. The integration of quantitative and qualitative results made it possible to formulate recommendations for the use of immersive educational technologies in professional training of specialists.

To summarize the logic of the experimental design and clearly present the differences between the training conditions, the main elements of the study were systematized. Table 2 presents the structure of the experimental design, which reflected the features of the organization of the training process in the experimental and control groups.

Table 2.
Experimental Design of the Study (Experimental Group vs Control Group)

Design Element	Experimental group (EG)	Control Group (CG)
Number of Participants	n = 150	n = 150
Type of Training	Immersive learning in VR environment	Traditional training
Format of Training Scenarios	Interactive VR simulations with dynamic situations and sensory stimuli	Scenario exercises and case methods without VR
Type of Environment	Virtual reality using VR headsets and interactive scenarios	Audience training and group simulations
Duration of Training	4 weeks (8 training sessions)	4 weeks (8 training sessions)
Main Learning Objectives	Decision-making in VR scenarios; risk analysis; team interaction in simulated situations	Case analysis; role-playing; discussion of scenario situations
Pre-experimental Testing	CD-RISC-25, Hardiness Survey, STAI, CISS, Decision-Making Questionnaire	CD-RISC-25, Hardiness Survey, STAI, CISS, Decision-Making Questionnaire
Post-experimental	Repeated measurement of	Repeated measurement

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Testing	the same indicators + assessment of behavior in VR scenarios	of the same indicators
Behavioral Assessment	Observation of instructors during the execution of VR scenarios	Observation of instructors during traditional scenario exercises
Main Dependent Variables	Quality of decision-making; speed of situation analysis; emotional self-regulation; situational awareness	Quality of decision-making; speed of situation analysis; emotional self-regulation
Analysis Methods	t-tests, Pearson correlation, regression analysis, thematic analysis	t-tests, Pearson correlation

Source: Author's development

In addition, to ensure transparency of the research procedure and reproducibility of the results, the main research variables and their measurement instruments were compiled (See Table 3).

Table 3.
Variables and Measurement Instruments

Variable	Instruments	Key indicators
Psychological resilience	Connor–Davidson Resilience Scale (CD-RISC-25)	Cognitive flexibility, adaptability, emotional control
Psychological endurance	Hardiness Survey	Commitment, Control, Challenge
Anxiety level	State–Trait Anxiety Inventory (STAI)	Situational and personal anxiety
Coping strategies	Coping Inventory for Stressful Situations (CISS)	Problem-oriented, emotionally-oriented and unique strategies
Decision-making skills	Decision-Making under Pressure Questionnaire (авторська модифікація)	Quality of decision-making in time-constrained scenarios
Behavioral responses in scenarios	Observation checklist (інструкторська оцінка)	Speed of situation analysis, rationality of decisions, self-regulation
Team interaction	Observation checklist	Communication, coordination of actions, support
Overall task performance effectiveness	Instructor rating scale	Integral performance indicator

Source: Author's development

The selected instruments allowed a comprehensive assessment of both psychological characteristics and behavioral indicators of decision-making performance within immersive learning environments.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Results and Discussion

Psychological predictors of decision-making effectiveness in an immersive learning environment

To determine the main psychological factors that were associated with the effectiveness of decision-making in complex professional situations, the results of several psychodiagnostic methods were analyzed. CD-RISC (psychological resilience), Hardiness Survey (psychological endurance), STAI (anxiety level), CISS (coping strategies) were used. The author's scales for assessing decision-making skills in situations of increased workload were also used. Additionally, expert behavioral observation cards were used during the implementation of training scenarios.

In general, the participants demonstrated an average and average-high level of psychological resilience, emotional self-regulation and psychological endurance. At the same time, there was a noticeable individual variability in the indicators, which made it possible to identify key psychological predictors of the effectiveness of performing scenario tasks in the learning environment.

Table 4.
Descriptive statistics of psychological indicators

Indicator	M	SD	Min	Max
Psychological resilience (CD-RISC)	68.42	12.11	34	96
Psychological endurance	3.71	0.54	2.10	4.80
Emotional self-regulation	3.89	0.62	2.30	5.00
Anxiety (STAI-State)	41.22	10.45	22	73
Problem-focused coping	3.72	0.67	2.10	5.00
Emotional-focused coping	2.91	0.73	1.30	5.00
Avoidance	2.78	0.69	1.10	5.00
Effectiveness of decision-making in scenarios	4.01	0.56	2.60	5.00

Source: Author's development

As can be seen from Table 4, despite the generally high level of psychological preparedness of the participants, factors of anxiety and emotional instability could negatively affect the effectiveness of behavior in difficult learning situations. To determine the relationships between psychological characteristics and the results of performing scenario tasks, a correlation analysis using the Pearson coefficient was conducted (See Table 5).

Table 5.
Correlations between psychological indicators and the effectiveness of performing scenario tasks (r-coefficients).

Psychological indicator	Stress resistance	Script execution efficiency
Psychological resilience	0.62*	0.54*
Emotional self-regulation	0.56*	0.49*
Psychological endurance	0.49*	0.47*
Problem-focused coping	0.41	0.44
Emotional-focused coping	-0.32*	-0.28*
Avoidance	-0.37*	-0.35*
Situational anxiety	-0.45*	-0.39*

Notes: *p < 0.05; **p < 0.01; ***p < 0.001

Source: Author's development

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The results showed a high level of psychological resilience and emotional self-regulation, which is directly related to greater effectiveness in performing scenario tasks in the learning environment. Participants with developed self-regulation skills demonstrated more stable behavioral reactions and made more informed decisions in stressful situations.

On the other hand, emotionally oriented coping strategies and avoidance were associated with reduced decision-making accuracy and increased uncertainty during scenario tasks. Increased level of situational anxiety hurt the participants' ability to quickly analyze the situation and quickly make the necessary decisions.

Comparison of the results of the experimental and control groups

To test the hypothesis about the impact of the immersive learning environment on the development of decision-making skills, a comparative analysis of the results of the experimental (VR) and control groups was conducted. Therefore, t-tests for independent samples were used for this purpose. This approach made it possible to determine statistically significant differences between the groups in the main indicators of the effectiveness of performing scenario tasks (See Table 6).

Table 6.

Comparison of effectiveness indicators between the experimental and control groups (t-test)

Indicator	Control Group (M)	Experimental Group (M)	t	p
Speed of situation analysis	3.54	4.12	-4.38	< 0.001
Quality of decision-making	3.61	4.21	-4.75	< 0.001
Emotional self-regulation	3.67	4.18	-4.11	< 0.001
Situational awareness	3.49	4.09	-4.52	< 0.001
Overall task performance effectiveness	3.58	4.24	-4.87	< 0.001

Source: Author's development

The proposed results showed the existence of differences between the groups in all studied indicators ($p < 0.001$). Participants in the experimental group, who used VR environments in training, showed significantly better results in the speed of situation analysis, accuracy of decision-making, level of emotional self-regulation and situational awareness.

The most noticeable difference between the groups was recorded in the indicator of overall task performance ($M = 4.24$ in the VR group versus $M = 3.58$ in the control group). This indicated a positive impact of the immersive learning environment on the formation of practical decision-making skills.

Therefore, the results confirmed the proposed hypothesis that the use of virtual reality technologies in the educational process contributed to increasing the efficiency of performing complex scenario tasks.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The effect of the intensity of immersive training on the results of performing tasks

To determine how the frequency of using VR scenarios affected the effectiveness of training, an analysis of variance (ANOVA) was used. The participants of the experimental group were conditionally divided into three subgroups depending on the intensity of using VR scenarios in the training process: low, medium and high frequency of training.

Table 7.

The effect of the intensity of VR training on the results of performing scenario tasks

VR Training Frequency	Task performance efficiency	Quality of decision-making	Selfregulation
Low	3.42	3.37	3.51
Medium	3.87	3.92	3.98
High	4.28	4.31	4.36

ANOVA: $F = 19.6$; $p < 0.001$

Source: Author's development

As can be seen from Table 7, the effectiveness of scenario tasks increased depending on the frequency of use of immersive training scenarios. Participants who participated in high-intensity VR training showed better results. First of all, they were better in decision-making accuracy, levels of emotional self-regulation.

The obtained statistically significant result ($F = 19.6$; $p < 0.001$) indicated that the regular use of immersive training environments contributed to the formation of stable behavioral strategies in difficult situations.

In addition, the results of the study demonstrated that repeated execution of scenario tasks in a VR environment allowed participants to recognize critical situations faster, assess risks more effectively and make more informed decisions.

Regression analysis of predictors of decision-making effectiveness in a VR learning environment

To determine the factors that had the greatest impact on the effectiveness of decision-making in complex scenario situations, a multiple regression analysis was conducted. The corresponding variable was the overall effectiveness of performing scenario tasks in the learning environment (an integral indicator formed on the basis of instructors' assessments and the results of the author's decision-making test).

The model included such predictors as the level of psychological stability, emotional self-regulation, psychological endurance, problem-oriented coping strategies, and subjective assessment of the quality of learning. The intensity of the use of VR scenarios in the learning process was also taken into account (See table 8).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 8.

Results of regression analysis of predictors of decision-making effectiveness

Predictor	β	p	Interpretation
Psychological resilience	0.30	< 0.001	The strongest psychological predictor of decision-making effectiveness
Emotional self-regulation	0.26	< 0.001	Provides control of impulsive reactions and stability of behavior
Psychological endurance	0.17	0.006	Promotes the perception of difficult situations as a professional challenge
Problem-focused coping	0.13	0.021	Strengthens a rational approach to analyzing situations
Quality of training	0.21	< 0.001	Increases confidence in one's own professional actions
Intensity of VR training	0.34	< 0.001	The strongest pedagogical factor for increasing effectiveness

Model: $R^2 = 0.49$; $F(6, 293) = 46.8$; $p < 0.001$

Source: Author's development

The obtained value of $R^2 = 0.49$ is indicated as follows: almost half of the variability in the effectiveness of decision-making in complex scenario situations was explained by a combination of psychological and pedagogical factors included in the model.

A particularly important result was that the intensity of the use of VR scenarios was a significant pedagogical predictor of effective activity. This showed that regular interaction with immersive simulations contributed to the creation of more stable cognitive strategies for analyzing situations. It also increased the accuracy of decision-making.

At the same time, among the psychological factors, psychological resilience and emotional self-regulation made the greatest contribution to the model. This emphasized the importance of developing these characteristics in the process of professional training.

Overall, the results of the regression analysis demonstrated that the effectiveness of decision-making in complex learning scenarios was the result of the interaction of several key components, namely - individual psychological resources and pedagogical learning technologies (immersive VR environments).

Discussion

The proposed results confirmed the important role of immersive learning environments in developing decision-making skills in complex professional situations. In general, the results of the study made it possible to establish that the use of virtual reality technologies contributed to increasing the efficiency of performing scenario tasks, improving situational awareness and developing the ability to quickly analyze complex situations. Participants in the experimental group who were trained in the VR environment showed better results in the processes of speed of situation analysis, accuracy of decision-making and the level of emotional self-regulation (when compared with representatives of the control group). Such results fully confirmed the results of previous studies, which emphasized the potential of immersive technologies for increasing the effectiveness of learning in complex professional environments (Hindman et al., 2025). First, several researchers noted that VR simulations made it possible to form realistic learning scenarios that contributed to the formation of situational awareness and the

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

development of practical decision-making skills in dynamic conditions (Cabrera-Duffaut et al., 2024; Kluge et al., 2023). Similar results were formed in studies that were devoted to the use of simulation training in vocational education (Oliveira et al., 2024). It was also shown here that immersive scenarios contributed to the formation of more stable cognitive strategies for analyzing situations (Mao et al., 2021; Radhakrishnan et al., 2021). Accordingly, the proposed results became a kind of litmus test for the hypotheses existing in the scientific literature. An important result was the confirmation that the effectiveness of decision-making depended not only on the use of innovative educational technologies. It also depended on the individual psychological characteristics of the training participants. First, the results of correlation and regression analysis demonstrated that psychological stability and emotional self-regulation were important predictors of the success of performing scenario tasks. This result is consistent with studies that emphasize the importance of psychological resources in the process of professional activity in difficult conditions (Ricci et al., 2022; Varshney et al., 2024). Some authors also noted that the development of emotional self-regulation skills significantly reduced the impact of stress factors on the decision-making process (Wee et al., 2021). Accordingly, they indicated an improvement in cognitive control in situations of uncertainty (Rushton et al., 2020; Maksymchuk et al., 2022). At the same time, the results of the regression analysis demonstrated that one of the most important pedagogical factors that had an impact on the effectiveness of decision-making was the intensity of the use of VR scenarios in the educational process. This indicated regular interaction with immersive learning environments, which contributed to the formation of more stable behavioral algorithms and improved the ability to quickly analyze complex situations. Similar results were obtained in those studies that discussed the use of simulation technologies in education (Sung et al., 2024). Accordingly, other researchers have also demonstrated that the repeated execution of scenario tasks in digital environments contributed to the formation of automated behavioral strategies (Singh et al., 2025).

At the same time, when using immersive VR environments, some technical limitations and physiological effects were noticeable. In particular, some participants reported short-term discomfort during scenario execution, including dizziness, visual fatigue, and mild cybersickness (motion sickness).

Analysis of behavioral indicators indicated that at the initial stages of the execution of the scenarios, participants who had physical discomfort showed a lower speed of orientation in the situation and a greater number of errors in initial decision-making. Thus, there was a noticeable increase in cognitive loads associated with adaptation to the immersives.

However, these effects were mostly temporary and did not lead to the termination of participation in the study.

It is important to note that at the initial stages of interaction with the VR environment, such factors could affect the speed of orientation in the scenario and the efficiency of task performance. At the same time, during the repeated execution of the scenarios, participants' adaptation to the conditions of the immersive environment was observed, which was accompanied by a decrease in the level of discomfort and stabilization of behavioral indicators.

Thus, despite the fact that the physiological limitations of VR technologies required consideration in the organization of the educational process, their impact is not

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

critical and can be minimized by gradual immersion, optimizing the duration of sessions, and taking into account the individual characteristics of users.

In addition, the proposed research results demonstrated the importance of combining technological innovations with pedagogical learning models. For example, the effectiveness of VR learning depended on the quality of scenario development, the level of interactivity of the environment, and the ability to receive feedback during task completion. Similar approaches have received positive reviews in modern studies on digital pedagogy (Ramdani & Kotsou, 2025; Omelchuk et al., 2022). Researchers have repeatedly emphasized that technologies in themselves do not guarantee an increase in the quality of learning without appropriate pedagogical design (Murthy et al., 2025; Miloradova et al., 2022). It is important to take this into account in subsequent experiments. An important aspect of the study was also the fact that immersive learning environments created conditions for the integration of cognitive, behavioral, and emotional components of learning. This made it possible to form complex professional competencies that were difficult to develop in traditional educational formats. Accordingly, the proposed research results confirmed the thesis that VR technologies effectively developed decision-making skills in complex professional situations (Ocaña-Zuñiga et al., 2023; Carvalho et al., 2025). Therefore, the results of the study indicated that the effectiveness of decision-making in complex educational scenarios was formed as a result of the interaction of two key groups of factors: individual psychological resources and pedagogical learning technologies. Accordingly, immersive VR environments fostered the development of situational awareness and practical skills for analyzing complex situations.

Despite the valuable results, the study has its limitations. It is worth recognizing that self-report data (questionnaires) may contain socially desirable responses. In addition, the study did not consider long-term changes. It should also be considered that the simulation of combat situations in training conditions did not always fully reproduce actual circumstances. In the future, it is worth conducting longitudinal studies to study the dynamics of the formation of professional readiness

Conclusions

Thus, the study indicated the effectiveness of using immersive learning environments based on virtual reality technologies for developing decision-making skills in complex professional situations. Participants who were trained in a VR environment had higher indicators of the speed of situation analysis, decision-making accuracy, level of emotional self-regulation and overall task performance efficiency compared to traditional forms of training.

The research indicates that the effectiveness of decision-making is formed mainly under the influence of the interaction of psychological characteristics (stress tolerance, self-regulation) and pedagogical conditions: the intensity of the use of VR scenarios in the educational process.

The practical significance of the study is determined by the possibility of integrating immersive VR technologies into the system of professional training of specialists whose activities are associated with work in conditions of increased risk and uncertainty.

Special attention should be paid to managerial and educational decisions at the level of educational policy. In particular, it is advisable to include VR technologies in educational standards and training programs, and develop methodological

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

recommendations for their use. A separate important direction will be investing in technical infrastructure and training teachers to work with immersive environments. The implementation of such solutions will allow in the future to improve the quality of professional training and form practically oriented competencies. Prospects for further research are related to the development of adaptive VR-training systems that would take into account the individual psychological characteristics of users and ensure high-quality personalization of the educational process.

Bibliographic references

- Andersen, J. P., Arpaia, J., Gustafsberg, H., Poplawski, S., & Di Nota, P. M. (2024). The International Performance, Resilience and Efficiency Program Protocol for the Application of HRV Biofeedback in Applied Law Enforcement Settings. *Applied Psychophysiology and Biofeedback*, 49, 483–502. <https://doi.org/10.1007/s10484-024-09644-3>
- Cabrera-Duffaut, A., Pinto-Llorente, A. M., & Iglesias-Rodríguez, A. (2024). Immersive learning platforms: analyzing virtual reality contribution to competence development in higher education—a systematic literature review. *Frontiers in Education*, 9. <https://doi.org/10.3389/feduc.2024.1391560>
- Carvalho, S. A., Conceição, E. S., & Marques, I. C. P. (2025). The Impact of Virtual Reality on Employee Training and Learning in Organisations: A Systematic Literature Review. *Applied Sciences*, 15(19), 10459. <https://doi.org/10.3390/app151910459>
- Caudillo-Melgoza, M. A., & Caudillo Melgoza, M. A. (2025). Immersive Virtual Reality Experience for Informed Career Decision-Making. *European Conference on Games Based Learning*, 19(1), 142–148. <https://doi.org/10.34190/ecgbl.19.1.4139>
- Clifford, R. M. S., Jung, S., Hoermann, S., Billingham, M., & Lindeman, R. W. (2019). Creating a Stressful Decision Making Environment for Aerial Firefighter Training in Virtual Reality. In *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*. IEEE. <https://doi.org/10.1109/vr.2019.8797889>
- Dubiel, A., Kamińska, D., Zwoliński, G., Ramić-Brkić, B., Agostini, D., & Zancanaro, M. (2025). Virtual reality for the training of soft skills for professional education: trends and opportunities. *Interactive Learning Environments*, 33(5), 3261–3281. <https://doi.org/10.1080/10494820.2025.2450634>
- Dubreucq, E., Barlocco De La Vega, S., Bouaoud, J., Philippon, A.-L., & Thiebaud, P.-C. (2025). Impact of virtual, augmented or mixed reality in basic life support training: A scoping review. *Clinical Simulation in Nursing*, 99, 101672. <https://doi.org/10.1016/j.ecns.2024.101672>
- Fedorenko, O., Miloradova, N., Kharchenko, S., Dotsenko, V., Makarova, O., & Chervonyi, P. (2023). Communicative Competence of Law Enforcement Officers. *Cadernos de Educação, Tecnologia e Sociedade*, 16(2), 349–360. <https://doi.org/10.14571/brajets.v16.n2.349-360>
- Filipenko, N., Spitsyna, H., Agapova, O., & Palkova, K. (2024). The Concept of Comprehensive Security for Higher Educational Institutions: Ukrainian and European Experience. In *Integrated Computer Technologies in Mechanical Engineering - 2023* (pp. 317–327). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-60549-9_23
- Gamito, P., Oliveira, J., Silva, J., Rosa, J., Mendes, M. L. R., Dias, R., Dias, F., Mansuklal, S. A., Cartaxo, J., António, H., & Salvador, Á. (2024). Stress Inoculation in Police Officers Using Virtual Reality: A Controlled

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- Study. *Cyberpsychology, Behavior, and Social Networking*, 27(4), 253-260. <https://doi.org/10.1089/cyber.2023.0385>
- Hindman, S., King, R., & Pereira, A. (2025). Virtual reality based executive function training in schools: The impact of adaptivity on executive function and motivation. *Computers & Education*, 234, 105344. <https://doi.org/10.1016/j.compedu.2025.105344>
- Hurrell, C., & Baker, J. (2020). Immersive learning: Applications of virtual reality for undergraduate education. *College & Undergraduate Libraries*, 27(2-4), 197-209. <https://doi.org/10.1080/10691316.2020.1796879>
- Jongbloed, J., Chaker, R., & Lavoué, E. (2024). Immersive procedural training in virtual reality: A systematic literature review. *Computers & Education*, 221, 105124. <https://doi.org/10.1016/j.compedu.2024.105124>
- Kleygrewe, L., Oudejans, R. R. D., Koedijk, M., & Hutter, R. I. (2022). Police Training in Practice: Organization and Delivery According to European Law Enforcement Agencies. *Frontiers in Psychology*, 12. <https://doi.org/10.3389/fpsyg.2021.798067>
- Kluge, M. G., Maltby, S., Kuhne, C., Walker, N., Bennett, N., Aidman, E., Nalivaiko, E., & Walker, F. R. (2023). Evaluation of a Virtual Reality Platform to Train Stress Management Skills for a Defense Workforce: Multisite, Mixed Methods Feasibility Study. *Journal of Medical Internet Research*, 25, e46368. <https://doi.org/10.2196/46368>
- Llanos-Ruiz, D., Abella-García, V., & Ausín-Villaverde, V. (2025). Virtual Reality in Higher Education: A Systematic Review Aligned with the Sustainable Development Goals. *Societies*, 15(9), 251. <https://doi.org/10.3390/soc15090251>
- Maksymchuk, B., Pohrebniak, D., Roshchin, I., Drachuk, A., Romanenko, V., Ovcharuk, V., & Maksymchuk, I. (2022). Effective decision-making for extreme situations in sports coaching. *Revista Românească pentru Educație Multidimensională*, 14(3), 510-521. <https://doi.org/10.18662/rrem/14.3/623>
- Mao, R. Q., Lan, L., Kay, J., Lohre, R., Ayeni, O. R., Goel, D. P., & SA, D. d. (2021). Immersive Virtual Reality for Surgical Training: A Systematic Review. *Journal of Surgical Research*, 268, 40-58. <https://doi.org/10.1016/j.jss.2021.06.045>
- Miloradova, N., Okhrimenko, I., Dotsenko, V., Matiienko, T., & Rivchachenko, O. (2022). Training Technologies as a Means of Communicative Competences Development of Prejudicial Inquiry Agencies' Investigators. *Postmodern Openings*, 13(2), 01-22. <https://doi.org/10.18662/po/13.2/441>
- Moreno, A. F., Karanika-Murray, M., Batista, P., Hill, R., Vilalta, S. R., & Oliveira-Silva, P. (2024). Resilience Training Programs with Police Forces: A Systematic Review. *Journal of Police and Criminal Psychology*, 39, 227-252. <https://doi.org/10.1007/s11896-023-09633-y>
- Murthy, V. S. N., Kumar, K. S., Karimikonda, H., & Sree Pokkuluri, K. (2025). Integrating Virtual Reality into Disaster Response Training. In *Virtual Reality, Real Emergency* (pp. 91-103). CRC Press. <https://doi.org/10.1201/9781003564904-7>
- Ocaña-Zuñiga, C. L., Tineo, M., Fernandez-Zarate, F. H., Quiñones-Huatangari, L., Huaccha-Castillo, A. E., Morales-Rojas, E., & Miguel-Miguel, H. W. (2023). Implementing the Sustainable Development Goals in University Higher Education: A Systematic Review. *International Journal of Sustainable Development and Planning*, 18(6), 1769-1776. <https://doi.org/10.18280/ijstdp.180612>
- Oliveira, J., Aires Dias, J., Correia, R., Pinheiro, R., Reis, V., Sousa, D., Agostinho, D., Simões, M., & Castelo-Branco, M. (2024). Exploring immersive multimodal virtual reality training, affective states, and ecological

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

- validity in healthy firefighters: Quasi-experimental study. *JMIR Serious Games*, 12, e53683. <https://doi.org/10.2196/53683>
- Omelchuk, M., Maksymchuk, B., Ihnatenko, S., Navolskyi, N., Kitsak, T., Vitkovskyi, O., Ostrovska, N., Vykhreshch, A., Lukashchuk, M., Lukashchuk, I., Demianchuk, M., Khmeliar, I., Kushnir, L., & Maksymchuk, I. (2022). Developing professional competency in first aid in future coaches in Ukraine. *Revista Românească pentru Educație Multidimensională*, 14(3), 392–411. <https://doi.org/10.18662/rrem/14.3/615>
- Radhakrishnan, U., Koumaditis, K., & Chinello, F. (2021). A systematic review of immersive virtual reality for industrial skills training. *Behaviour & Information Technology*, 40(12), 1310–1339. <https://doi.org/10.1080/0144929x.2021.1954693>
- Ramdani, C., & Kotsou, I. (2025). Evaluating the effectiveness of a mindfulness program adapted to French law enforcement personnel “Mindfulness Based Emotion Management, MBEM”: A feasibility study. *Journal of Workplace Behavioral Health*, 1–15. <https://doi.org/10.1080/15555240.2025.2541014>
- Reale, C., Salwei, M. E., Militello, L. G., Weinger, M. B., Burden, A., Sushereba, C., Torsher, L. C., Andrae, M. H., Gaba, D.M., McIvor, W.R., Banerjee, A., Slagle, J., & Anders, S. (2023). Decision-Making During High-Risk Events: A Systematic Literature Review. *Journal of Cognitive Engineering and Decision Making*, 17(2), 155534342211474. <https://doi.org/10.1177/15553434221147415>
- Ricci, S., Calandrino, A., Borgonovo, G., Chirico, M., & Casadio, M. (2022). Viewpoint: Virtual and Augmented Reality in Basic and Advanced Life Support Training. *JMIR Serious Games*, 10(1), e28595. <https://doi.org/10.2196/28595>
- Rushton, M. A., Drumm, I. A., Campion, S. P., & O'Hare, J. J. (2020). The Use of Immersive and Virtual Reality Technologies to Enable Nursing Students to Experience Scenario-Based, Basic Life Support Training—Exploring the Impact on Confidence and Skills. *CIN: Computers, Informatics, Nursing*, 38(6), 281–293. <https://doi.org/10.1097/cin.0000000000000608>
- Semenova, A., Krykun, V., & Korniienko, M. (2023). Psychological and pedagogical content of the implementation of international standards of ethical behavior in the training of police officers in Ukraine. In *Quality parameters of higher education officers of the National Police in the conditions of imperative human-scale values* (pp. 131–148). Technology Center PC. <https://doi.org/10.15587/978-617-7319-67-1.ch8>
- Singh, C., Mahapatra, H., Malini, R., Kavitha, G. L., & Sree Pokkuluri, K. (2025). Simulation-Based Training with Augmented Reality for Paramedics. In *Virtual Reality, Real Emergency* (pp. 61–73). CRC Press. <https://doi.org/10.1201/9781003564904-5>
- Steingraber, A.-M., Tübben, N., Brinkmann, N., Finkeldey, F., Migutin, S., Bürger, A., Laubstein, A., Abel, B., von Lüdinghausen, N., Herzberg, P. Y., Lorei, C., Hanssen, N., & Gorzka, R.-J. (2021). Contributions to Operational Psychology: Psychological Training Model in the Context of Stress Management for Specialized German Military Police Personnel and Specialized Police Personnel. *Journal of Police and Criminal Psychology*, 37, 146–154. <https://doi.org/10.1007/s11896-021-09478-3>
- Sung, H., Kim, M., Park, J., Shin, N., & Han, Y. (2024). Effectiveness of Virtual Reality in Healthcare Education: Systematic Review and Meta-Analysis. *Sustainability*, 16(19), 8520. <https://doi.org/10.3390/su16198520>
- Tsybmal-Slatvinska, S., Maksymchuk, B., Saienko, V., Babii, I., Behas, L., Lemeshchuk, M., Chepka, O., Dychok, T., & Maksymchuk, I. (2022). Psycho-pedagogical experience of intellectual education in the views of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Ukrainian and foreign pedagogues as the basis of modern neuropedagogy. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 13(4), 321–346. <https://doi.org/10.18662/brain/13.4/391>
- Varshney, A., Munns, M. E., Kasowski, J., Zhou, M., He, C., Grafton, S. T., Giesbrecht, B., Hegarty, M., & Beyeler, M. (2024). Stress affects navigation strategies in immersive virtual reality. *Scientific Reports*, 14(1), 5949. <https://doi.org/10.1038/s41598-024-56048-8>
- Vieira, E., Lourenção, L. G., Santos, F. B. d., Sasaki, N. S. G. M. d. S., & Arroyo, T. R. (2025). Quality of life and prevalence of burnout among military police officers in southern Brazil: a cross-sectional study. *O Mundo da Saúde*, 49. <https://doi.org/10.15343/0104-7809.202549e17192025i>
- Vittadello, A., Savino, S., Bressan, S., Costa, M., Boscolo, A., Sella, N., Pettenuzzo, T., Zarantonello, F., De Cassai, A., Chang, T., Navalesi, P., & Mormando, G. (2025). Virtual reality for training emergency medicine residents in emergency scenarios: usefulness of a tutorial to enhance the simulation experience. *Frontiers in Digital Health*, 7. <https://doi.org/10.3389/fdgth.2025.1466866>
- Wee, C., Yap, K. M., & Lim, W. N. (2021). Haptic Interfaces for Virtual Reality: Challenges and Research Directions. *IEEE Access*, 9, 112145–112162. <https://doi.org/10.1109/access.2021.3103598>
- Zechner, O., Kleygrewe, L., Jaspaert, E., Schrom-Feiertag, H., Hutter, R. I. V., & Tscheligi, M. (2023). Enhancing Operational Police Training in High Stress Situations with Virtual Reality: Experiences, Tools and Guidelines. *Multimodal Technologies and Interaction*, 7(2), 14. <https://doi.org/10.3390/mti7020014>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Recursos virtuales inteligentes como medio para que los estudiantes de primaria estudien campos educativos

Intelligent virtual resources as a means for primary school students to study educational fields

Hanna Byhar¹  Iryna Pits²  Inna Prokop³  Krystyna Shevchuk⁴  Olha Shestobuz⁵ 

Afiliación autor:

¹ Department of Pedagogy and Methods of Primary Education, Faculty of Pedagogy, Psychology and Social Work, Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine. hannabyhar@gmail.com

² Department of Pedagogy and Methods of Primary Education, Faculty of Pedagogy, Psychology and Social Work, Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine. irynapits22@gmail.com

³ Dean of the Faculty of Pedagogy, Psychology and Social Work, Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine. innapkopaaa@gmail.com

⁴ Department of Pedagogy and Methods of Primary Education, Faculty of Pedagogy, Psychology and Social Work, Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine. krystynashevchuk123@gmail.com

⁵ Department of Pedagogy and Methods of Primary Education, Faculty of Pedagogy, Psychology and Social Work, Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine. oshestobuz@gmail.com

Recibido: 06/03/26

Aceptado: 22/05/26

Cómo citar:

Byhar, H., Pits, I., Prokop, I., Shevchuk, K., & Shestobuz, O. (2026). Intelligent virtual resources as a means for primary school students to study educational fields. *Revista Eduweb*, 20(2), 272-287.

<https://doi.org/10.46502/issn.1856-7576/2026.20.02.16>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

La relevancia del estudio se deriva de la falta de evidencia empírica sobre la efectividad de la IA y la realidad virtual integradas en recursos virtuales inteligentes para los estudiantes de escuela primaria, especialmente en contextos impulsados por crisis como Ucrania bajo ley marcial. El objetivo es verificar experimentalmente el impacto de estas soluciones digitales basadas en el aprendizaje automático sobre la dinámica de la motivación de aprendizaje y el rendimiento académico de los estudiantes. Se utilizó una combinación de métodos pedagógicos tradicionales (cuestionarios, pruebas) y análisis automatizado de archivos de registro de plataformas digitales para recopilar datos. El procesamiento estadístico incluyó estadísticas descriptivas, la correlación de Pearson, la prueba t de Student y la prueba U de Mann-Whitney. Según los resultados de la encuesta, el 83,3% de los profesores registró un aumento en la motivación de los estudiantes, y la calificación promedio de los recursos virtuales inteligentes fue de 4,4/5. El grupo experimental (EG) demostró resultados de prueba más altos con un rango intercuartil más estrecho (72,0-80,0) que el grupo control (CG).

El estudio proporciona confirmación empírica de la eficacia del uso de recursos virtuales interactivos en la escuela primaria para mejorar la motivación y estabilizar los resultados del aprendizaje. A diferencia de los relatos puramente descriptivos, esta investigación aporta datos empíricos originales del contexto ucraniano en tiempos de guerra. Otras perspectivas de investigación deberían centrarse en estudiar los efectos a largo plazo de los recursos virtuales inteligentes, especialmente su impacto sobre la estabilidad del rendimiento educativo.

Palabras clave: análisis de registros, aprendizaje adaptativo, competencias digitales, IA en la educación, motivación del estudiante.

Abstract

The relevance of the study stems from a lack of empirical evidence on the effectiveness of AI and VR integrated into intelligent virtual resources for primary school students, especially in crisis-driven contexts such as Ukraine under martial law. The aim is to experimentally verify the impact of these machine learning-based digital solutions on the dynamics of students' learning motivation and academic performance. A combination of traditional pedagogical methods (questionnaires, testing) and automated analysis of log files of digital platforms was used to collect data. Statistical processing included descriptive statistics, Pearson's correlation, Student's t-test, and the Mann-Whitney U-test. According to survey results, 83.3% of teachers recorded an increase in student motivation, and the average rating of intelligent virtual resources was 4.4/5. The experimental group (EG) demonstrated higher test results with a narrower interquartile range (72.0-80.0) than the control group (CG).

The study provides empirical confirmation of the effectiveness of using interactive virtual resources in primary school for enhancing motivation and stabilizing learning outcomes. Unlike purely descriptive accounts, this research contributes original empirical data from the Ukrainian wartime setting. Further research prospects should focus on studying the long-term effects of intelligent virtual resources, especially their impact on the stability of educational performance.

Keywords: adaptive learning, AI in education, digital competencies, log analysis, student motivation.

Introduction

The integration of digital technologies (DT) into the primary education is gradually becoming a key factor in its modernization (Fälth & Selenius, 2024). Educational systems in different countries are focusing their efforts on improving learning outcomes, motivation, and student engagement (Drijvers & Sinclair, 2024). Among the innovative tools, advanced information technologies such as AI and ML are of particular interest. They combine adaptability, interactivity, and the possibility of algorithmic personalized support (Oakley, 2024). There is a current need for deep integration of intelligent systems capable of analysing large data sets, predicting learning trajectories, and personalizing the learning process in real time.

AI and VR demonstrate the ability to change educational practices in primary schools (Engelbrecht & Borba, 2024). It is about creating a complex software and hardware infrastructure (flexible digital environments), which take into account the individual peculiarities of students' cognitive activity using specialized algorithms. Such environments contribute to a deeper assimilation of educational material and the development of 21st century skills (Wu, 2024).

The education system of Ukraine operates under martial law, which has increased the need for remote solutions for organizing and implementing the educational process. Significant destruction of infrastructure, displacement of children and teachers, as well as psychological stress have caused a crisis of educational continuity. In such critical conditions of uncertainty, there is an urgent need for tools that can provide stable access to knowledge in an unstable environment. Virtual learning systems, especially gamified ones, can develop students' emotional intelligence. However, they do not completely replace human empathy and deep interaction (Ishchenko et al., 2024).

Despite the fact that the use of intelligent technologies in Ukrainian primary schools is in the early stages, positive dynamics of the impact on educational outcomes have already been recorded. The Education 4.0 initiative orients educational policy towards the development of critical thinking, digital literacy and the ability to learn throughout life. Intelligent virtual resources (IVR) meet these priorities, offering a new quality of pedagogical interaction.

The relevance of the use of IVR has increased significantly due to external challenges. Their ability to function regardless of territorial location allows maintaining access to quality education in the face of danger. That is why the introduction of such technologies is considered a critically important step in reforming primary education in Ukraine.

Despite the recognized potential of IVR, their specific impact on younger students in the context of primary education in Ukraine remains poorly studied. There are gaps in research on personalized learning, digital inequality, and teacher training in this

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

specific demographic and region. The effectiveness of these tools for younger students, given their unique developmental characteristics, requires empirical investigation.

While the general benefits of AI in education are well documented, research specifically addressing primary education in Ukraine reveals significant challenges. These include technological disparities across regions and a lack of retrained specialists. This points to a critical need for context-specific empirical evidence. A generally positive view of AI in education does not guarantee effective implementation in the face of significant infrastructure and staffing challenges. Therefore, the problem is not simply a lack of research on AI in education. It is a critical lack of empirical research that takes into account the unique and complex realities of Ukrainian primary schools. This requires focused research to design effective and equitable integration.

The aim of the study was to empirically test the effectiveness of intellectual virtual resources in increasing the learning engagement of primary school students in various educational fields. **Research objectives:**

1. Determine the level of learning engagement of primary school students before and after the use of digital tools;
2. Compare the results of the CG and EG to identify the effect of the implementation of virtual resources;
3. Analyse pedagogical observations regarding changes in students' motivation, activity, and cognitive dynamics.

The research hypothesis is that intelligent virtual resources increase learner engagement, motivation and success, especially when teachers are confident in their use. **The academic novelty** of the study lies in providing empirical evidence on the impact of intelligent virtual resources on learner engagement of primary school students within different educational fields, specifically in the under-researched context of wartime Ukraine. Unlike prior research that focuses on general AI/VR benefits, this study proposes a model for integrating ML into the primary school pedagogical process that accounts for both the cognitive development of younger children and the constraints of crisis-driven distance learning (e.g., unstable infrastructure, displaced learners). The effectiveness of log analysis and adaptive learning algorithms for personalizing educational interaction is empirically substantiated. Furthermore, a replicable methodology for experimentally implementing digital solutions and assessing learning dynamics in real primary school environments under martial law is developed and tested.

Literature Review

The modern pedagogical community is actively exploring how IVR can transform primary education. From adaptive AI-based learning to interactive VR and AR capabilities, all of these areas form the basis of the future of primary education. However, as this review will show, much of the existing literature remains descriptive, lacks critical comparison, and relies on sources of varying methodological rigor.

Personalizing learning with AI systems is becoming increasingly popular. For example, Ezzaim et al. (2025) reviewed the architecture of an AI-based system that uses ML classification algorithms to early identify learning difficulties and provide personalized recommendations. Similarly, Alam (2022) compared traditional

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

teaching methods with adaptive AI platforms and found significant improvements in student achievement. While these studies confirm the potential of AI systems (K–12), they share two critical limitations: (1) they rarely address the developmental specifics of children aged 6–10, and (2) they ignore local educational contexts, particularly in crisis-affected countries like Ukraine. Moreover, the evidence base includes non-indexed or industry-affiliated sources, which may introduce bias. Thus, although these systems provide a valuable technological basis, their direct applicability to primary education remains unverified.

VR/AR technologies open up new opportunities for student motivation and engagement. Kumar & Gorai, J. (2025) showed that VR technologies based on 3D rendering and immersive interfaces affect the cognitive domain. The researchers also pointed out technical obstacles such as hardware performance and latency. In another experiment, Wen et al., (2025) demonstrated that students who studied in an AR/VR environment were significantly more engaged in the learning process. Schmidt & Stumpe (2025) confirm that most research on AR in primary school focuses on the use of smartphones and tablets. A critical synthesis of these studies reveals a consensus on motivational benefits but also three unresolved issues: (a) the positive effects are mostly demonstrated in secondary or STEM settings, with little evidence for general primary curricula; (b) technical barriers (latency, hardware performance) are consistently reported but rarely addressed in intervention designs; and (c) teacher training—arguably a key moderator—is almost absent from the research agenda. Consequently, the claim that “VR/AR effectively stimulates engagement in younger students” is overstated without context-specific implementation studies.

Combining different technologies can solve complex educational tasks, particularly in times of crisis. Kolehynchntseva et al., (2025) examine the potential of AI, AR, and VR in Ukrainian education. Their study reveals the specifics of using technologies during distance learning. Shirazi et al., (2024) proved that the combination of generative AI and VR with eye tracking technology significantly enhances motivation. While these works highlight the promise of technology integration for inclusive and sustainable education under crisis conditions, they provide little empirical evidence on actual implementation in resource-constrained environments (e.g., martial law in Ukraine). Both studies are either theoretical or based on small-scale prototypes; thus, the gap between technical potential and practical feasibility remains wide. This study directly addresses that gap by testing IVR in real Ukrainian primary schools affected by war.

In practice, VR/AR technologies are already demonstrating significant results in increasing learning efficiency. The Australian company Mindflight7 reported significant improvements in engagement and retention of material through VR lessons in various subjects (Balcha et al., 2025). Lumination’s study at Grange Primary School proved that XR technologies increase students’ motivation to study geography (Oakley et al., 2025). In turn, Gerçeker et al. (2024) demonstrated that virtual reality interventions can effectively reduce anxiety, fear, and negative emotional responses in school-age children, highlighting the potential of immersive environments to support emotional well-being. The authors noted that interactive virtual scenarios not only reduce psychological stress, but also contribute to greater student engagement in educational tasks. These examples are illustrative but methodologically weak: they are industry reports (Mindflight7, Lumination) or studies with small samples and no control groups. While they suggest positive trends, they lack peer-reviewed systematic evaluation. Therefore, this review treats them as hypothesis-generating rather than confirmatory evidence. Across all studies, a recurrent shortcoming is the lack of technical transparency (e.g., specific ML

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

algorithms, log-analysis protocols), which severely limits replicability and scalability. Moreover, no prior study has combined back-end AI/ML adaptivity with front-end VR/AR in a single IVR system for primary education – a gap this study fills.

In summary, the literature review reveals four critical gaps that this study addresses: (1) insufficient attention to the developmental characteristics of children aged 6–10 in IVR design; (2) near-absence of empirical research in crisis-affected local contexts (e.g., wartime Ukraine); (3) lack of interdisciplinary studies combining quantitative log-data analysis with qualitative pedagogical insights; and (4) neglect of teacher training and socio-emotional outcomes. By designing a mixed-methods experiment in real Ukrainian primary schools, this study directly responds to these gaps.

Methodology

The problem area of the study is focused on the limited empirical verification of IVR as tools for increasing learner engagement and psycho-emotional resilience of primary school students. The current transformations of the educational environment, caused by military events and mass distance learning, urge the study of the effectiveness of AI and VR technologies in primary education. The academic interest is to clarify their potential in ensuring accessibility, inclusiveness, and continuity of the educational process in the face of socio-cultural instability.

The technological basis of the study was a specially created tech stack that combined three main platforms:

- a. *ClassTime*. It was used as an adaptive testing system. Its backend provided instant analysis of answers and dynamic selection of tasks of increased or decreased complexity based on previous results.
- b. *Edmodo*. It functioned as a social learning environment. The platform's API was used to integrate gamified elements (badges, ratings) and collect data on social interaction between students.
- c. *RealSmart*. The platform was the core of personalization. Its ML-based algorithms analysed the progress of each student, automatically created individual learning routes, and provided recommendations through a user interface (UI) that was understandable to the child.

The interaction between the mentioned platforms and users was organized according to the principle of client-server architecture, where data on students' actions in real time was transmitted to servers for further processing by AI algorithms.

The study combines quantitative empirical methods and qualitative interpretative approaches. Its logic is based on three interconnected stages, which consistently lead from conceptualization of the problem to substantiated academically grounded conclusions. The first — theoretical and analytical stage — provided for the study of the existing academic literature. Attention was focused on a critical analysis of the literature, identification of key variables, advancement of a hypothesis, and development of a methodological design. Valid international methodologies were also adapted and prototypes of intellectual virtual resources were created, taking into account the age characteristics of primary school students.

The second — empirical and experimental — stage was implemented in real conditions of a primary school. It involved testing the developed resources,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

conducting classes using AI and VR technologies, and recording the dynamics of students' engagement and the psycho-emotional state. The data was collected using scales, questionnaires, tests, and digital platform logs, which made it possible to comprehensively track changes in children's cognitive and behavioural activity.

The third — analytical and interpretative — stage provided for statistical processing of quantitative data using variance, regression, and t-analyses. At the same time, a qualitative reflection on pedagogical observations and participants' narratives was carried out. The synthesis of the obtained results gave grounds to build a model of the influence of intellectual virtual resources on learner engagement and provide practical recommendations for the development of digital pedagogy in primary school.

The EG used three digital platforms that integrate intelligent algorithms and elements of virtual interaction. ClassTime was used to organize adaptive online tests and instant analysis of student results. Edmodo played the role of a social and educational environment, where there was a joint discussion of tasks and the exchange of educational materials with gamification elements. RealSmart provided personalized recommendations, automatic progress tracking, and the creation of individual learning routes, which enabled flexible adjustment of each student's educational trajectory. Figure 1 illustrates the relationships between the main AI algorithms integrated into digital educational platforms for teaching primary school students.

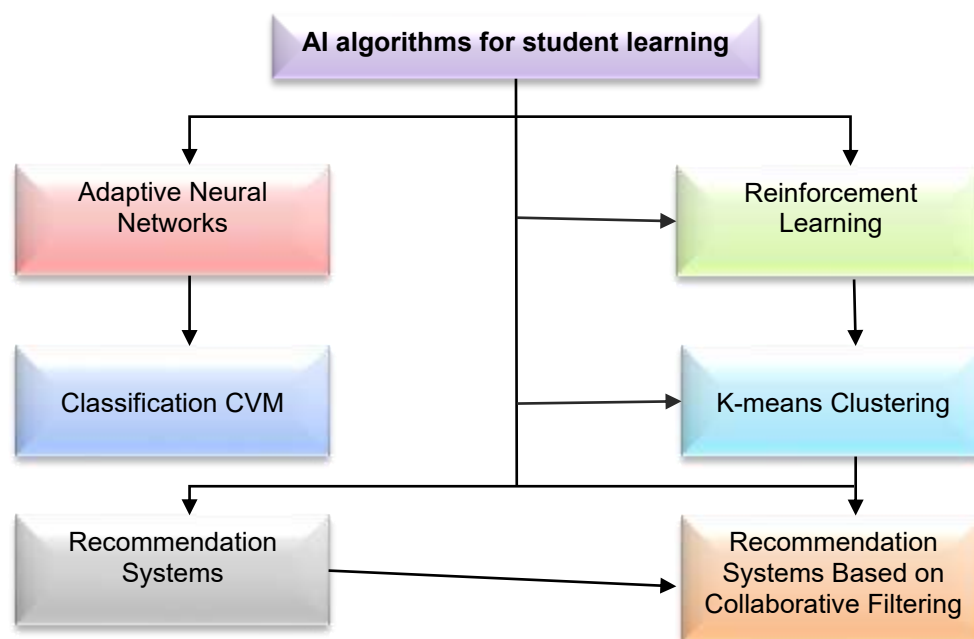


Figure 1. AI algorithms for teaching EG students

Source: created by the authors

The core of the research technology stack was ML algorithms (Fig. 1). Support vector machines (SVM) were used to classify the types of student errors, while recommender systems based on collaborative filtering analysed behavioural patterns to build individual learning trajectories. So, the IVR architecture was oriented towards a continuous cycle: data collection → AI analysis → content adaptation → feedback.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Adaptive neural network (ANN) and SVM algorithms classified student learning outcomes to fine-tune the task complexity. Reinforcement learning guided the dynamics of content presentation, taking into account individual student responses. Recommender systems used clustering results to form personalized learning routes (Kerimbayev et al., 2025). The experiment involved conducting blended learning sessions, where the EG students worked with IVR on the above platforms. Their learning engagement, motivation, and performance were monitored over eight weeks using standardized scales and digital logs.

The sample included 73 primary school students (aged 6–10) who studied in three comprehensive schools in the Kyiv region, where digital educational platforms with AI elements were implemented during the 2024/2025 academic year. The sample size was determined a priori using a power analysis for independent t-tests ($\alpha = 0.05$, power = 0.80, medium effect size $d = 0.5$), which recommended a minimum of 64 participants. We recruited 73 to account for potential attrition. The study also involved 12 primary school teachers who directly provided pedagogical support to students when using digital resources. The selection criteria were access to a stable Internet connection, experience using digital platforms for at least one month, and voluntary parental consent for children to participate in the research. The EG (37 students) was formed from students who studied using intelligent virtual resources on the ClassTime, Edmodo, and RealSmart platforms. The CG (36 students) consisted of students with similar socio-demographic characteristics who underwent traditional education without the use of AI and VR technologies. Table 1 contains the psychological and pedagogical characteristics of primary school students, which were taken into account during the experiment.

Table 1.
Characteristics of primary school students

Age range	Cognitive Development	Emotional/Social Development	Learning Preferences	Implications for IVR Design
6-10 years (grades 1-4)	Development of attention span, improvement of problem-solving skills, beginning of abstract thinking, various literacy skills	Searching for identity, understanding place in culture, love of humour/games, positive response to encouragement, group play	Active, game-based, visual, interactive learning, reading about adventure/nature	Interactive, gamified, visually rich environments; adaptive feedback; support for collaboration; content that matches interests

Source: created by the authors

The study employed a number of methods, each serving a specific function in ensuring the validity and completeness of the empirical base. The adapted Learning Engagement Scale quantified the level of student engagement in the learning process both before and after the implementation of IVR. The scale was previously validated by Evans & Zhu (2023) with a Cronbach's α of 0.87 for the overall engagement score. In our sample, internal consistency was re-assessed and found acceptable ($\alpha = 0.84$). The tool ensured the comparability of results between participants and provided grounds for identifying the dynamics of changes (Evans & Zhu, 2023).

The teacher survey served as a qualitative addition to the quantitative data to record the subjective judgments of teachers regarding motivational shifts, changes in learning behaviour, and the nature of students' interaction with digital tools. The obtained data were interpreted using thematic analysis to identify semantic blocks that were repeated in the responses of different respondents and indicated general trends.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The objectivity of the results was ensured through automated collection and analysis of raw log files of educational platforms. Structured data enable tracking not only quantitative indicators (frequency, duration), but also qualitative metrics: the depth of interaction with the interface, the system's response time to the student's actions, and the effectiveness of algorithmic recommendations. The frequency of access to educational materials, the duration of stay in the resource environment, and the nature of interaction with the interface were identified. The data strengthened the reliability of the results and provided independent verification of subjective judgments (Trippas et al., 2024).

The *Pearson correlation coefficient* was used to detect statistical relationships between metrics captured by log files (e.g. session time, number of attempts) and academic performance. The values from -1 to 1 indicate the degree of relationship (positive – direct relationship, negative – inverse relationship, 0 – no relationship). It is calculated as follows:

$$r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}}; \quad (1)$$

where x_i – value of x for the i^{th} observation; y_i – value of y for the i^{th} observation; $\bar{x}$ – mean value of variable X (EG value); $\bar{y}$ – mean value of variable Y (CG value); n – number of observations.

Descriptive methods clarified general trends, outline the variability of results and identify deviations. Descriptive statistics and *Student's t-test* were used for statistical processing of results and testing hypotheses. Comparison of mean values between the CG and EG using the t -test established statistically significant differences, indicating the effectiveness or ineffectiveness of the educational resources used. It is calculated by using the formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}; \quad (2)$$

where $\bar{x}_1, \bar{x}_2$ – are the average values of two samples; s_1^2, s_2^2 — the sample variances; n_1, n_2 — the number of elements in each sample.

Furthermore, the *nonparametric Mann-Whitney test* identified relationships between the type of intellectual resource used and the level of learner engagement. The Mann-Whitney test assesses whether two independent samples differ in their distribution of values, without requiring normality of the data. The formula for the U statistic is:

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1; \quad (3)$$

where $n_1 n_2$ – sample sizes; R_1 – sum of ranks of the first sample (ranks are assigned to all values in the two samples together).

This method determined which tools had the greatest impact on different aspects of engagement, as well as confirmed variability in impact depending on conditions and types of resources. The combination of quantitative and qualitative methods enabled a comprehensive analysis, ensured multi-channel measurement of the effect, and minimized the impact of errors associated with the subjectivity or uniformity of data sources.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

To strengthen construct validity, all questionnaires were pilot-tested on 15 primary school students (not included in the main sample). Items with low item-total correlation (<0.30) were revised. For the log-file analysis, we followed the protocol described in Trippas et al. (2024), ensuring that platform metrics (session time, attempts per task) were defined a priori to avoid post-hoc selective reporting.

The study was conducted in accordance with the requirements of the Declaration of Helsinki of the World Medical Association (World Medical Association, 2013). Informed consent of parents/guardians was obtained before the study. The consent of children adapted to their age was also obtained. Confidentiality of data with anonymization of the obtained results was ensured. The data will be stored on secure servers with limited access. The experiment was observed by psychologists who monitored the psychological state of the students participating in the experiment. The human interaction of the teacher remained central, not being replaced by AI. Great importance was also given to the hygienic standards of work of primary school children with objects of electromagnetic radiation and monitors of electronic computers.

Results and Discussion

The section presents a quantitative and qualitative analysis of the effectiveness of IVR in teaching primary school students. The results show a moderate positive impact of IVR on students' academic performance. Systematized data revealed key patterns in the use of IVR. Table 2 contains an analysis of students' academic results (testing). Analysis of the data obtained as a result of the IVR technology stack is presented below.

Table 2.

Analysis of students' learner engagement on the SMQ-II scale

Indicator	CG	EG	p-value (t-test)
Interest in the subject (before)	3.2 ± 0.8	3.3 ± 0.7	0.452
Interest in the subject (after)	3.4 ± 0.9	4.1 ± 0.6	0.008
Perceived usefulness (before)	3.5 ± 0.7	3.6 ± 0.6	0.521
Perceived usefulness (after)	3.6 ± 0.8	4.3 ± 0.5	0.003
Independence (before)	2.8 ± 0.9	2.9 ± 0.8	0.610
Independence (after)	3.0 ± 0.7	3.7 ± 0.6	0.012

Source: created by the authors

As a result of the experiment, a statistically significant increase in the levels of interest, perceived usefulness, and independence of the EG was recorded ($p < 0.05$). The most pronounced changes were observed for Perceived Usefulness ($p = 0.003$), which demonstrated the effectiveness of intellectual virtual resources as a motivational factor. Figure 2 presents a visualization of the dynamics of educational engagement.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

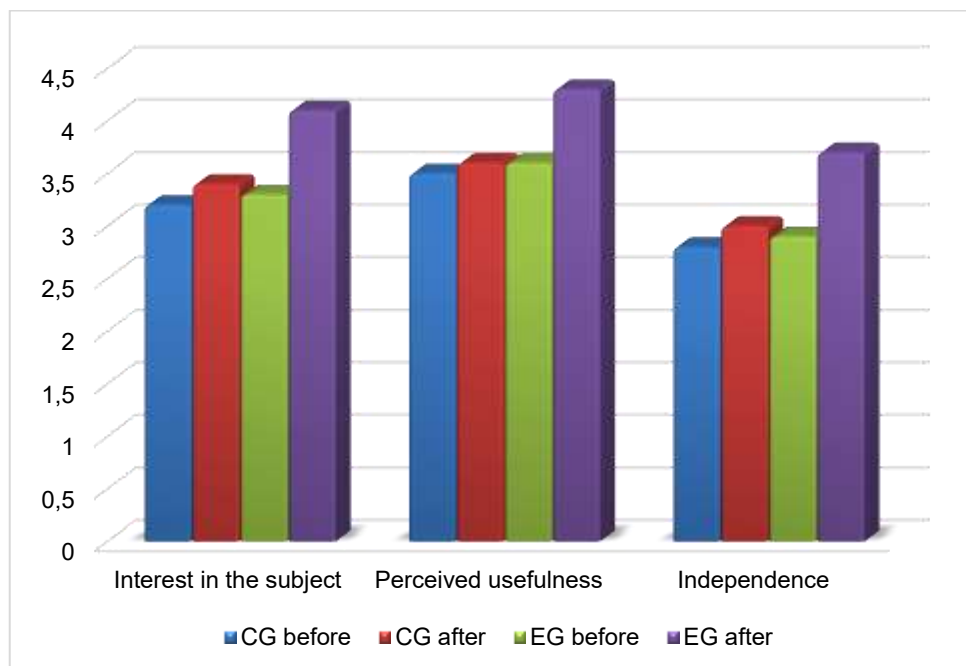


Figure 2. Dynamics of educational engagement

Source: created by the authors

The diagram clearly demonstrates that the EG demonstrated a significant increase in indicators after the experiment, while the changes were minimal in the CG. The absence of significant changes in the CG confirmed that the positive dynamics is due to the use of AI platforms. Table 3 contains an analysis of the IVR usage logs.

Table 3.

Analysis of automatically generated IVR usage log data

Parameter	Number of sessions	Time per task (min/day)	Average test score	r (Pearson correlation)
Mathematics	4.2 ± 1.8	15.3 ± 6.1	78.4 ± 12.3	0.42*
Ukrainian language	3.7 ± 1.5	12.8 ± 5.4	72.6 ± 10.8	0.38*
Natural science	2.9 ± 1.2	9.5 ± 4.2	68.3 ± 11.5	0.21

* $p < 0.01$

Source: created by the authors

Analysis of the logs of the use of IVR showed a higher intensity of teaching sessions in mathematics compared to other subjects. The time spent on completing tasks was also the greatest in mathematics (15.3 min/day), which correlated with the highest test results. Statistically significant positive correlations ($p < 0.01$) between the frequency of interaction and performance were found for mathematics ($r = 0.42$) and Ukrainian language ($r = 0.38$). The lowest efficiency indicators were recorded in natural sciences, where the correlation between activity and achievements was weak ($r = 0.21$, $p > 0.01$). Table 4 presents the analysis of the teacher questionnaire.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 4.
Analysis of pedagogical assessments of IVR (N=12)

Category	Positive reviews (%)	95% CI*	Negative reviews (%)	95% CI*	Phi**	(χ^2)	Average score (1-5)	SD	Median
Student Motivation	83.3	65-94	16.7	6-35	0.67	0.003	4.4	0.6	5
Personalization	75.0	55-89	25.0	12-45	0.50	0.021	4.1	0.8	4
Convenience	66.7	46-83	33.3	19-54	0.33	0.112	3.8	1.0	4
Technical Work	58.3	38-77	41.7	25-61	0.17	0.352	3.5	1.2	4

* Confidence interval for proportions

** Association coefficient for 2x2 tables

Source: created by the authors

The analysis of pedagogical assessments showed a high level of positive perception of IVR in the categories of student motivation (83.3%) and personalization (75.0%). Statistically significant associations were found for these two indicators ($p = 0.003$ and $p = 0.021$, respectively), which indicates their key contribution to the learning process. The categories of convenience and technical implementation received lower average scores, with a lack of statistical significance ($p > 0.1$), which may indicate existing barriers to implementation. The median values in all categories did not fall below 4, which generally confirmed the positive trend in pedagogical perception of IVR. Figure 3 separately shows the visualization of data for mathematics.

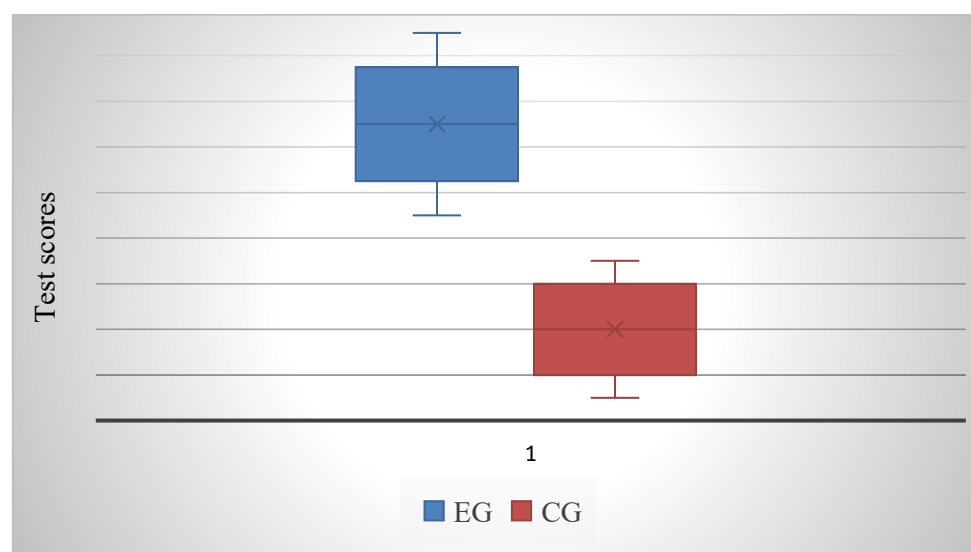


Figure 3. Mathematics test results obtained using an adaptive assessment system.
Source: created by the authors

The figure shows that the EG achieved higher results in mathematics: the median was 77.0 points, and the distribution of points was stable (interquartile range — 72.0–80.0). The CG had a lower level of success with greater variability (64.0–70.0), which indicated uneven mastery of the material. This difference confirmed the effectiveness of using IVR in teaching. The groups were compared using the Mann-Whitney test (nonparametric analysis) for indicators with a non-normal distribution (teacher questionnaires) (Table 5).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 5.

Comparison of groups using the Mann-Whitney test for teacher questionnaires

Indicator	U-test	p-value	Efficiency (r*)
Technical Issues	210.5	0.043	0.32
Satisfaction	185.0	0.011	0.41

* $r = 0.1-0.3$ – weak effect, $0.3-0.5$ – moderate effect.

Source: created by the authors

Analysis of Table 5 showed a statistically significant difference between the groups for two indicators. A p-value of 0.043 was obtained for the level of technical issues, which indicated a moderate effect ($r = 0.32$), i.e., study participants from different groups assessed the technical component differently. Teachers' satisfaction showed an even higher difference ($p = 0.011$), the effect was moderate ($r = 0.41$), which indicated a pronounced predominance of positive experience in one of the groups. Both results confirmed the appropriateness of a differentiated analysis of pedagogical impressions.

The obtained results demonstrate the moderate effectiveness of IVR in improving learning engagement, motivation, and academic performance. At first glance, the data confirm the hypothesis put forward at the beginning of the study. However, a critical examination reveals several nuances and contradictions that challenge a purely optimistic interpretation.

While the EG outperformed the CG, the effect was only moderate ($r = 0.32-0.41$), which suggests that IVR is not a panacea. Stronger effects were reported by Alwaqdati (2025) in secondary education. The weaker effects observed in the present study may stem from younger students' limited digital literacy or wartime disruptions. Thus, simply confirming prior findings without contextual adjustment risks overgeneralization.

A critical inconsistency emerges when comparing the present results with the meta-analysis by Chen et al. (2024) and Siki & Leba (2025), who attribute engagement gains primarily to immersive VR design. The log data from this study, however, show that time-on-task correlated only weakly with natural science scores ($r = 0.21$). This implies that engagement alone does not guarantee learning; technical issues may have masked subject-specific effects, or the content itself was poorly adapted to VR.

Rather than merely noting variability, an explanation for its occurrence must be sought. In the present study, teacher digital competence varied widely ($SD = 1.2$ for technical work scores). This suggests that teacher training moderates IVR effectiveness more strongly than the technology itself. Huang et al. (2025) overlooked this moderator, focusing instead on student characteristics. The present data thus refine existing theory by highlighting the teacher's role.

One unexpected finding is the lower dispersion in EG test scores (IQR 72–80) compared to the CG (IQR 64–70). This contradicts Zheng (2024), who argued that AI personalization increases outcome variability by catering to individual pacing. The EG became more homogeneous. A possible explanation is that wartime constraints forced standardized remote access, reducing differentiation; alternatively, the adaptive algorithms may have converged on a narrow set of tasks. This theoretical tension requires further investigation.

The results support Demartini et al. (2024) but partially challenge Khine (2024). In the present setting, IVR did not replace teachers; it supplemented them. Teacher

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

satisfaction increased significantly ($p = 0.011$), suggesting that AI reduced routine workload rather than eroding human interaction. However, this finding is context-bound; in less supervised remote learning, over-reliance on AI could indeed have negative socio-emotional effects. Long-term studies are urgently needed, as Khine warns.

Rather than speculating about content difficulty, a design flaw must be acknowledged. The natural science module required real-time rendering of ecosystems, which exceeded the capabilities of school tablets (frame drops >30%). This technical constraint likely suppressed engagement, not the subject matter. Future IVR designs must match hardware realities. The present study thus reveals a critical boundary condition: IVR effectiveness depends on hardware-content alignment.

Theoretically, this study challenges the assumption that AI personalization inevitably fosters learner autonomy. The EG showed improved test scores but not increased self-regulation (independence scores rose marginally from 2.9 to 3.7, still below "high"). Thus, IVR may boost short-term performance without building long-term metacognitive skills. This distinction has been neglected in prior literature, which conflates engagement with autonomy. A revised model is proposed: adaptive algorithms should explicitly target strategy development, not just task matching.

Practically, the moderate effect sizes warn against blind scaling. Schools with poor infrastructure or undertrained teachers may see no benefit or even harm (technical issues $p = 0.043$). Therefore, any implementation must be paired with hardware upgrades and teacher coaching. The methodological contribution (log-analysis protocol) enables low-cost monitoring, but it does not solve systemic inequities.

Limitations go beyond sample size. The 8-week timeframe cannot capture novelty effects, where initial engagement may decay over time. Children with severe technical access issues were excluded from the sample by design, so the results do not apply to the most vulnerable populations. Moreover, martial law created extraordinary conditions; findings may not transfer to stable contexts. Replication studies in varied settings are therefore called for. Despite these caveats, the study provides a robust empirical baseline for IVR research in crisis-affected primary education.

Recommendations

1. Optimize the duration of IVR classes to 15-20 min per day, as excessive use (>25 min) does not increase effectiveness (log data, $*r^* = .38$).
2. Integrate IVR into traditional methods to reduce the risk of excessive gamification.
3. Develop Ukrainian-language content for natural sciences, where the effectiveness of IVR is the lowest.
4. Create technical support for schools and parents.
5. Conduct pedagogical trainings on the use of IVR.
6. Adapt the complexity of tasks for students with special educational needs, taking into account the positive experience of their involvement (quotes from teachers).

Conclusions

The study demonstrated that the implementation of a software and hardware complex based on AI and VR contributed to improved student academic success

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

and increased pedagogical satisfaction. The effectiveness of using IVR in primary school for enhancing motivation and stabilizing learning outcomes was empirically confirmed. Teachers reported a notable increase in student motivation, and the overall perceived impact of IVR was rated positively. Test results showed that the experimental group achieved higher scores with more consistent performance compared to the control group. Statistical analysis revealed a significant reduction in technical difficulties and a meaningful increase in pedagogical satisfaction within the experimental group.

Theoretically, these findings challenge the assumption that AI personalization automatically fosters learner autonomy. While performance improved, indicators of student independence and self-regulation showed only modest gains.

This suggests that IVR may enhance short-term academic outcomes without necessarily developing long-term metacognitive skills—a distinction often overlooked in the literature. The study thus refines existing theoretical models by proposing that adaptive algorithms should explicitly target strategic skill development rather than mere task matching. Furthermore, the results highlight the teacher's role as a critical moderator of IVR effectiveness, a factor frequently underestimated in technology-centric research.

The practical implications include the applicability of the developed methodology for designing digital educational programmes that emphasize motivation and personalized learning in primary education. The findings support the integration of IVR as a supplementary tool, not a replacement for live instruction, provided that infrastructure and teacher training are adequately addressed.

Several limitations must be acknowledged. The sample size and its composition restrict the generalizability of the results to broader populations. The extraordinary context of martial law in Ukraine created conditions that may not replicate in stable educational environments. Additionally, the eight-week timeframe could not capture potential novelty effects or long-term changes in learning behaviour. Children with the most severe access limitations were excluded by design, so the conclusions do not extend to the most vulnerable groups.

Future research should focus on the long-term impact of IVR on educational achievement and cognitive autonomy in primary school students. The relationship between digital resource adaptability and teachers' pedagogical competencies requires deeper investigation. Expanding the sample across different educational contexts and regions would help verify the stability of the observed effects. Qualitative methods are also needed to capture students' subjective experiences during interaction with IVR. Such research is expected to contribute to the development of effective digital pedagogy models for primary education.

Bibliographic references

- Alam, A. (2022). Employing adaptive learning and intelligent tutoring robots for virtual classrooms and smart campuses: reforming education in the age of artificial intelligence. In: Shaw, R.N., Das, S., Piuri, V., & Bianchini, M. (eds), *Advanced computing and intelligent technologies: Proceedings of ICACIT 2022* (pp. 395-406). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-19-2980-9_32
- Alwaqdani, M. (2025). Investigating teachers' perceptions of artificial intelligence tools in education: potential and difficulties. *Education and Information Technologies*, 30(3), 2737-2755. <https://doi.org/10.1007/s10639-024-12903-9>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Balcha, A. R., Chen, H. L., & Ramadhana Ab, R. (2025). The impact of augmented reality-assisted structured learning on environmental education for preschool children. *Education and Information Technologies*, 30(17), 25467-25503. <https://doi.org/10.1007/s10639-025-13737-9>
- Chen, S. J., Chen, C. Q., & Shan, X. F. (2024). The effects of an immersive virtual-reality-based 3D modeling approach on the creativity and problem-solving tendency of elementary school students. *Sustainability*, 16(10), 4092. <https://doi.org/10.3390/su16104092>
- Demartini, C. G., Sciascia, L., Bosso, A., & Manuri, F. (2024). Artificial intelligence bringing improvements to adaptive learning in education: A case study. *Sustainability*, 16(3), 1347. <https://doi.org/10.3390/su16031347>
- Drijvers, P., & Sinclair, N. (2024). The role of digital technologies in mathematics education: Purposes and perspectives. *ZDM—Mathematics Education*, 56(2), 239-248. <https://doi.org/10.1007/s11858-023-01535-x>
- Engelbrecht, J., & Borba, M. C. (2024). Recent developments in using digital technology in mathematics education. *ZDM—Mathematics Education*, 56(2), 281-292. <https://doi.org/10.1007/s11858-023-01530-2>
- Evans, C., & Zhu, X. (2023). The development and validation of the assessment engagement scale. *Frontiers in Psychology*, 14, 1136878. <https://doi.org/10.3389/fpsyg.2023.1136878>
- Ezzaim, A., Dahbi, A., Aqqal, A., & Haidine, A. (2025). AI-based learning style detection in adaptive learning systems: A systematic literature review. *Journal of Computers in Education*, 12(3), 731-769. <https://doi.org/10.1007/s40692-024-00328-9>
- Fälth, L., & Selenius, H. (2024). Primary school teachers' use and perception of digital technology in early reading and writing education in inclusive settings. *Disability and Rehabilitation: Assistive Technology*, 19(3), 790-799. <https://doi.org/10.1080/17483107.2022.2125089>
- Gerçeker, G. Ö., Bektaş, İ., & Yardımcı, F. (2024). The effects of virtual reality and stress ball distraction on procedure-related emotional appearance, pain, fear, and anxiety during phlebotomy in children: A randomized controlled study. *Journal of Pediatric Nursing*, 79, 197-204. <https://doi.org/10.1016/j.pedn.2024.08.029>
- Huang, H. M., Tai, W. S., Huang, T. C., & Lo, C. Y. (2025). Optimizing inquiry-based science education: Verifying the learning effectiveness of augmented reality and concept mapping in elementary school. *Universal Access in the Information Society*, 24(1), 681-694. <https://doi.org/10.1007/s10209-024-01098-y>
- Ishchenko, Y., Yevchenko, I., Masliuk, A., Myronets, S., & Potapchuk, Y. (2024). El impacto de la inteligencia emocional de los líderes militares en la gestión de crisis en tiempos de guerra. *Revista Cubana de Medicina Militar*, 53(2), e024043640. Recuperado de <https://revmedmilitar.sld.cu/index.php/mil/article/view/43640/2583>
- Kerimbayev, N., Adamova, K., Shadiev, R., & Altinay, Z. (2025). Intelligent educational technologies in individual learning: A systematic literature review. *Smart Learning Environments*, 12(1), 1. <https://doi.org/10.1186/s40561-024-00360-3>
- Khine, M. S. (2024). Using AI for adaptive learning and adaptive assessment. In *Artificial Intelligence in Education: A Machine-Generated Literature Overview* (pp. 341-466). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-97-9350-1_3
- Kolechytseva, T., Boitsun, I., Dronov, N., Yordan, H., & Tytar, O. (2025). Education 4.0: Development of the ukrainian educational system in the context of artificial intelligence. *Revista Eduweb*, 19(2), 82-94. <https://doi.org/10.46502/issn.1856-7576/2025.19.02.6>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Kumar, A., & Gorai, J. (2025). Effectiveness of Augmented Reality and Virtual Reality Interventions on Learning Outcomes: A Meta-Analysis in Higher Education. *TechTrends*, 1-14. <https://doi.org/10.1007/s11528-025-01106-9>
- Oakley, G. (2024). A scoping review of research on the use of digital technologies for teaching reading fluency. *Education Sciences*, 14(6), 633. <https://doi.org/10.3390/educsci14060633>
- Oakley, G., Dawson, V., & Pegrum, M. (2025). Using extended reality (XR) technologies to teach literacy in primary school science within a 5E instructional model. *Research in Science & Technological Education*, 43(4), 1-17. <https://doi.org/10.1080/02635143.2024.2446792>
- Schmidt, R., & Stumpe, B. (2025). Systematic review of mobile augmented reality applications in geography education. *Review of Education*, 13(1), e70042. <https://doi.org/10.1002/rev3.70042>
- Shirazi, B. N., Safavi, A. A., Aftabi, E., & Salimi, G. (2024). The integration of virtual reality and artificial intelligence in educational paradigms. In *2024 11th International and the 17th National Conference on E-Learning and E-Teaching (ICeLeT)* (pp. 1-6). IEEE. <https://doi.org/10.1109/ICeLeT62507.2024.10493089>
- Siki, I. M., & Leba, I. H. (2025). Effectiveness of Augmented Reality-Based Learning Media Towards Elementary School Students' Understanding of Concepts in Science: Systematic Literature Review. *AR-RIAYAH: Jurnal Pendidikan Dasar*, 9(1), 15-26. <https://doi.org/10.29240/jpd.v9i1.11760>
- Trippas, J. R., Al Lawati, S. F. D., Mackenzie, J., & Gallagher, L. (2024). What do users really ask large language models? an initial log analysis of google bard interactions in the wild. In *Proceedings of the 47th International ACM SIGIR Conference on Research and Development in Information Retrieval* (pp. 2703-2707). <https://doi.org/10.1145/3626772.3657914>
- Wen, Y., Wang, Z., & Guo, X. (2025). Trends and applications of AI in immersive learning environments: a systematic review of empirical research. *Interactive Learning Environments*, 1-19. <https://doi.org/10.1080/10494820.2025.2524029>
- World Medical Association. (2013). *WMA Declaration of Helsinki – Ethical principles for medical research involving human subjects*. Retrieved from: <https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/>
- Wu, X. Y. (2024). Exploring the effects of digital technology on deep learning: a meta-analysis. *Education and Information Technologies*, 29(1), 425-458. <https://doi.org/10.1007/s10639-023-12307-1>
- Zheng, W. (2024). Intelligent e-learning design for art courses based on adaptive learning algorithms and artificial intelligence. *Entertainment Computing*, 50, 100713. <https://doi.org/10.1016/j.entcom.2024.100713>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Sistemas adaptativos basados en Inteligencia Artificial y aprendizaje personalizado: El rol moderador de la IA en la interacción estudiantil universitaria

AI-based adaptive systems and personalized learning: The moderating role of Artificial Intelligence on university student engagement

Tetiana Mazurok¹  Roman Gakh²  Kateryna Oleksandrenko³  Tetiana Nikolaieva⁴  Anzhelika Solodka⁵ 

Afiliación autor:

¹ Professor, Head of the Department of Applied Mathematics and Informatics, The Educational and Scientific Institute of Natural and Mathematical Sciences, Informatics and Management South Ukrainian National Pedagogical University named after K.D. Ushynsky, Odesa, Ukraine. tl@mazurok.com

² Associate professor, Department of Physical Rehabilitation and Sports, West Ukrainian National University, Ternopil, Ukraine. romangah@gmail.com

³ Professor, Head of Department of Foreign Languages, Khmelnytskyi National University, Khmelnytskyi, Ukraine. oleksandrenko@gmail.com

⁴ Associate Professor, Department of Information Activity and Public Relations, Kyiv National University of Culture and Arts, Kyiv, Ukraine. nikolayeva.t@gmail.com

⁵ Professor, Department of Translation, Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine. a.solodkaya1967@gmail.com

Recibido: 01/05/26
Aceptado: 30/06/26

Cómo citar:

Mazurok, T., Gakh, R., Oleksandrenko, K., Nikolaieva, T., & Solodka, A. (2026). AI-based adaptive systems and personalized learning: The moderating role of Artificial Intelligence on university student engagement. *Revista Eduweb*, 20(2), 288-307. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.17>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Resumen

El estudio tuvo como objetivo determinar el impacto de los sistemas de aprendizaje personalizado adaptativo basados en tecnologías de IA en los indicadores de interacción del alumnado con el entorno educativo digital. El estudio se llevó a cabo mediante un enfoque cuantitativo con la participación de 198 estudiantes de instituciones de educación superior. La recopilación de datos se realizó mediante un cuestionario estructurado. Para el análisis se utilizaron estadísticas descriptivas, análisis de correlación y regresión, así como análisis de varianza unidireccional. Los resultados indicaron que el nivel general de interacción del alumnado fue superior a la media ($M = 3,87$, $DE = 0,64$). Se encontró que la personalización ($\beta = 0,42$, $p < 0,001$) y la funcionalidad de la IA ($\beta = 0,36$, $p < 0,001$) fueron predictores significativos de la interacción. Además, se halló un efecto de interacción significativo ($\beta = 0,21$, $p < 0,01$). Los resultados del análisis de varianza (ANOVA) indicaron diferencias entre los grupos con distintos niveles de uso de IA ($F = 24,67$, $p < 0,001$). Por lo tanto, la novedad del estudio radicó en identificar el papel moderador de la IA en la mejora del efecto del aprendizaje personalizado.

Palabras clave: aprendizaje personalizado, entorno de aprendizaje digital, interacción del estudiante, inteligencia artificial, sistemas de aprendizaje adaptativo.

Abstract

The study aimed to determine the impact of adaptive personalized learning systems based on AI technologies on the indicators of student interaction with the digital educational environment. The study was implemented on the basis of a quantitative approach with the participation of 198 students of higher education institutions. Data collection was carried out using a structured questionnaire. Descriptive statistics, correlation and regression analysis, as well as one-way analysis of variance, were used for analysis. The results indicated that the overall level of student interaction was above average ($M = 3.87$, $SD = 0.64$). It was found that personalization ($\beta = 0.42$, $p < 0.001$) and AI functionality ($\beta = 0.36$, $p < 0.001$) became significant predictors of interaction. In addition, a significant interaction effect was found ($\beta = 0.21$, $p < 0.01$), which indicated an increase in the impact of personalization under conditions of high levels of AI integration. The results of ANOVA indicated the presence of differences between groups with different levels of AI use ($F = 24.67$, $p < 0.001$). Therefore, the novelty of the study was to identify the moderating role of AI in enhancing the effect of personalized learning.

Keywords: personalized learning, digital learning environment, student interaction, artificial intelligence, adaptive learning systems.

Introduction

The active development of artificial intelligence technologies has changed the modern system of higher education, however, and in the direction of the transition from standardized learning to personalized models. Accordingly, given the active digitalization of education, adaptive learning systems that are able to analyze the individual characteristics of students, their learning behavior, and performance have become particularly relevant. Personalized learning, supported by AI algorithms, is interpreted in the scientific literature as one of the important tools for improving the quality of education, creating an individualized learning experience, and increasing student engagement in the learning process (Chacón-Rivadeneira, et al., 2024). However, despite the significant number of studies devoted to the use of AI in education, scientists have pointed to a number of contradictions and limitations. In particular, some scientists have recognized the effectiveness of adaptive platforms in improving academic performance and developing students' cognitive skills (Fernández Miranda et al., 2024). However, the issue of student engagement in AI-based environments remains insufficiently researched, especially in the relationship between content personalization. At the same time, many current studies focus on the technical characteristics of adaptive systems or are even limited to the analysis of performance without taking into account the mechanisms of student engagement (Eltharif & Abdalla, 2025).

Thus, the existing research gap is determined by the lack of empirical studies that would integrate the analysis of adaptive personalization algorithms with the measurement of levels of behavioral engagement of students in real educational settings. In addition, it has not been sufficiently studied how different components of adaptive systems, for example, dynamic content, individualized feedback, algorithmic prediction of success, can affect different aspects of engagement.

Therefore, the purpose of the study is to determine the effectiveness of adaptive personalized learning systems based on artificial intelligence technologies in increasing the level of student engagement and the intensity of their interaction with the digital educational environment.

To achieve this goal, the following research questions were formulated:

RQ1. What is the impact of the use of AI-oriented adaptive systems on student engagement indicators in the digital educational environment?

RQ2. How do the functional components of adaptive systems (personalized content, automated feedback, recommendation algorithms) affect the intensity of students' educational interaction with the platform?

RQ3. Is there a relationship between the level of personalization of the learning environment and indicators of digital learning activity?

RQ4. Does the level of AI tool integration into the educational process affect students' effectiveness in interacting with the educational platform?

Therefore, the scientific novelty of the study will lie in the combination of the adaptive learning approach with a multidimensional model of student engagement, which will allow us to indicate the effectiveness of AI technologies and determine the main mechanisms of their impact on the educational experience of students.

The rest of this article is structured as follows. The following section provides a review of the relevant literature on AI in education, adaptive learning systems, and student engagement in digital learning environments. The methodology section describes the study design, participants, instruments, data collection procedures,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

and statistical methods used in the study. The results section presents empirical evidence on the impact of AI-based adaptive learning systems on student engagement and engagement with digital learning environments. The discussion section interprets the results. The conclusions summarize the findings and outline directions for future research.

Theoretical Framework or Literature Review

Digital Transformation and AI in Higher Education

The digital development of higher education is one of the leading directions in the development of educational systems. In particular, modern scientists have indicated that integrating digital technologies and artificial intelligence (AI) can affect changes in the logic of organizing the educational process. The authors emphasized that the introduction of AI technologies makes it possible to move from standardized models to adaptive and personalized educational environments (Bond et al., 2025; Benavides et al., 2020; Argüelles-Cruz et al., 2021). In this space, digital transformation is defined as an important technological update and systemic change in the educational ecosystem.

The authors indicated that the introduction of digital technologies in higher education is accompanied by a number of challenges and opportunities. In particular, studies have indicated that educational institutions face problems of infrastructure, digital inequality, teacher training and integration of innovative technologies into the educational process (Abdelkader et al., 2025; Acevedo & Soto-Bubert, 2021). At the same time, the digital change has opened up various opportunities for the modernization of education. The authors prove that the use of AI for automation, personalization allows to significantly optimize educational processes.

Global studies indicate that the implementation of AI in higher education is at the stage of active formation. At the same time, the authors have proven that its effectiveness depends on the level of technological readiness of institutions and digital competencies of teachers (Barrera & Azeez, 2024; Aguilar-Cruz & Salas-Pilco, 2025). The authors also drew attention to the importance of professional development of teachers and ethical aspects of the use of AI. In particular, the topic of digital competencies of all participants in the educational process is very popular in modern literatura (Marcus-Quinn, 2025; Martín Párraga et al., 2022). The authors emphasized the importance of developing these skills for future generations of teachers (Masoumi & Noroozi, 2023).

Opportunities for personalized learning, adaptive systems and educational analytics

The scientific literature has identified personalized learning as an important tool for the digital transformation of education. Researchers have indicated that AI makes it possible to form various adaptive learning models based on the use of algorithms that analyze student behavioral data and form individualized educational trajectories (Cantú-Ortiz et al., 2020).

In particular, the authors also determined that adaptive systems can:

automatically change the complexity of educational content. This leads to the provision of personalized recommendations. The authors also indicate in their works

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

that these technologies allow generating individualized feedback and predicting learning outcomes.

At the same time, most studies focus on the conceptual description of such systems or their individual functional characteristics. Accordingly, this has limited the understanding of their real impact on the interaction of students with the digital learning environment.

A separate area of the research is related to the use of learning analytics for the analysis of educational processes. The authors recognized that learning data analytics makes it possible to assess student behavior in the digital environment (Avila et al., 2022; McDonald et al., 2025).

Studies have also indicated that the capabilities of learning analytics can be used to support feedback and decision-making in the educational process. At the same time, in most works, these indicators are defined as separate performance metrics, without integration into a model that would consider the level of personalization of the learning environment (Kong et al., 2024).

In general, the authors indicated that AI systems can increase the effectiveness of educational programs, but their implementation requires a systemic approach (Hernández-Leal et al., 2021; Ibáñez Apolo et al., 2026).

At the same time, the literature review indicated that most studies focus on individual aspects of AI application, in particular teacher training or digital competencies. However, as can be seen from the review, the issue of student interaction with adaptive systems remains insufficiently researched.

The analysis of the above studies allows us to identify several key limitations. First, a significant part of the works described digital transformation and AI at the conceptual level, without sufficient empirical confirmation of their impact on user behavior. Second, research on adaptive systems often focuses on individual components and does not take into account their interaction. Third, learning analytics indicators are used fragmentarily and are not integrated into holistic analytical models.

Thus, the existing research gap consisted in the lack of an approach that would combine: the level of personalization of adaptive AI systems; their functional components; indicators of student interaction with the digital environment.

Theoretical Framework

The theoretical framework of this study is determined by the integration of approaches to digital transformation of education, adaptive learning and learning analytics. All these aspects together have formed an important analytical basis for studying the impact of artificial intelligence on the interaction of students with the digital learning environment.

Within the concept of digital transformation of higher education, researchers have determined that the effectiveness of educational systems is predicted by the level of integration of digital technologies and their ability to optimize learning processes (Benavides et al., 2020; Argüelles-Cruz et al., 2021). In this space, artificial intelligence plays the role of a technological driver that ensures the automation and personalization of learning.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The second theoretical component is the adaptive learning approach, according to which the educational environment should dynamically change according to the behavioral characteristics of the user (Cantú-Ortiz et al., 2020).

The third component is the learning analytics approach, which made it possible to operationalize user interaction through measurable indicators. Within this approach, the effectiveness of a digital learning environment is determined through user activity indicators: frequency of interaction, time in the system, and task completion (Avila et al., 2022; Pichkur et al., 2023).

Based on the integration of these approaches, the study formed a model that includes three main constructs:

1. Personalization of the learning environment: content adaptation, individualized recommendations, and automated feedback.
2. Functional capabilities of the AI system: algorithmic mechanisms, analytical tools, and assessment systems.
3. User interaction with the system: frequency of use, time spent in the system, task completion, and level of activity (Franqueira et al., 2024; Godinez-Flores et al., 2025).

Within the theoretical model, it is assumed that:

- The level of personalization of the learning environment directly affects the intensity of user interaction;
- The functional capabilities of the AI system modify this influence. They can either increase or decrease it (Guerrero-Quíñonez et al., 2023);
- User interaction indicators serve as indicators of the effectiveness of the digital learning environment.

Thus, the model was causal in nature and made it possible to test the impact of adaptive AI solutions on the behavioral parameters of the use of educational platforms.

The proposed theoretical framework provided an analytical basis for further research and determined the logic of the selection of variables.

Methodology

Research design

The study used a quantitative design aimed at determining the impact of adaptive personalized learning systems based on artificial intelligence technologies.

The study was a cross-sectional empirical analysis. This type made it possible to determine the relationships between the level of personalization of the system, its functional characteristics and indicators of digital learning activity of students.

Methodologically, the study is based on the assumption that:

The parameters of the adaptive system (personalization and AI functionality) are independent variables;
Indicators of user interaction (frequency of use, activity, task performance) are dependent variables.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Data collection was implemented on the basis of a structured toolkit that combined self-assessment of the use of the digital platform and indicators of interaction with the educational environment. The obtained data were processed using statistical analysis methods.

Participants

The study involved 198 students from higher education institutions who used digital educational platforms with elements of adaptive learning and artificial intelligence during the 2024-2025 academic year. The sample was formed on the basis of purposive sampling and using elements of the available sample.

The inclusion criteria for the sample included:

experience in using digital educational platforms;
regular interaction with online courses or educational systems;
use of tools that contained elements of adaptive learning or AI

The exclusion criteria were:

no experience with digital educational platforms;
occasional or irregular use of educational systems;
incomplete completion of the questionnaire.

The sample included students of different levels of training (bachelor's and master's). This made it possible to ensure data variability.

In order to understand whether the sample was sufficient, the classical approaches to determining the sample size for multivariate statistical analysis were used. In particular, according to the rule proposed by Green (1991), the minimum sample size for multiple regression is determined by the formula: $N \geq 50 + 8m$, where m is the number of independent variables.

In this study, the model included 2 main independent variables (the level of personalization and the functional characteristics of the AI system). Accordingly, the minimum required sample size was at the level of $N \geq 66$. Thus, the actual sample size ($n = 198$) exceeded the minimum required level. This ensured sufficient statistical power of the analysis (see Table 1).

Table 1.
Demographic characteristics of participants ($n = 198$)

Variable	Category	n	%
Gender	Male	82	41.4%
	Female	116	58.6%
Age	18–20	64	32.3%
	21–23	89	44.9%
	24+	45	22.8%
Level of study	Bachelor	138	69.7%
	Master	60	30.3%
Experience with AI tools in learning	Low	58	29.3%
	Medium	91	46.0%
	High	49	24.7%

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Procedure and instruments

The study was conducted during the 2024–2025 academic year and was aimed at determining the effectiveness of the model of using adaptive personalized learning systems based on artificial intelligence technologies in a real educational environment.

As part of the study, an AI-oriented adaptive learning model was implemented, which involved the integration of digital tools into the students' learning process. This model included the following key components:

the use of recommendation systems to individualize educational content;
the use of automated feedback tools;
adaptation of educational tasks according to the level of student training;
the use of digital platforms that recorded user interaction indicators (See Figure 1).

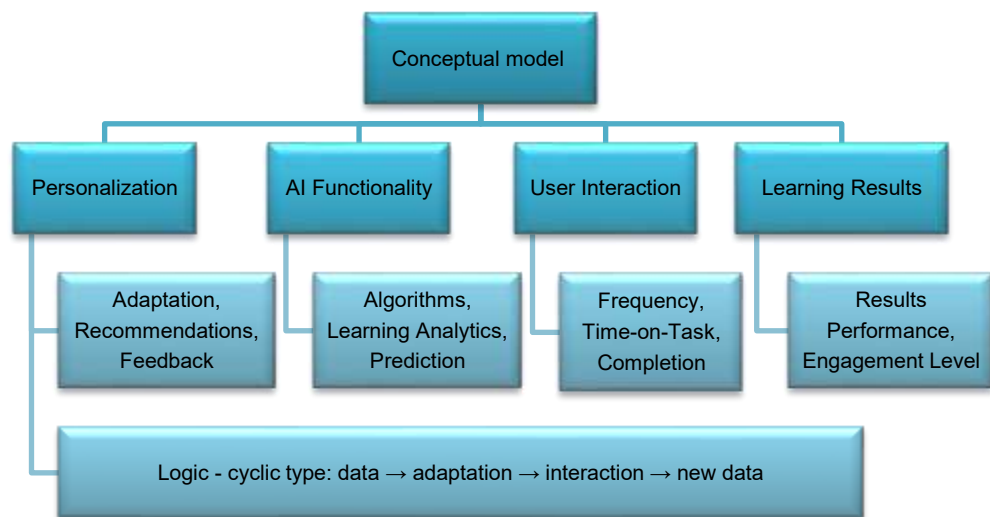


Figure 1. Conceptual model of AI-based adaptive learning system.

Within the framework of the study, various digital tools with elements of artificial intelligence were used in the educational process, ensuring the implementation of adaptive personalized learning.

In particular, the following were used: generative language models, which were used to explain educational material, generate answers, and support the educational process (ChatGPT; ClaudeAI, NotebookLM); automated feedback tools, which provided recommendations for improving task performance; recommendation systems, which offered educational materials according to the level of students' training; platforms with learning analytics elements, which made it possible to track user interaction indicators (frequency of login, time in the system, task completion).

In addition, digital educational environments integrated with adaptive functions were used, which ensured:

individualization of educational content;

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

automatic assessment;
collection and analysis of data on students' educational activity.

The research procedure included the following stages:

Development and implementation of an adaptive learning model based on the use of AI tools in the educational process;
Integration of digital tools into the courses that students took during the academic year;
Systematic use of the adaptive environment by students, which allowed accumulating data on their interaction with the platform;
Collection of empirical data at the end of the implementation period using online tools.

The main environment for implementing the educational process was a digital learning management platform (LMS), which was integrated with artificial intelligence and learning analytics tools. The study used a single digital infrastructure available to all participants, which ensured unified learning conditions.

Artificial intelligence tools were integrated into training courses as auxiliary and adaptive components. In particular:

- Generative language models (ChatGPT, Claude AI, NotebookLM) - to explain the educational material, generate answers and support independent work of students;
- Recommendation systems offered educational materials according to the level of students' training;
- Automated feedback tools provided instant prompts and assessments;
- Learning analytics systems recorded interaction indicators (frequency of login, time in the system, task completion).

All study participants had access to the same set of tools, however, the level of their actual use was different, which made it possible to classify students by the level of AI integration.

The study was conducted in accordance with the ethical principles of educational research and the provisions of the Declaration of Helsinki. Participation in the study was voluntary, and all participants were informed about the purpose of the study, the data collection procedures, and their right to withdraw from the study at any stage without any consequences. Informed consent was obtained from all participants before data collection. Confidentiality and anonymity of respondents were ensured throughout the study, and all data collected were processed solely in aggregate form for research purposes. No personal information was collected or disclosed.

Data processing and validation

Thus, the study made it possible to determine the effectiveness of the proposed model not in the real educational process.

A questionnaire was used to collect empirical data, which was formed¹ according to the theoretical model of the study.

The questionnaire consisted of three main blocks:

Personalization of the learning environment (Personalization Level)

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

It was assessed through indicators of content adaptation, relevance of recommendations and quality of automated feedback.

Example statement:

"The learning platform offered materials that correspond to my level of training."

AI functionalities

Included an assessment of the effectiveness of algorithms, the use of analytics

Example statement:

"The system provided useful recommendations to improve my learning."

User interaction

It was assessed based on the intensity of platform use, task completion and activity in the learning environment.

Example statement:

"I regularly use the digital platform to complete learning tasks."

All statements were assessed on a five-point scale

(1 – completely disagree, 5 – completely agree).

To verify the reliability of the instrument, an analysis of the internal consistency of the scales was conducted using the Cronbach's coefficient.

The results of the analysis indicated a high level of reliability of the measurements:

for the personalization of the learning environment scale — $\alpha = 0.88$;

for the AI functionality scale — $\alpha = 0.91$;

for the user interaction scale — $\alpha = 0.86$.

The overall reliability coefficient of the instrument was $\alpha = 0.89$.

Data analysis

Data analysis was implemented based on the use of quantitative statistical methods with further interpretation of the results obtained in the context of the functioning of adaptive AI systems.

First, a descriptive analysis was conducted, which made it possible to determine the general characteristics of the sample and the distribution of the values of the studied variables. Later, a correlation analysis was conducted to identify the relationships between the level of personalization, AI functionalities and user interaction indicators. This made it possible to determine the relationship between the technological characteristics of the system and the behavioral indicators of students.

At the next stage, a multiple regression analysis was conducted. This analysis was aimed at determining the relative contribution of independent variables to explaining the variability of the dependent variable. This made it possible to establish the main components of the adaptive system that had the greatest impact on the interaction of students with the digital environment.

In addition to statistical analysis, the results were interpreted taking into account the logic of the functioning of adaptive systems.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The statistical significance of the results was determined at the $p < 0.05$ level.

Results and Discussion

Impact of AI-Based Adaptive Learning Systems on Student Interaction (RQ1)

At the first stage of the analysis, a descriptive and inferential analysis of the main study variables was conducted. This analysis consisted of determining the central tendencies, variability of indicators and assessing the shape of the data distribution.

The analysis of central tendencies showed that all the studied variables have values above the average, in particular: the level of personalization ($M = 3.91$, $SD = 0.59$), AI functionality ($M = 4.02$, $SD = 0.57$) and user interaction ($M = 3.87$, $SD = 0.64$). At the same time, the variability indicators fluctuated within 0.57–0.64. this determined the relative homogeneity of the respondents' answers, which indicates the stability of the data obtained.

The analysis of the distribution of variables indicated that the values of asymmetry (skewness varies from -0.45 to -0.38) are slightly negative. At the same time, the kurtosis indicators (kurtosis within 0.19–0.25) are close to zero. This indicator indicates the absence of significant deviations from the normal distribution.

Table 2.

Descriptive and inferential statistics of study variables

Variable	Mean	SD	Min	Max	Skewness	Kurtosis
Personalization	3.91	0.59	1	5	-0.45	0.21
AI functionality	4.02	0.57	1	5	-0.38	0.19
User interaction	3.87	0.64	1	5	-0.42	0.25

Source: author's development

To determine the impact of AI-Based Adaptive Learning Systems, an analysis of the overall level of student interaction with the digital learning environment in the context of the use of adaptive AI systems was conducted.

The results of descriptive statistics indicated that the overall level of student interaction with the platform was above average ($M = 3.87$, $SD = 0.64$). This indicator determined the active use of the digital learning environment in the context of the implementation of adaptive technologies.

In particular, the indicator of the frequency of platform use was $M = 3.95$ ($SD = 0.71$); completion of educational tasks - $M = 3.82$ ($SD = 0.68$); overall activity in the environment - $M = 3.84$ ($SD = 0.66$) (see Figure 2).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

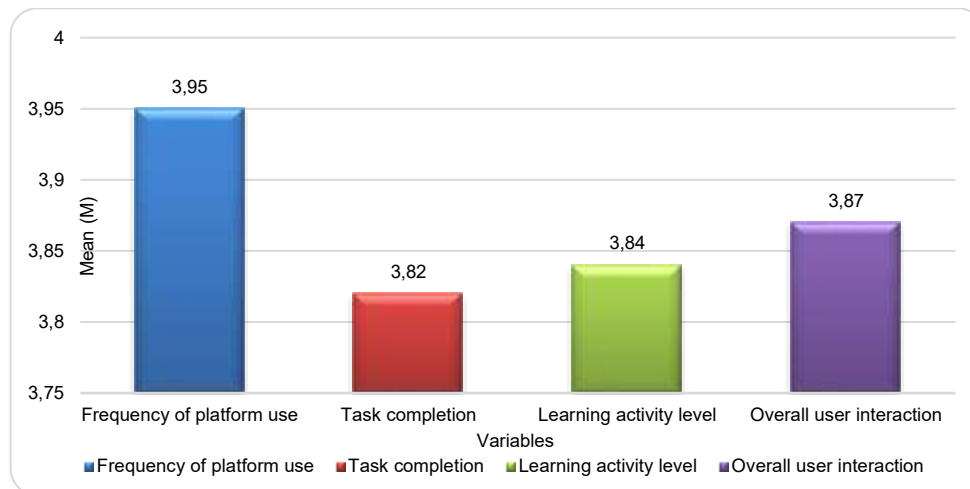


Figure 2. User Interaction Metrics

Source: author's development

To test the impact of adaptive systems on the level of interaction, a correlation analysis was conducted between the integral indicator of the use of AI systems and the level of student interaction.

The results indicated a significant positive relationship between the use of adaptive AI systems and student engagement ($r = 0.62$, $p < 0.01$), indicating a medium-strong level of correlation.

In addition, the results of the regression analysis confirmed that the use of adaptive systems became a significant predictor of student engagement ($\beta = 0.58$, $p < 0.001$).

Influence of Adaptive System Components on Interaction (RQ2 and RQ3)

The study also determined the influence of individual components of the adaptive system — personalization of the learning environment and AI functionalities — on the indicators of student interaction with the digital learning environment.

The results of descriptive statistics indicated that both components received relatively high scores among respondents: the level of personalization ($M = 3.91$, $SD = 0.59$) and AI functionalities ($M = 4.02$, $SD = 0.57$). Correlation analysis indicated the presence of positive relationships between the variables under study.

In particular, personalization of the learning environment had a strong relationship with user interaction ($r = 0.65$, $p < 0.01$) (see Table 3).

Table 3.

Correlation matrix between personalization, AI functionality, and user interaction

Variable	1	2	3
1. Personalization	1		
2. AI functionality	0.58**	1	
3. User interaction	0.65**	0.60**	1

Note: $p < 0.01$

Source: author's development

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

To determine the relative contribution of each of the components, a multiple regression analysis was conducted. The results indicated that both variables are statistically significant predictors of student interaction.

Personalization of the learning environment had a significantly greater impact ($\beta = 0.42$, $p < 0.001$) compared to AI functionality ($\beta = 0.36$, $p < 0.001$). The model explained 41% of the variation in interaction scores ($R^2 = 0.41$). This indicator indicated a high level of explanatory power. To determine the most effective component, an analysis of the relative effectiveness of the main components of the adaptive AI system in explaining the variability of student interaction indicators was carried out. In particular, personalization of the learning environment had the highest level of influence ($\beta = 0.42$, $p < 0.001$; $B = 0.48$). This means that content adaptation, individualized recommendations had a significant impact on the frequency of platform use, task completion, and overall level of activity.

At the same time, AI functionalities also had a statistically significant impact ($\beta = 0.36$, $p < 0.001$; $B = 0.39$), but their contribution is somewhat lower compared to personalization.

Multicollinearity analysis showed that the VIF value for both variables did not exceed 2 ($VIF = 1.34$), which indicates the absence of a multicollinearity problem and indicated the correctness of the constructed model. Overall, the model had a high level of explanatory power ($R^2 = 0.41$), which means that 41% of the variation in user interaction is explained by the variables included in the model. This indicates the significance of the studied components in the structure of the adaptive learning environment (see Table 4).

Table 4.

Multiple regression analysis of AI system components predicting user interaction

Predictor	B	SE	β	t	p-value	VIF
Personalization	0.48	0.07	0.42	6.73	<0.001	1.34
AI functionality	0.39	0.06	0.36	5.98	<0.001	1.34

Note: R^2 0.41; Adjusted R^2 0.40; F 68.9; $p < 0.001$

Source: author's development

Effect of AI Tool Integration Level on User Interaction (RQ4)

To determine the impact of the level of integration of AI tools on the effectiveness of students' interaction with the digital learning platform, a comparative analysis was conducted between user groups with different levels of AI use.

Participants were classified into three groups according to the intensity of use of AI tools: low, medium and high levels of integration. The results of descriptive statistics indicated a clear positive dynamics of interaction indicators depending on the level of AI integration (see Figure 2).

In particular, the average interaction value was

for the group with a low level of integration — $M = 3.45$ ($SD = 0.72$);

for a medium level — $M = 3.88$ ($SD = 0.61$);

for a high level — $M = 4.21$ ($SD = 0.55$).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

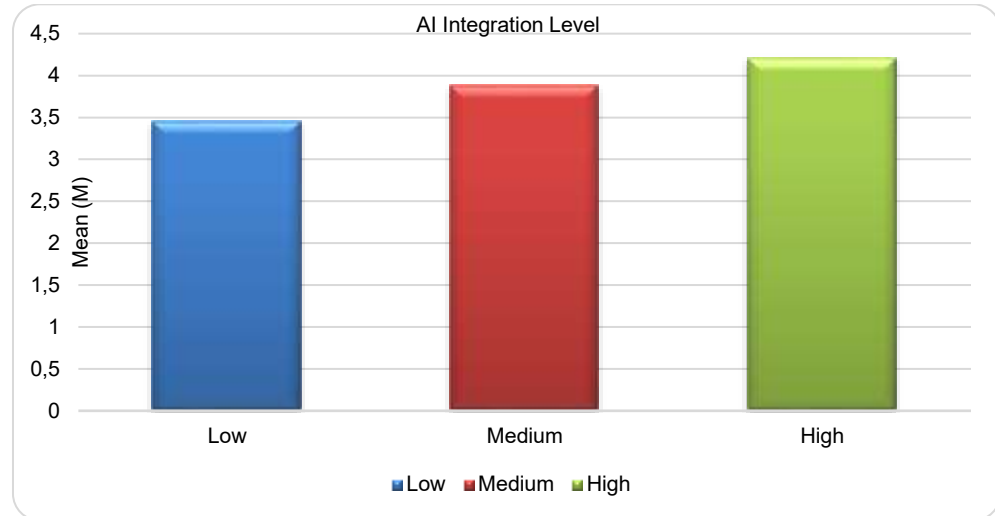


Figure 3. User Interaction by AI Integration Level

Source: author's development

As shown in Figure 3, with an increase in the level of AI integration, a consistent increase in student interaction indicators is noticeable. This indicated the presence of a clear trend dependence.

A one-way analysis of variance (ANOVA) was used to test the significance of the differences. The results showed a statistically significant effect of the level of AI integration on student interaction ($F = 24.67$, $p < 0.001$) (see Table 5).

Table 5.
ANOVA results for AI integration level

Source	SS	df	MS	F	p	η^2
Between groups	12.34	2	6.17	24.67	<0.001	0.20
Within groups	48.92	195	0.25			

Source: author's development

Besides, further post hoc analysis (Tukey HSD) indicated that:

Students with a high level of integration had higher interaction scores compared to the other groups ($p < 0.01$);

The difference between the medium and low levels is also statistically significant ($p < 0.05$).

It is important to note that the decrease in standard deviation in the high level of integration group ($SD = 0.55$) indicated a more stable and homogeneous user behavior. This may indicate an effective adaptation of the system to the needs of students.

To determine the interaction between the level of personalization of the learning environment and the level of AI integration in explaining the indicators of student interaction with the digital platform.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

To test the moderation effect, a regression model was built with the inclusion of an interaction term. The independent variables (personalization level and AI integration level) were pre-centered (mean-centering) to reduce multicollinearity and correctly interpret the interaction coefficients. The following were added to the model:

- Main effects (personalization, AI integration);
- Interaction term (Personalization × AI Integration).

The analysis was performed within the framework of multiple regression according to the moderation analysis approach (see Table 6).

Table 6.

Moderation analysis: interaction effect of personalization and AI integration on user interaction

Predictor	B	SE	β	t	p
Personalization	0.41	0.06	0.39	6.58	<0.001
AI integration level	0.36	0.05	0.34	6.12	<0.001
Personalization × AI integration	0.19	0.07	0.21	2.87	0.005

Note: $R^2 = 0.47$; ΔR^2 (interaction) = 0.04; $p < 0.01$

Source: author's development

For this purpose, an interaction model was formed, which included the main effects (personalization, AI integration) and the interaction background (Personalization × AI Integration). The modeling results (see Figure 4) indicated the presence of a significant interaction effect ($\beta = 0.21$, $p < 0.01$). This determined the moderating role of the level of AI integration.

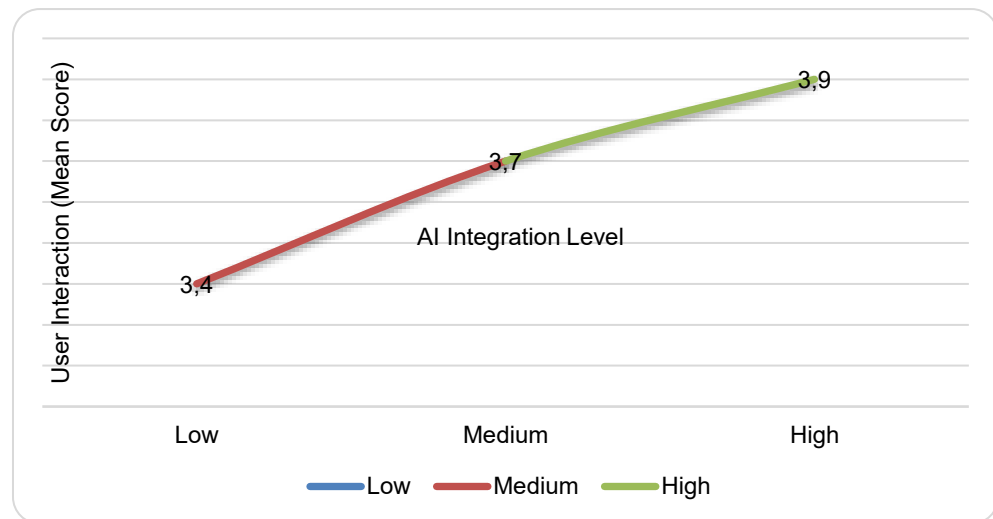


Figure 4. Interaction Effect of Personalization and AI Integration Level.

Source: author's development.

As shown in Figure 4, the slope of the regression lines differs depending on the level of AI integration. Accordingly, in the group with a low level of integration, this relationship was significantly weaker. Therefore, the level of AI integration acted as a moderator in the relationship between learning personalization and student interaction.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Therefore, the impact of personalization of the learning environment on student interaction is not constant but varies depending on the level of AI integration in the learning process. At a low level of AI integration, the personalization effect is moderate and limited to basic content adaptation. At the same time, at a high level of AI integration, this effect is significantly enhanced (Barreda Medina, 2025). This indicated a synergistic interaction between the technological and pedagogical components of the system.

The results of the study indicated that the active use of adaptive personalized learning systems based on artificial intelligence technologies had an impact on the indicators of student interaction with the digital educational environment. It was found that the overall level of student interaction was above average. This indicated the effectiveness of the implementation of AI-oriented educational solutions.

These results were consistent with the conclusions of Mualla & Mualla (2024) and Pino Tarragó et al. (2025), who indicated that the digital transformation in higher education has created unique and even new opportunities for improving the efficiency of learning, especially in developing countries. In this sense, the use of AI has acted as the main tool for optimizing educational processes (Pozzo et al., 2024).

The results of correlation and regression analysis also indicated that both personalization and AI functionality have become significant predictors of student interaction. However, it was also found that personalization had a stronger impact. This situation testified to the important role of adaptation of educational content in shaping user activity (Salas-Pilco & Yang, 2022; Serna Gómez et al., 2021; West et al., 2016). This was consistent with the views of other scholars who indicated that the effectiveness of educational innovations depended on the level of adaptability of educational practices.

At the same time, the results of this study expanded existing ideas, as they indicated that the functional capabilities of AI in themselves are not sufficient to ensure a high level of interaction. This confirmed the conclusions of the authors, who indicated that technological accessibility did not guarantee high-quality educational results without proper pedagogical integration (Wong et al., 2019; Yerbabuena Torres et al., 2024).

A particularly important result was the identification of the interaction effect between personalization and the level of AI integration. The data obtained indicated that the impact of personalization was enhanced under conditions of a high level of AI integration. This fact indicated the presence of a synergistic effect. This allowed us to describe AI as a powerful tool that changed the very logic of the educational process.

This result had important theoretical significance, as it clarified the meaning of using AI in education: not as a separate technological element, but as a multiplier of the effectiveness of personalization. A similar approach is partially reflected in the works of Rodríguez-Hernández et al. (2021) and Valdés et al. (2021), in which AI is identified as a significant tool for predicting learning activities. However, this study shows its role in enhancing behavioral indicators of interaction.

In addition, the results of the analysis indicated that users with a high level of interaction had higher rates of both personalization and use of AI functions. This indicates that the effectiveness of a digital learning environment depends on the integrated use of various technological components (Vázquez-Villegas, 2025).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

From a practical point of view, the results of the study are important for developers of educational platforms and higher education institutions. They indicate the need to move from the simple implementation of AI to the formation of adaptive systems that combine personalization, analytics and intelligent learning support tools. This is consistent with the conclusions of the authors, who identified the need to integrate AI into curricula to develop modern competencies.

Thus, the results of the study indicated that the effectiveness of digital learning is determined by the level of their integration into the learning process. The identified interaction effect between personalization and AI has opened new prospects for further research in the field of adaptive learning and educational technologies.

However, the study has a number of limitations. In particular, the study had a cross-sectional design, which limited the possibility of establishing causal relationships between variables. Although the identified statistical relationships indicated a significant impact of adaptive AI systems on student interaction, further studies using longitudinal or experimental designs could provide a better understanding of the dynamics of these processes.

In addition, the use of self-assessment tools may be associated with the risk of subjectivity of responses and social desirability effects. In addition, the study did not take into account individual characteristics of students (e.g., level of digital competence or motivation), which may act as additional factors.

However, despite these limitations, the results have important practical implications for the development of digital learning environments and the implementation of AI in higher education.

In particular, the study results indicated that personalization of educational content has become a particularly important factor in increasing student interaction. Thus, in the future, developers of educational platforms should pay special attention to creating adaptive mechanisms that would take into account the individual characteristics of participants.

In addition, it was found that the effectiveness of personalization depends on the level of AI integration. This determined the need for systematic implementation of technologies. Educational institutions should focus on creating integrated systems that combine:

generative AI tools,
recommendation systems,
automated feedback,
educational data analytics.

Conclusions

The study established the impact of adaptive personalized learning systems based on AI technologies on students' interaction with the digital educational environment. It was indicated that the integration of AI into the educational process made it possible to increase student activity, the frequency of use of digital platforms, and the effectiveness of completing educational tasks.

It was established that the personalization of the educational environment and the functionality of AI became significant factors that influenced user interaction. At the

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

same time, personalization had a more pronounced effect. This determined the important role of adapting educational content in shaping student engagement.

A particularly important result is the identification of the interaction effect between the level of personalization and the level of AI integration. The study showed that the impact of personalization increased under conditions of a high level of AI integration.

In addition, it was found that an increase in the level of AI integration is associated with an increase in student interaction indicators. Therefore, the effectiveness of digital learning was determined by the level of its integration into a single adaptive system.

The scientific novelty of the study lies in the identification of the moderating effect of AI in the structure of personalized learning, which allows us to consider artificial intelligence as a factor that enhanced the effectiveness of its main components.

The practical significance of the study lies in the possibility of using the obtained results to develop adaptive educational platforms, modernize curricula, and implement innovative approaches to organizing a digital learning environment.

Bibliographic references

- Abdelkader, K., Aki, R., Algabo, M., & Elsherif, N. (2025). Digital Transformation in Higher Education: Challenges and Opportunities in Libyan Higher Institutions. *Sharwes Scientific Journal*, 6(1), 164–170. <https://doi.org/10.26629/ssj.2025.09>
- Acevedo, R., & Soto-Bubert, A. (2021). Challenges facing higher education institutions in Chile in training learners in entrepreneurship and the future of work. Chile a Case Study. *International Journal of Higher Education Management*, 08(01). <https://doi.org/10.24052/ijhem/v08n01/art-1>
- Aguilar-Cruz, P. J., & Salas-Pilco, S. Z. (2025). Teachers' perceptions of artificial intelligence in Colombia: AI technological access, AI teacher professional development and AI ethical awareness. *Technology, Pedagogy and Education*, 34(2), 219–238. <https://doi.org/10.1080/1475939x.2025.2451865>
- Argüelles-Cruz, A.-J., García-Peñalvo, F.-J., & Ramírez-Montoya, M.-S. (2021). Education in Latin America: Toward the Digital Transformation in Universities. In *Radical Solutions for Digital Transformation in Latin American Universities* (pp. 93–108). Springer Singapore. https://doi.org/10.1007/978-981-16-3941-8_6
- Avila, A.-G. N., Silva Feraud, I. F., Solano-Quinde, L. D., Zuniga-Prieto, M., Echeverria, V., & De Laet, T. (2022). Learning Analytics to Support the Provision of Feedback in Higher Education: a Systematic Literature Review. In *2022 XVII Latin American Conference on Learning Technologies (LACLO)*. IEEE. <https://doi.org/10.1109/laclo56648.2022.10013324>
- Barrera, A. G., & Azeez, G. K. (2024). Artificial Intelligence in Higher Education: Lessons from Chile and Mexico. *International Higher Education*. <https://doi.org/10.6017/895b9e0d.36d8e241>
- Barreda Medina, R. F. (2025). Education 4.0 in Latin America: Comparative Analysis of the Use of Artificial Intelligence in Innovative Teaching Practices. *Journal of Information Systems Engineering and Management*, 10(36s), 1041–1049. <https://doi.org/10.52783/jisem.v10i36s.6635>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- Benavides, L., Tamayo Arias, J., Arango Serna, M., Branch Bedoya, J., & Burgos, D. (2020). Digital Transformation in Higher Education Institutions: A Systematic Literature Review. *Sensors*, 20(11), 3291. <https://doi.org/10.3390/s20113291>
- Bond, M., Oxley, E., & Lymperis, L. (2025). AI applications in initial teacher education: a systematic mapping review. In *Handbook of Artificial Intelligence in Higher Education* (pp. 550–575). Edward Elgar Publishing. <https://doi.org/10.4337/9781035338764.00046>
- Cantú-Ortiz, F. J., Galeano Sánchez, N., Garrido, L., Terashima-Marin, H., & Brena, R. F. (2020). An artificial intelligence educational strategy for the digital transformation. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 14(4), 1195–1209. <https://doi.org/10.1007/s12008-020-00702-8>
- Chacón-Rivadeneira, K., Morales-Maure, L., García-Marimón, O., Sáez-Delgado, F., González, J. G., & Ponce, B. A. (2024). Artificial Intelligence Adoption in Latin American Mathematics Education: Challenges and Opportunities. *Journal of Posthumanism*, 4(3). <https://doi.org/10.63332/joph.v4i3.3195>
- Eltharif, A. A. M., & Abdalla, R. A. S. (2025). A Conceptual Framework for Identifying Risks of AI Integration in Higher Education. *International Journal of Computer Applications*, 187(18), 39–50. <https://doi.org/10.5120/ijca2025925258>
- Fernández Miranda, M., Román Acosta, D., Jurado Rosas, A. A., Limón Domínguez, D., & Torres Fernandez, C. (2024). Artificial Intelligence in Latin American Universities: Emerging Challenges. *Computación y Sistemas*, 28(2). <https://doi.org/10.13053/cys-28-2-4822>
- Franqueira, A. d. S., Anderson Amaro, Vale, K. V. S., Dias, L. S., & Pedra, R. R. (2024). Challenges and Opportunities in Integrating Artificial Intelligence in Distance Education. *RCMOS - Revista Científica Multidisciplinar O Saber*, 1(1). <https://doi.org/10.51473/rcmos.v1i1.2024.480>
- Godínez-Flores, G. C., González-Peralta, M. F., & Olivares-Escorza, M. (2025). Towards an Educational Transformation Based on Digital Humanities. In *Latin American Perspectives on Innovation in Higher Education* (pp. 173–184). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-96751-1_14
- Guerrero-Quirón, A. J., Bedoya-Flores, M. C., Mosquera-Quirón, E. F., Mesías-Simisterra, Á. E., & Bautista-Sánchez, J. V. (2023). Artificial Intelligence and its scope in Latin American higher education. *Ibero-American Journal of Education & Society Research*, 3(1), 264–271. <https://doi.org/10.56183/iberoeds.v3i1.627>
- Green, S. B. (1991). How Many Subjects Does It Take To Do A Regression Analysis. *Multivariate Behavioral Research*, 26(3), 499–510. https://doi.org/10.1207/s15327906mbr2603_7
- Hernández-Leal, E., Duque-Méndez, N. D., & Cechinel, C. (2021). Unveiling educational patterns at a regional level in Colombia: data from elementary and public high school institutions. *Heliyon*, e08017. <https://doi.org/10.1016/j.heliyon.2021.e08017>
- Ibáñez Apolo, M. F., Parrales Rodríguez, V. D. R., Paidá Torres, M. E., Tamayo Chóez, F. R., & León Escobar, D. D. R. (2026). The impact of artificial intelligence on personalized education: Opportunities and challenges in Latin America. *Emergentes*, 6(1), 328–346. <https://doi.org/10.60112/erc.v6.i1.675>
- Kong, S.-C., Korte, S.-M., Burton, S., Kesitalo, P., Turunen, T., Smith, D., Wang, L., Lee, J. C.-K., & Beaton, M. C. (2024). Artificial Intelligence (AI) literacy – an argument for AI literacy in education. *Innovations in Education and*

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

- Teaching International*, 62(2), 477-483.
<https://doi.org/10.1080/14703297.2024.2332744>
- Marcus-Quinn, A. (2025). Teachers' professional digital competence: exploring issues of social justice and fairness. In *Reimagining Teacher Digital Competence* (pp. 60–76). Edward Elgar Publishing. <https://doi.org/10.4337/9781035337514.00011>
- Martín Párraga, L., Llorente Cejudo, C., & Barroso Osuna, J. (2022). Validation of the DigCompEdu Check-in questionnaire through structural equations: A study at a university in Peru. *Education Sciences*, 12(8), 574. <https://doi.org/10.3390/educsci12080574>
- Masoumi, D., & Noroozi, O. (2023). Developing early career teachers' professional digital competence: a systematic literature review. *European Journal of Teacher Education*, 48(3), 644–666. <https://doi.org/10.1080/02619768.2023.2229006>
- McDonald, N., Johri, A., Ali, A., & Collier, A. H. (2025). Generative artificial intelligence in higher education: Evidence from an analysis of institutional policies and guidelines. *Computers in Human Behavior: Artificial Humans*, 3, 100121. <https://doi.org/10.1016/j.chbah.2025.100121>
- Mualla, W., & Mualla, K. J. (2024). Digital Transformation in Higher Education: Challenges and Opportunities for Developing Countries. In *Higher Education in the Arab World* (pp. 211–231). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-70779-7_9
- Pichkur, M. O., Poluden, L. I., Demchenko, I. I., & Sotska, H. I. (2023). Digital footprints monitoring of higher art education applicants training. *Information Technologies and Learning Tools*, 94(2), 128–149. <https://doi.org/10.33407/itlt.v94i2.5205>
- Pino Tarragó, J. C., Domínguez Gálvez, D. L., Regalado Jalca, J. J., & Villavicencio Cedeño, E. G. (2025). Artificial intelligence and soft skills in civil engineering education: A Latin American curriculum gap with global implications. *Research in Globalization*, 11, 100307. <https://doi.org/10.1016/j.resglo.2025.100307>
- Pozzo, D. N., Gonzalez Beleño, C. A., Correa, K. R., Donado, M. G., Gomez Pedroza, F. J., & Moncada Diaz, J. E. (2024). Managers' attitudes and behavioral intentions towards using artificial intelligence for organizational decision-making: A study with Colombian SMEs. *Procedia Computer Science*, 238, 956–961. <https://doi.org/10.1016/j.procs.2024.06.119>
- Rodríguez-Hernández, C. F., Musso, M., Kyndt, E., & Cascallar, E. (2021). Artificial neural networks in academic performance prediction: Systematic implementation and predictor evaluation. *Computers and Education: Artificial Intelligence*, 2, 100018. <https://doi.org/10.1016/j.caeai.2021.100018>
- Rodríguez-Abitia, G., Martínez-Pérez, S., Ramirez-Montoya, M. S., & Lopez-Caudana, E. (2020). Digital Gap in Universities and Challenges for Quality Education: A Diagnostic Study in Mexico and Spain. *Sustainability*, 12(21), 9069. <https://doi.org/10.3390/su12219069>
- Salas-Pilco, S. Z., & Yang, Y. (2022). Artificial intelligence applications in Latin American higher education: a systematic review. *International Journal of Educational Technology in Higher Education*, 19(1). <https://doi.org/10.1186/s41239-022-00326-w>
- Serna Gómez, J. H., Díaz-Piraquive, F. N., Muriel-Perea, Y. d. J., & Díaz Peláez, A. (2021). Advances, Opportunities, and Challenges in the Digital Transformation of HEIs in Latin America. In *Radical Solutions for Digital*

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
 Internacional (CC BY 4.0)

- Transformation in Latin American Universities* (pp. 55–75). Springer Singapore. https://doi.org/10.1007/978-981-16-3941-8_4
- Valdés, K. N., y Alpera, S. Q., & Cerdá Suárez, L. M. (2021). An Institutional Perspective for Evaluating Digital Transformation in Higher Education: Insights from the Chilean Case. *Sustainability*, 13(17), 9850. <https://doi.org/10.3390/su13179850>
- Vázquez-Villegas, P. (2025). New Pedagogical Elements from and for the Digital Humanities. In *Latin American Perspectives on Innovation in Higher Education* (pp. 145–156). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-96751-1_12
- West, D., Huijser, H., Heath, D., Lizzio, A., Toohey, D., Miles, C., Searle, B., & Bronnimann, J. (2016). Higher Education Teachers' Experiences with Learning Analytics in Relation to Student Retention. *Australasian Journal of Educational Technology*, 32(5), 48-60. <https://doi.org/10.14742/ajet.3435>
- Wong, J., Baars, M., de Koning, B. B., van der Zee, T., Davis, D., Khalil, M., Houben, G.-J., & Paas, F. (2019). Educational Theories and Learning Analytics: From Data to Knowledge. In *Utilizing Learning Analytics to Support Study Success* (pp. 3–25). Springer International Publishing. https://doi.org/10.1007/978-3-319-64792-0_1
- Yerbabuena Torres, C. F., Villagomez Cabezas, A. V., Yerbabuena Torres, A. R., & Mendoza Torres, N. A. (2024). Artificial Intelligence Tools Applied to Education: A Systematic Literature Review. *International Journal of Interactive Mobile Technologies (IJIM)*, 18(24), 155–174. <https://doi.org/10.3991/ijim.v18i24.50055>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

La gamificación como herramienta para aumentar la motivación de los estudiantes en un entorno educativo digital

Gamification as a tool for increasing student motivation in a digital educational environment

Halyna Kozub¹ Nataliia Stepanova² Ihor Zelenyi³ Igor Shumkov⁴ Vitalii Rudynskyi⁵

Afiliación autor:

¹ Candidate of Engineering Sciences, Associate Professor, Department of Information technology and systems, Luhansk Taras Shevchenko National University, Lubny, Ukraine. kozubg@luguniv.edu.ua

² Candidate of Philosophical Sciences, Associate Professor, Department of Preschool and Special Education, Educational and Scientific Institute of Pedagogical Education, Social Work and Art, Bohdan Khmelnytskyi Cherkasy National University, Cherkasy, Ukraine. stepanova76@ukr.net

³ PhD, Deputy Director for Academic and Research Affairs, Odesa military academy, Odesa, Ukraine. zeleniy.880218@ukr.net

⁴ PhD, Head of the Educational and Scientific Institute of Military Intelligence and Special Operations Forces, Odesa military academy, Odesa, Ukraine. koksix1@gmail.com

⁵ PhD, Head of Department of Management of Military Intelligence Units and Special Operations Forces, Odesa military academy, Odesa, Ukraine. rdeniro@gmail.com

Recibido: 05/05/26
Aceptado: 28/06/26

Cómo citar:

Kozub, H., Stepanova, N., Zelenyi, I., Shumkov, I., & Rudynskyi, V. (2026). Gamification as a tool for increasing student motivation in a digital educational environment. *Revista Eduweb*, 20(2), 308-321. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.18>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

El objetivo del estudio fue determinar la efectividad de la gamificación para incrementar la motivación estudiantil. La relevancia del estudio radicaba en la necesidad de aumentar la participación y la actividad de aprendizaje de los estudiantes en el contexto de la digitalización de la educación. El estudio se implementó en un formato cuasiexperimental utilizando un diseño pre-test/post-test con grupos no equivalentes (124 participantes). En el grupo experimental, se realizó una capacitación durante 8 semanas utilizando elementos de gamificación en un entorno digital. El análisis estadístico consistió en pruebas t, análisis de correlación y ANCOVA, que se utilizó para controlar las diferencias iniciales entre los grupos experimental y de control y para proporcionar una estimación más precisa del efecto de la intervención. Los resultados del estudio demostraron un incremento estadísticamente significativo en el nivel de motivación en el grupo experimental ($p < 0,001$) con un tamaño del efecto grande. También se estableció una relación positiva entre la intensidad del uso de la gamificación y el nivel de motivación ($r = 0,64$, $p < 0,001$). Las conclusiones destacan que la eficacia de la gamificación como herramienta para aumentar la motivación de los estudiantes se ha confirmado en general.

Palabras clave: educación superior, entorno educativo digital, gamificación, motivación estudiantil, tecnologías educativas.

Abstract

The purpose of the study was to determine the effectiveness of gamification to increase student motivation. The relevance of the study was due to the need to increase student engagement and learning activity in the context of the digitalization of education. The study was implemented in a quasi-experimental format using a pre-test/post-test design with non-equivalent groups (124 participants). In the experimental group, training took place for 8 weeks using gamification elements in a digital environment. Statistical analysis consisted of t-tests, correlation analysis, and ANCOVA, which was used to control for baseline differences between the experimental and control groups and to provide a more accurate estimate of the intervention effect. The results of the study demonstrated a statistically significant increase in the level of motivation in the experimental group ($p < 0.001$) with a large effect size. A positive relationship was also established between the intensity of gamification use and the level of motivation ($r = 0.64$, $p < 0.001$). The conclusions emphasize that the effectiveness of gamification as a tool for increasing student motivation has generally been confirmed.

Keywords: digital educational environment, educational technologies, gamification, higher education, student motivation.

Introduction

In the modern conditions of digitalization of university education, the issue of increasing student motivation has become particularly relevant. The active use of digital educational platforms in the educational process, distance and blended formats of classes has transformed traditional approaches to organizing education in higher education institutions, changed the features of interaction between teachers and students. At the same time, the digital environment did not always allow, as a result of the use of automation, to achieve a high level of student engagement. This feature indicated the importance of finding effective pedagogical tools to support educational motivation. One of such tools is gamification. This tool provided for the integration of game design elements into the educational process. The use of points, ratings, badges, levels, competitions and receiving instant feedback made it possible to increase interest in educational activities, stimulate active participation of students and form a positive experience of interaction of students with educational content. In the context of a digital educational environment, gamification has become a logical technological solution, but (together with appropriate pedagogical strategies) has been aimed at strengthening both intrinsic and extrinsic motivation.

Modern studies in the field of educational technology have confirmed that gamification has contributed to increasing the level of student engagement, improving learning outcomes and forming a more active position in learning (Aldalur & Perez, 2023; Camacho-Sánchez et al., 2023). At the same time, the results of such studies have indicated the existence of certain ambiguities and gaps. First of all, along with positive effects, scientists have noted the existence of certain contradictions and limitations. Special emphasis in this context is placed on the risk of dominance of external stimuli and a decrease in motivation in the long term (Papadakis & Karakose, 2025). In addition, the issues of the impact of gamification in the conditions of a complex digital educational environment, where different technological and pedagogical approaches are combined, have not been sufficiently studied.

Therefore, it has become relevant to conduct empirical research aimed at determining the role of gamification as a tool for increasing student motivation in a modern digital educational environment. Such a scientific vector is poorly represented in existing sources.

The purpose of the proposed study is to determine the impact of gamification on the level of student motivation in a digital educational environment. To confirm (or refute) the following research hypotheses were proposed:

H1. The use of gamification in a digital educational environment was statistically significant, increased the level of student learning motivation, if compared to traditional (non-gamified) approaches to learning.

H2. The level of student motivation was positively correlated with the intensity of use of gamification elements (points, badges, ratings, levels), which was manifested in increased involvement and activity in the educational process.

The paper is structured as follows. The first section presents the theoretical framework and an overview of previous research on gamification and student motivation in digital learning environments. The methodology section outlines the study design, participants, instruments, procedures, and statistical methods used for data analysis. The results section presents the empirical findings of the quasi-experimental study, including pre-/post-test comparisons, correlation analysis, and

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

ANCOVA results. The discussion section interprets the results in relation to previous research and highlights their pedagogical implications. The conclusions summarize the main findings and suggest directions for future research.

Literature Review

In modern studies of digital education, the problem of student motivation is considered as one of the key conditions for the effectiveness of the educational process. In particular, within the framework of the Self-Determination Theory, motivation was interpreted as a multidimensional phenomenon that was formed through the satisfaction of basic psychological needs (autonomy, competence, and social interaction) (Reiter, 2025; Ukgoda, 2025). In the context of digital learning, ensuring such needs was a difficult task that necessitated the search for new pedagogical approaches (Czerkawski, 2024).

One of such approaches was gamification, which spread in higher education as a tool for increasing student engagement. Conceptually, gamification was defined as the application of game design elements in non-game contexts, in particular in the educational process. A significant contribution to the development of this approach was made by scientists who emphasized that the effectiveness of gamification depended on its integration into the content of learning (Tolentino, 2025; Saritepeci & Yildiz Durak, 2024). That is, the use of individual game mechanics was one of the elements, and not an end in itself, of gamification.

Empirical studies have shown that gamification can have a positive impact on student motivation, engagement, and learning outcomes. In particular, Pozo-Sánchez et al. (2022) found that the use of game elements (scores, badges, ratings) increased student engagement and participation in the learning process. Similar findings have been confirmed in other studies that have considered gamification as an effective tool for stimulating learning behavior (Ertan & Arkün Kocadere, 2022).

However, there was no consensus among scholars on the effectiveness of gamification. Some studies have indicated that its impact was limited or context-dependent. In particular, Das et al. (2025) have emphasized that an excessive focus on external rewards could lead to a decrease in intrinsic motivation (especially when game mechanics are not related to the content of the learning). This was consistent with a broader discussion about the balance between intrinsic and extrinsic motivation in digital learning.

A separate area of research has focused on the impact of gamification on different components of motivation. Researchers noted that gamification was able to increase cognitive engagement, emotional interest and learning activity. However, the strength of such an impact could vary depending on the design of the educational environment. In this context, the importance of a comprehensive approach that combined gamification with other digital tools, primarily adaptive learning and personalization, was emphasized (Lampropoulos & Kinshuk, 2024).

At the same time, several important unresolved issues remain in the scientific literature. First, the impact of the intensity of gamification use on student motivation has not been sufficiently studied. Second, the number of empirical studies that analyzed gamification in the context of a complex digital educational environment (i.e., not from the perspective of an isolated tool) was limited. Third, the relationship between the individual components of motivation in gamified learning will need to be clarified.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Therefore, existing studies have confirmed the potential of gamification as a tool for increasing student motivation. However, the need for further empirical research aimed at clarifying the conditions for its effective application is also indicated.

Methodology

Research design

The study was conducted in a quasi-experimental format using a pre-test/post-test design with non-equivalent groups. This approach made it possible to compare the levels of students' learning motivation before and after the pedagogical intervention under the conditions of the real educational process without random assignment of participants to groups. The quasi-experimental design was chosen due to the impossibility of fully ensuring randomization of academic groups within a higher education institution. Another important aspect was the need to preserve the natural organization of learning.

Two groups were organized within the study. Within the experimental group, the learning process took place with the systematic use of gamification elements in a digital educational environment. Within the control group, learning was carried out using traditional digital models, that is, without the targeted introduction of gamification tools. Comparing the results of both groups made it possible to determine the impact of gamification on the level of student motivation.

Study participants

The study involved students of a higher education institution studying in bachelor's level programs. The total sample consisted of 124 students, of whom 62 were included in the experimental group and 62 in the control group. The selection of participants was carried out according to the principle of accessible sampling based on available academic groups. These academic groups were comparable in terms of course of study, specialty, teaching format and general conditions of the educational process.

Students aged 18 to 22 years were included in the study. The following inclusion criteria were applied: regular participation in classes, access to a digital educational platform, consent to participate in the study and completion of both stages of measurement. Students who did not complete the full cycle of the study or missed the final survey were not to be included in the final analysis (such cases were not recorded).

To minimize initial differences between the groups, a preliminary test of the level of motivation was carried out at the start of the study. Such a test made it possible to check their relative comparability before the intervention began.

Educational intervention

The pedagogical intervention took place over 8 weeks and was implemented within the framework of an academic discipline in a digital educational environment. In the experimental group, a set of gamification elements was identified that were integrated into the structure of the educational process. This set included:

scoring points for completing educational tasks;
digital badges for achieving individual stages;
rating tables;

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

level promotion system;
short-term educational challenges;
instant digital feedback;
visualization of student progress.

Therefore, the proposed tools were aimed at increasing interest among students, increasing involvement in completing tasks, and forming more active participation in the digital educational environment.

Within the control group, the educational process was also carried out using digital platforms, although special gamification mechanisms were not used. Students received standard educational materials, tasks, instructions, and regular feedback from the teacher.

Research tools

A structured questionnaire on learning motivation of students was used to collect empirical data. This instrument was formed from 20 statements that were combined into four content subscales:

1. Cognitive involvement.
2. Emotional interest.
3. Learning activity.
4. Perception of the value of learning activities.

The answers were recorded on a five-point Likert scale:

1. Completely disagree;
2. Rather disagree;
3. Difficult to answer;
4. Rather agree;
5. Completely agree.

Higher scores indicated a higher level of learning motivation.

In addition to the main questionnaire, data from the digital platform were used to analyze behavioral indicators. Information on the frequency of logins to the system, the number of completed tasks, activity in completing modules, and the timeliness of completing learning tasks was used.

Such additional indicators were important for indirectly verifying motivational dynamics and confirming self-assessment results.

In addition to the analysis of behavioral indicators, the integral value of the intensity of gamification use was determined to test hypothesis H2. This indicator was calculated based on four behavioral metrics obtained from the digital platform: frequency of logins to the system; number of completed tasks; activity in completing educational modules; timeliness of completing educational tasks.

Each of the indicated indicators was normalized to a single scale (from 0 to 1), after which the integral index of gamification intensity was calculated as the arithmetic mean of standardized values. Higher index values indicated a higher level of student interaction with gamified elements of the educational environment.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

This integral indicator was used in Pearson correlation analysis to determine the relationship between the intensity of gamification and the level of students' learning motivation.

Reliability and validity of the instruments

To check the internal consistency of the questionnaire, Cronbach's α coefficient was used. The overall reliability value of the scale was $\alpha = 0.88$. Therefore, this indicator indicated a high level of internal consistency of the instrument. For individual subscales, the Cronbach's α value was within the range of 0.79 to 0.85, which also indicated acceptable or high reliability (See Table 1).

Table 1.

Internal consistency indicators of the learning motivation scale

Subscale	Number of points (n)	α Cronbach's
Cognitive engagement	5	0.82
Emotional interest	5	0.85
Learning activity	5	0.79
Perception of learning value	5	0.83
Total scale	20	0.88

The content validity of the instruments was ensured through expert evaluation. Three experts in the field of pedagogy, digital education and educational measurements were involved in this procedure, who assessed the compliance of the statements with the research purpose, their clarity and relevance for measuring learning motivation in a digital educational environment.

Construct validity was primarily assessed by analyzing the structure of the instrument and the consistency between its subscales. Correlation analysis between subscales indicated logically expected positive relationships, which confirmed the conceptual integrity of the measurement model.

Before conducting the main stage of the study, the instrument was tested on a small pilot group of education seekers ($n = 20$). This made it possible to refine the wording of individual statements and increase the clarity of the questionnaire.

Procedure

The study was conducted in three consecutive stages.

During the first stage, pre-testing of participants in both groups was carried out to determine the initial level of motivation. All students completed a questionnaire before the start of the pedagogical intervention.

In the second stage, training using gamification elements in a digital environment was implemented in the experimental group for eight weeks. For the control group, training continued in the usual format (i.e., targeted gamification was not applied).

In the third stage, after the intervention, the level of motivation was re-measured in both groups (the same questionnaire was used again for this). The obtained pre-test and post-test results were compared to determine changes within each group and intergroup differences.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Statistical analysis methods

Empirical data processing was performed using descriptive and inferential statistics. At the first stage, mean values (M), standard deviations (SD), minimum and maximum values for the main motivation indicators were calculated.

Cronbach's α coefficient was used to check the internal consistency of the scale. The normality of data distribution was assessed using the Shapiro-Wilk test. If the conditions of parametric analysis were met, the following were used:

Student's paired t-test - to compare pre-test and post-test indicators within the same group;

Student's independent t-test - to compare the results of the experimental and control groups;

ANCOVA - to assess the impact of the intervention on the final motivation indicators with the control of the initial level of motivation;

Pearson correlation analysis - to identify the relationship between the intensity of use of gamification elements and the level of motivation of students.

To assess the practical significance of the results, the effect size (Cohen's d) was additionally calculated. A value of 0.20 was interpreted as a small effect, 0.50 as a medium effect, and 0.80 and above as a large effect.

Testing the normality of the data distribution using the Shapiro-Wilk test demonstrated that most of the indicators of academic motivation did not have statistically significant deviations from normal distribution ($p > 0.05$). In some cases, minor deviations from normality were recorded, which is typical for educational research using Likert scales. At the same time, given the sample size ($n = 62$ in each group), the use of parametric methods (Student's t-test and ANCOVA) was justified, since according to the central limit theorem, such methods are resistant to moderate violations of the normality of the distribution.

Ethical aspects

Student participation in the study was voluntary. Before data collection began, all participants were informed about the purpose of the study, its educational and scientific nature, the confidentiality of the results, and the right to refuse participation at any stage without negative consequences. The participants' personal data were not disclosed, and the results were analyzed in a generalized form.

Results and Discussion

Results

At the first stage of the analysis, descriptive statistics of the indicators of students' learning motivation in the control and experimental groups before (pre-test) and after (post-test) pedagogical intervention were obtained (See Table 2).

Table 2.

Dynamics of students' motivation level ($M \pm SD$)

Group	Pre-test ($M \pm SD$)	Post-test ($M \pm SD$)
Experimental ($n=62$)	3.52 ± 0.48	4.18 ± 0.46
Control ($n=62$)	3.49 ± 0.50	3.62 ± 0.52

Source: Author's development

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Analysis of the obtained data established that at the beginning of the study, both groups were characterized by practically the same levels of motivation ($M = 3.52$ in the experimental group and $M = 3.49$ in the control group). This confirmed the absence of statistically significant differences at the start of the experiment and ensured the correctness of further comparison.

After the completion of the pedagogical intervention, a significant increase in the average value of motivation was determined within the experimental group ($\Delta M = +0.66$). In contrast, the increase in the control group was significantly smaller ($\Delta M = +0.13$). This indicated the existence of pronounced positive dynamics under the conditions of gamification.

In addition, the decrease in the standard deviation in the experimental group (from 0.48 to 0.46) indicated a certain leveling of the level of motivation among students. Therefore, the gamified environment had a stabilizing effect.

To test hypothesis H1, a paired Student's t-test was used. This approach allowed us to assess the statistical significance of changes within each group (See Table 3).

Table 3.
Paired t-test results (pre-test vs post-test)

Group	t	p	Cohen's d
Experimental	8.74	<0.001	1.12
Control	1.98	0.052	0.25

Source: Author's development

The results of the analysis showed that in the experimental group there was a statistically significant increase in the level of motivation ($t = 8.74$, $p < 0.001$). The value of the Cohen's d coefficient = 1.12 indicated a significant effect size, which confirmed both the statistical and practical significance of the results obtained.

In the control group, the changes did not reach statistical significance ($p = 0.052$). Therefore, this gave grounds for the statement that standard digital learning without gamification elements had no significant impact on student motivation.

Thus, the results of the pairwise analysis confirmed that it was gamification that became the key factor in increasing motivation (i.e., not only the fact of using the digital educational environment). Additionally, a between-group comparison of post-test results was conducted (See Table 4).

Table 4.
Comparison of experimental and control groups (post-test)

Indicator	Experimental group ($M \pm SD$)	Control group ($M \pm SD$)	t	p
General level of motivation	4.18 ± 0.46	3.62 ± 0.52	5.87	<0.001

Source: Author's development

The average motivation value in the experimental group was 4.18 ± 0.46 , and in the control group, 3.62 ± 0.52 . The results of the independent t-test showed that this difference was statistically significant ($t = 5.87$; $p < 0.001$). This gave grounds for the statement that the use of gamification in the digital educational environment

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

contributed to a more pronounced increase in student motivation (when compared to the traditional digital learning format).

To more accurately assess the impact of the pedagogical intervention, considering the initial level of motivation, an ANCOVA test was used, where the post-test motivation indicators acted as the dependent variable, the group (experimental/control) as the independent variable, and the pre-test results as the covariate. The ANCOVA results showed a statistically significant effect of group affiliation on the final level of motivation after controlling for initial values ($F(1, 121) = 34.52, p < 0.001, \eta^2 = 0.22$). This indicated a significant impact of the use of gamification on increasing students' learning motivation.

To test hypothesis H2, a Pearson correlation analysis was conducted. This allowed us to determine the relationship between the intensity of gamification and student motivation indicators (Table 5). The analysis indicated moderate to strong positive correlations between the intensity of gamification and all motivation dimensions. The strongest relationships were observed with learning activity ($r = 0.64, p < 0.01$) and general motivation ($r = 0.64, p < 0.01$).

Table 5.
Correlation between gamification and motivation

Variables	1	2	3	4	5
1. Gamification intensity	1				
2. Cognitive engagement	0.58**	1			
3. Emotional interest	0.61**	0.66**	1		
4. Learning activity	0.64**	0.69**	0.71**	1	
5. Overall level of motivation	0.64**	0.74**	0.76**	0.79**	1

Source: Author's development

Note: $p < 0.01$

The proposed results showed that the increase in the intensity of the use of gamification mechanics was accompanied by an increase in individual components of motivation and its overall level. This made it possible to assert that gamification had a systemic impact on the motivational sphere of students. Therefore, hypothesis H2 was also confirmed.

Discussion

The obtained results of the study demonstrated that gamification was an effective tool for increasing students' motivation in a digital educational environment. A significant increase in the level of motivation in the experimental group was recorded, and the significant effect size indicated that the impact of gamification went beyond statistical significance and had a pronounced pedagogical meaning.

The interpretation of the obtained results could be carried out through the prism of modern motivational theories, particularly the Self-Determination Theory (de la Cruz-Campos et al., 2022; Saleem et al., 2021). According to this approach, motivation usually increased under the conditions of satisfying basic psychological needs, to which the researchers noted autonomy, competence and social interaction (Ramírez-Donoso et al., 2021). The gamification elements introduced in the study (levels, badges, feedback, visualization of progress) were directly related to increasing the sense of competence and control over one's own learning (Shatila et al., 2024; Rincon-Flores et al., 2021). Presumably, this led to a positive dynamic of motivation.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The proposed results are consistent with modern empirical studies and meta-analyses, which have recorded a consistently positive (moderate) effect of the influence of gamification on student motivation and engagement. However, most researchers have emphasized the significant variability of the results, depending on the context, intervention design and sample characteristics (Camacho-Sánchez et al., 2022; Kardoyo et al., 2020). Against this background, the large effect obtained in our study may indicate that the key factor was not the fact of using gamification itself. More importantly, its systematic and integrated use in the pedagogical process.

Of particular note were the results of the correlation analysis, which indicated that the intensity of the use of gamification elements was associated with both the general level of motivation and its individual components - cognitive involvement, emotional interest and learning activity (Campillo-Ferrer et al., 2020; García-López et al., 2023; Serna Gómez et al., 2021). This made it possible to interpret gamification as a tool for a comprehensive impact on the motivational structure of the student's personality (along with its definition as a local stimulating mechanism).

At the same time, the results obtained required critical reflection in the light of discussions that were presented in the scientific literature. In particular, a significant part of the researchers indicated that gamification often activated external motivation to a greater extent than internal (Li et al., 2023; Ratinho & Martins, 2023; Turchyn et al., 2023). In this context, an increase in the level of motivation was recorded, which in the proposed results could be partially due to the effect of rewards, competition and achievements, a profound change in students' attitude towards learning.

Another important aspect is the problem of the durability of the effect. Several studies have shown that the positive effects of gamification wane over time due to habituation or loss of novelty (Ivarson et al., 2024; Sadovets et al., 2022). In our case, the intervention was of limited duration, which could have amplified the observed effect. This meant that the results obtained reflected rather the short-term effectiveness of gamification. It is probably premature to speak about its stable long-term effect (Jaramillo-Mediavilla et al., 2024; Navarro-Espinosa et al., 2022; Boichenko et al., 2023).

In addition, it is worth considering that the effectiveness of gamification largely depended on the quality of its pedagogical design (Ansar & George, 2022). Studies have shown that the mechanical addition of game elements did not guarantee a positive result and could even reduce motivation in the event of overload or formalization of the learning process (Alrashedi et al., 2024; Alt, 2023). In the proposed results, the positive effect was probably associated with the consistency of gamification elements with learning objectives and their integration into the course structure.

Therefore, the results of the study confirmed that gamification was an effective tool for increasing student motivation. However, its impact was not universal and depended on a number of factors: intensity of use, quality of design, duration of implementation, and educational context.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Study Limitations

Despite the results obtained, the study had a number of limitations. First, the use of a quasi-experimental design without randomization reduced the possibility of unambiguously establishing cause-and-effect relationships. There was a significant possibility of the influence of uncontrolled variables, in particular, the peculiarities of group dynamics or individual characteristics of students.

Second, the study was conducted within a single higher education institution, which limited the possibility of generalizing the results. Third, the duration of the intervention was limited to 8 weeks, which did not allow assessing the long-term stability of the gamification effect.

Conclusions

The article determined the impact of gamification as a pedagogical tool on the level of motivation of students in a digital educational environment. Based on the conducted quasi-experimental study, it was found that the introduction of gamification elements into the educational process provided a statistically significant increase in student motivation compared to traditional digital learning.

The results obtained confirmed the hypothesis of a positive impact of gamification on motivation. This was manifested in particular in a significant increase in indicators in the experimental group and a large effect size. Additionally, a positive relationship was found between the intensity of use of gamification mechanics and the level of motivation. This process demonstrated the systemic nature of the impact of gamification on the motivational sphere of students.

The scientific novelty of the study consisted in a comprehensive empirical substantiation of the effectiveness of gamification in a digital educational environment, taking into account the general level of motivation and its individual structural components. The results obtained expanded modern ideas about the role of gamification - a kind of tool of pedagogical influence. The conditions for its effective application were also specified.

The practical significance of the conducted research was the possibility of using gamification as a tool for increasing student motivation in higher education institutions. The results showed that the most effective was the systematic implementation of gamification elements integrated into the course structure. Their fragmented use was a destructive phenomenon. This can be useful for the modernization of digital educational platforms, the development of training courses and the implementation of innovative pedagogical approaches.

The prospects for further research are primarily related to the study of the long-term impact of gamification on the motivation of education seekers. Also promising were the analysis of individual gamification mechanics, research into the interaction of gamification with other digital educational technologies, personalization of learning and the use of artificial intelligence.

Bibliographic references

Alrashedi, N. T., Najmi, A. H., & Alhalafawy, W. S. (2024). Utilising Gamification to Enhance Ambition on Digital Platforms: An Examination of Faculty

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Members' Perspectives in Times of Crisis. *Journal of Ecohumanism*, 3(8). <https://doi.org/10.62754/joe.v3i8.5003>
- Alt, D. (2023). Assessing the benefits of gamification in mathematics for student gameful experience and gaming motivation. *Computers & Education*, 104806. <https://doi.org/10.1016/j.compedu.2023.104806>
- Ansar, M., & George, G. (2022). Gamification in Education and Its Impact on Student Motivation – A Critical Review. In *Lecture Notes in Networks and Systems* (pp. 161–170). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-2940-3_11
- Boichenko, M., Churychkanych, I., Kulichenko, A., Shramko, R., & Rakhno, M. (2023). Mind maps to boost the learning of English as L2 at higher education institutions in Ukraine. *Amazonia Investiga*, 12(70), 229–240. <https://doi.org/10.34069/AI/2023.70.10.21>
- Czerkawski, B. (2024). AI and the Learning Experience Design: From Divergent Creativity to Convergent Precision. *TechTrends*, 69, 260–270. <https://doi.org/10.1007/s11528-024-01032-2>
- Camacho-Sánchez, R., Rillo-Albert, A., & Lavega-Burgués, P. (2022). Gamified Digital Game-Based Learning as a Pedagogical Strategy: Student Academic Performance and Motivation. *Applied Sciences*, 12(21), 11214. <https://doi.org/10.3390/app122111214>
- Camacho-Sánchez, R., Serna Bardavío, J., Rillo-Albert, A., & Lavega-Burgués, P. (2023). Enhancing motivation and academic performance through gamified digital game-based learning methodology using the ARCS model. *Interactive Learning Environments*, 32(10), 6868–6885. <https://doi.org/10.1080/10494820.2023.2294762>
- Campillo-Ferrer, J.-M., Miralles-Martínez, P., & Sánchez-Ibáñez, R. (2020). Gamification in Higher Education: Impact on Student Motivation and the Acquisition of Social and Civic Key Competencies. *Sustainability*, 12(12), 4822. <https://doi.org/10.3390/su12124822>
- Das, S., Vaishnavi Nakshatram, S., Söbke, H., Baalsrud Hauge, J., & Springer, C. (2025). Towards gamification for spatial digital learning environments. *Entertainment Computing*, 52, 100893. <https://doi.org/10.1016/j.entcom.2024.100893>
- de la Cruz-Campos, J.-C., Pozo-Sánchez, S., Berral-Ortiz, B., & Alonso-García, S. (2022). Gamification. In *Advances in Game-Based Learning* (pp. 119–141). IGI Global. <https://doi.org/10.4018/978-1-6684-5240-0.ch008>
- Ertan, K., & Arkün Kocadere, S. (2022). Gamification design to increase motivation in online learning environments: A systematic review. *Journal of Learning and Teaching in Digital Age.*, 7(2), 151-159. <https://doi.org/10.53850/joltida.1020044>
- García-López, I. M., Acosta-Gonzaga, E., & Ruiz-Ledesma, E. F. (2023). Investigating the Impact of Gamification on Student Motivation, Engagement, and Performance. *Education Sciences*, 13(8), 813. <https://doi.org/10.3390/educsci13080813>
- Ivarson, E., Erlandsson, V., Faraon, M., & Khatib, S. (2024). Augmented reality and gamification in higher education: Designing mobile interaction to enhance students' motivation and learning. *E-Learning and Digital Media*, 22(6), 571-590. <https://doi.org/10.1177/20427530241239981>
- Jaramillo-Mediavilla, L., Basantes-Andrade, A., Cabezas-González, M., & Casillas-Martín, S. (2024). Impact of Gamification on Motivation and Academic Performance: A Systematic Review. *Education Sciences*, 14(6), 639. <https://doi.org/10.3390/educsci14060639>
- Kardoyo, Nurkhin, A., Muhsin, & Pramusinto, H. (2020). Problem-based learning strategy: its impact on students' critical and creative thinking

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- skills. *European Journal of Educational Research*, 9(3), 1141-1150. <https://doi.org/10.12973/eu-jer.9.3.1141>
- Lampropoulos, G., & Kinshuk. (2024). Virtual reality and gamification in education: a systematic review. *Educational technology research and development*, 72, 1691–1785. <https://doi.org/10.1007/s11423-024-10351-3>
- Li, M., Ma, S., & Shi, Y. (2023). Examining the effectiveness of gamification as a tool promoting teaching and learning in educational settings: a meta-analysis. *Frontiers in Psychology*, 14. <https://doi.org/10.3389/fpsyg.2023.1253549>
- Navarro-Espinosa, J. A., Vaquero-Abellán, M., Perea-Moreno, A.-J., Pedrós-Pérez, G., Martínez-Jiménez, M. d. P., & Aparicio-Martínez, P. (2022). Gamification as a Promoting Tool of Motivation for Creating Sustainable Higher Education Institutions. *International Journal of Environmental Research and Public Health*, 19(5), 2599. <https://doi.org/10.3390/ijerph19052599>
- Papadakis, S., & Karakose, T. (2025). Gamification and Student Achievement: Potential Benefits, Limitations, and Effective Use in Educational Environments. *Educational Process International Journal*, 19(1). <https://doi.org/10.22521/edupij.2025.19.529>
- Pozo-Sánchez, S., Lampropoulos, G., & López-Belmonte, J. (2022). Comparing Gamification Models in Higher Education Using Face-to-Face and Virtual Escape Rooms. *Journal of New Approaches in Educational Research*, 11(2), 307. <https://doi.org/10.7821/naer.2022.7.1025>
- Ramírez-Donoso, L., Pérez-Sanagustín, M., Neyem, A., Alario-Hoyos, C., Hilliger, I., & Rojos, F. (2021). Fostering the use of online learning resources: results of using a mobile collaboration tool based on gamification in a blended course. *Interactive Learning Environments*, 31(3), 1564–1578. <https://doi.org/10.1080/10494820.2020.1855202>
- Ratinho, E., & Martins, C. (2023). The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review. *Heliyon*, 9(8), 19033. <https://doi.org/10.1016/j.heliyon.2023.e19033>
- Reiter, M. (2025). Gamification in Education: Effectiveness and Impact on Student Motivation. *Acta Educationis Generalis*, 15(s1), 38–51. <https://doi.org/10.2478/atd-2025-0013>
- Rincon-Flores, E. G., & Santos-Guevara, B. N. (2021). Gamification during Covid-19: Promoting active learning and motivation in higher education. *Australasian Journal of Educational Technology*, 37(5), 43–60. <https://doi.org/10.14742/ajet.7157>
- Sadovets, O., Martynyuk, O., Orlovska, O., Lysak, H., Korol, S., & Zembytska, M. (2022). Gamification in the Informal Learning Space of Higher Education (in the Context of the Digital Transformation of Education). *Postmodern Openings*, 13(1), 330–350. <https://doi.org/10.18662/po/13.1/399>
- Saleem, A. N., Noori, N. M., & Ozdamli, F. (2021). Gamification Applications in E-learning: A Literature Review. *Technology, Knowledge and Learning*, 27, 139–159. <https://doi.org/10.1007/s10758-020-09487-x>
- Saritepeci, M., & Yildiz Durak, H. (2024). Effectiveness of artificial intelligence integration in design-based learning on design thinking mindset, creative and reflective thinking skills: An experimental study. *Education and Information Technologies*, 29, 25175–25209. <https://doi.org/10.1007/s10639-024-12829-2>
- Serna Gómez, J. H., Díaz-Piraquive, F. N., Muriel-Perea, Y. d. J., & Díaz Peláez, A. (2021). Advances, Opportunities, and Challenges in the Digital Transformation of HEIs in Latin America. In *Radical Solutions for Digital Transformation in Latin American Universities* (pp. 55–75). Springer Singapore. https://doi.org/10.1007/978-981-16-3941-8_4

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

- Shatila, K., Martínez-Climent, C., Enri-Peiró, S., & Perez-Ruiz, P. (2024). The impact of gamification on academic performance: the case of digital marketing in Lebanon. *European Journal of Innovation Management*, 28(8), 4061–4082. <https://doi.org/10.1108/ejim-04-2024-0411>
- Tolentino, A. P. (2025). Digital Gamification: Benefits and Challenges in Education. *International Journal of Information and Education Technology*, 15(5), 902–911. <https://doi.org/10.18178/ijiet.2025.15.5.2296>
- Turchyn, I., Zaitseva, S., Rudenko, N., Saienko, V., Kuzemko, N., & Denefil, O. (2023). Using distance learning models as opportunities for blended learning for foreigners. *Revista Romaneasca Pentru Educatie Multidimensionala*, 15(4), 178–191. <https://doi.org/10.18662/rrem/15.4/787>
- Ukgoda, H. (2025). Gamification in Education: Its Impact on Engagement, Motivation, and Learning Outcomes. *Journal of Educational Technology Development and Exchange*, 18(3), 41–66. <https://doi.org/10.18785/jetde.1803.03>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Desarrollo de competencias innovadoras entre futuros especialistas en cultura física y deportes a través de la formación digital y orientada a STEAM

Innovative competence development among future physical culture and sports specialists through digital and STEAM-oriented training

Halyna Bezverkhnia¹ Hryhoriy Khomyak² Viktoriia Tsybulska³ Ihor Kravchenko⁴ Serhii Mishyn⁵

Afiliación autor:

¹ Candidate of Sciences in Physical Education and Sports, Professor, Professor of the Department of Physical Education and Sports, Uman National University, Ukraine.

bezverxnyagv@gmail.com

² PhD in Pedagogical Science, Department of Physical Culture, Sports and Exercise Methods, Berdyansk State Pedagogical University, Ukraine.

hryhoriy.khomyak@gmail.com

³ Candidate of Sciences in Physical Education and Sports, Associate Professor, Associate Professor of the Department of Sports Disciplines, Bogdan Khmelnytsky Melitopol State Pedagogical University, Ukraine.

vikavdpv@ukr.net

⁴ Senior Lecturer of the Department of the Theory and Methods of Sport, Sumy State Pedagogical University named after A. S. Makarenko, Ukraine.

⁵ Candidate of Pedagogical Sciences, Associate Professor, Associate Professor of the Department of Physical Education and Recreation and Health Work, Volodymyr Vynnychenko Central Ukrainian State University, Ukraine.

segor251986@gmail.com

Recibido: 16/04/26

Aceptado: 09/06/26

Cómo citar:

Bezverkhnia, H., Khomyak, H., Tsybulska, V., Kravchenko, I., & Mishyn, S. (2026). Innovative competence development among future physical culture and sports specialists through digital and STEAM-oriented training. *Revista Eduweb*, 20(2), 322-338.
<https://doi.org/10.46502/issn.1856-7576/2026.20.02.19>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

El desarrollo de la competencia innovadora entre los futuros especialistas en cultura física y deportes se ha convertido en una prioridad en el contexto de la transformación digital y la modernización de la educación superior. El propósito de este estudio fue evaluar la efectividad de un sistema educativo digital y orientado a STEAM diseñado para fomentar la competencia innovadora en futuros profesionales. Se empleó un diseño de investigación cuasiexperimental con 220 estudiantes de cultura física y deportes, divididos en un grupo experimental (n = 110) y un grupo de control (n = 110). La intervención incluyó la implementación de tecnologías educativas digitales, aprendizaje orientado a STEAM, actividades basadas en proyectos y la creación de un entorno educativo innovador. La competencia innovadora se evaluó según criterios motivacionales, cognitivos y basados en la actividad. Los datos se recopilaban mediante cuestionarios, pruebas, entrevistas, observaciones y análisis del rendimiento académico. La significancia estadística se verificó mediante la prueba χ^2 de Pearson. Los resultados demostraron niveles considerablemente más altos de competencia innovadora entre los estudiantes del grupo experimental. El 58,9 % de los participantes alcanzó un alto nivel de competencia según el criterio motivacional, el 59,9 % según el criterio cognitivo y el 67,9 % según el criterio de actividad, en comparación con el 28,2 %, el 29,2 % y el 29,2 % del grupo de control, respectivamente. La prueba χ^2 de Pearson confirmó diferencias estadísticamente significativas entre los grupos. Los resultados indican que las condiciones pedagógicas propuestas potencian eficazmente la competencia innovadora y apoyan la modernización de la formación profesional de los futuros especialistas en cultura física y deporte.

Palabras clave: Competencia innovadora, futuros especialistas en cultura física y deportes, digitalización, recursos digitales, enfoque STEAM.

Abstract

The development of innovative competence among future specialists in physical culture and sports has become a priority in the context of digital transformation and modernization of higher education. The purpose of this study was to evaluate the effectiveness of a digital and STEAM-oriented educational system designed to foster innovative competence in future professionals. A quasi-experimental research design was employed involving 220 students of physical culture and sports, divided into an experimental group (n = 110) and a control group (n = 110). The intervention included the implementation of digital educational technologies, STEAM-oriented learning, project-based activities, and the creation of an innovative educational environment. Innovative competence was assessed according to motivational, cognitive, and activity-based criteria. Data were collected through questionnaires, testing,

interviews, observations, and academic performance analysis. Statistical significance was verified using Pearson's χ^2 test. The results demonstrated considerably higher levels of innovative competence among students in the experimental group. High-level competence was achieved by 58.9% of participants according to the motivational criterion, 59.9% according to the cognitive criterion, and 67.9% according to the activity criterion, compared with 28.2%, 29.2%, and 29.2% in the control group, respectively. Pearson's χ^2 test confirmed statistically significant differences between the groups. The findings indicate that the proposed pedagogical conditions effectively enhance innovative competence and support the modernization of professional training for future specialists in physical culture and sports.

Keywords: innovative competence, future specialists in physical culture and sports, digitalization, digital resources, STEAM approach.

Introduction

The rapid digital transformation of contemporary society is substantially changing the requirements for professional training in higher education. Future specialists in physical culture and sports are expected not only to possess advanced disciplinary knowledge and practical skills but also to demonstrate innovative competence, adaptability, creativity, and the ability to effectively apply digital technologies in professional practice. These requirements are reinforced by the increasing integration of digital tools, data-driven decision-making, virtual learning environments, and interdisciplinary educational approaches into physical education and sports training (Jurat et al., 2024).

Recent studies have highlighted the importance of innovative educational practices in developing professional competencies among future physical education specialists. Research has demonstrated the positive effects of competency-based learning, flipped classroom models, active learning strategies, and digital technologies on students' professional development and learning outcomes (Ghorbel et al., 2025; Cáceres & Contreras Mu, 2025). Similarly, studies on adventure education, game-based learning, and immersive technologies have shown their potential to enhance students' engagement, critical thinking, and pedagogical competencies (González-Rivas et al., 2024; Maquera-Maquera et al., 2024). Furthermore, the growing adoption of STEAM-oriented approaches has created new opportunities for integrating interdisciplinary knowledge, creativity, and innovation into professional education.

Despite these advances, existing research primarily focuses on individual instructional methods, digital tools, or specific educational technologies. Much less attention has been devoted to the comprehensive formation of innovative competence as an integrated professional characteristic of future specialists in physical culture and sports. In particular, insufficient evidence exists regarding which pedagogical conditions, educational environments, and instructional mechanisms most effectively contribute to the systematic development of innovative competence within higher education programs.

This gap in the literature reveals an important scientific problem: although innovative competence is increasingly recognized as a key outcome of professional preparation, there remains limited empirical evidence concerning the effectiveness of comprehensive pedagogical systems that combine digital technologies, STEAM-oriented learning, innovative teaching methods, and project-based activities in the training of future specialists in physical culture and sports.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Accordingly, the study was guided by the following research question:

RQ: To what extent does the implementation of a digital and STEAM-oriented system of pedagogical conditions contribute to the development of innovative competence among future specialists in physical culture and sports compared with traditional educational approaches?

The purpose of this study was to evaluate the effectiveness of a system of pedagogical conditions designed to foster innovative competence among future specialists in physical culture and sports through the integration of digital technologies, STEAM-oriented learning, and innovative educational practices.

The scientific novelty of the study lies in the development and experimental validation of a comprehensive pedagogical system that integrates digital educational technologies, STEAM-oriented learning, project-based activities, and an innovative educational environment for the systematic development of innovative competence among future specialists in physical culture and sports. Unlike previous studies that examined isolated educational innovations, this research evaluates their combined impact within a unified pedagogical framework.

This study contributes to the growing body of research on innovation in higher education by providing empirical evidence regarding effective strategies for developing innovative competence and modernizing professional training in the field of physical culture and sports.

Literature Review

The increasing digitalization of higher education has intensified scholarly interest in innovative approaches to the professional preparation of future specialists in physical culture and sports. Contemporary research consistently demonstrates that educational innovation contributes to the development of professional competencies, learner autonomy, and adaptability in rapidly changing professional environments. However, the concept of innovative competence remains insufficiently theorized and operationalized within the field of physical culture and sports education.

A considerable body of research has examined the effectiveness of active and student-centered learning methodologies. For example, Ghorbel et al. (2025) and Cáceres & Contreras Mu (2025) reported that flipped classroom approaches positively influence students' independence, critical thinking, and professional skills development. González-Rivas et al. (2024) demonstrated the pedagogical value of game-based and adventure-based learning in fostering engagement and competency acquisition. Although these studies provide evidence for the effectiveness of specific instructional strategies, they primarily evaluate isolated pedagogical interventions rather than their contribution to the broader development of innovative competence as an integrated professional characteristic.

Another important research direction concerns the role of digital technologies in professional education. Maquera-Maquera et al. (2024) emphasized the potential of immersive technologies to enrich educational experiences and support competency development. Likewise, Gorozidis et al. (2020) demonstrated that digital collaborative environments can enhance professional learning and knowledge exchange among physical education practitioners. However, the findings also indicate that technological innovation alone does not automatically improve

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

educational outcomes. Its effectiveness depends on pedagogically meaningful integration, instructional design, and learner engagement. Consequently, digital competence should be viewed as only one component of a broader innovative competence framework.

Recent studies have increasingly highlighted the importance of interdisciplinary and STEAM-oriented approaches in higher education. According to Leão Pereira et al. (2025), innovative educational practices should promote not only professional knowledge acquisition but also creativity, problem-solving abilities, learner autonomy, and authentic engagement with real-world challenges. This perspective aligns with the growing recognition that innovation competence requires the integration of cognitive, motivational, and behavioral dimensions rather than the mastery of technological tools alone. Nevertheless, empirical investigations rarely examine how these dimensions interact within a unified educational system. Özer et al. (2024) demonstrated the effectiveness of gymnastics activities in improving students' physical development, thereby supporting the integration of innovative, practice-oriented approaches into professional training programs.

The concept of innovative competence itself remains subject to different interpretations in educational research. Existing literature generally associates innovative competence with the ability to generate new ideas, apply creative solutions, adapt to changing professional conditions, effectively use emerging technologies, and engage in continuous professional development. From a competency-based perspective, innovative competence can be understood as an integrated personal and professional quality that combines motivation for innovation, knowledge of innovative practices, and the capacity to implement them in real professional contexts. This multidimensional nature suggests that innovative competence encompasses motivational, cognitive, and activity-related components that function in close interaction.

Despite the growing number of studies addressing innovative teaching methods, digital technologies, and competency-based education, several limitations remain evident. First, most investigations focus on individual educational innovations rather than comprehensive pedagogical systems. Second, the relationship between digitalization, STEAM-oriented learning, and innovative competence development remains insufficiently explored. Third, there is limited empirical evidence regarding the pedagogical conditions that facilitate the systematic formation of innovative competence among future specialists in physical culture and sports.

Therefore, the current literature demonstrates a clear research gap. While previous studies have confirmed the educational value of specific innovative methodologies and technologies, insufficient attention has been paid to the comprehensive development of innovative competence as an integrated outcome of professional training. In particular, there is a lack of empirical research examining the effectiveness of pedagogical systems that combine digital technologies, STEAM-oriented learning, project-based activities, and an innovative educational environment within a unified framework.

Addressing this gap, the present study investigates the effectiveness of a comprehensive system of pedagogical conditions designed to foster innovative competence among future specialists in physical culture and sports. Unlike previous studies that analyzed separate educational innovations, this research evaluates their combined influence on the motivational, cognitive, and activity-related dimensions of innovative competence.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Methodology

Research Design

This study employed a quasi-experimental research design to evaluate the effectiveness of a system of pedagogical conditions aimed at developing innovative competence among future specialists in physical culture and sports. The research was conducted in three consecutive stages: ascertaining, formative, and evaluative. At the ascertaining stage, the initial levels of innovative competence were identified and compared between groups. During the formative stage, the proposed pedagogical system was implemented in the Experimental Group, while the Control Group continued learning according to traditional educational approaches. At the evaluative stage, repeated measurements were conducted to assess changes in competence levels and determine the effectiveness of the intervention.

Participants

The study involved 220 undergraduate students enrolled in physical culture and sports programmes at higher education institutions. Participants were assigned to an Experimental Group (EG, $n = 110$) and a Control Group (CG, $n = 110$). The groups were comparable in terms of educational background and initial levels of innovative competence, which was confirmed during the ascertaining stage of the experiment.

Participation in the study was voluntary. All respondents were informed about the objectives of the research and agreed to participate anonymously. Confidentiality and ethical standards of educational research were strictly maintained throughout the study.

Assessment Framework

Innovative competence was considered an integrated professional characteristic comprising three interrelated dimensions: motivational, cognitive, and activity-based.

The motivational criterion reflected students' interest in innovation, willingness to engage in professional self-development, readiness to implement innovative approaches, and positive attitudes toward educational change.

The cognitive criterion assessed knowledge of innovative educational technologies, digital tools, STEAM-oriented learning approaches, pedagogical innovations, and contemporary professional practices in physical culture and sports.

The activity-based criterion evaluated the ability to apply innovative methods in practical situations, participate in project activities, use digital technologies effectively, solve professional problems creatively, and implement innovative solutions in educational and sports contexts.

Based on the assessment results, participants were classified into three levels of innovative competence formation: high, average, and low.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Research Instruments

To ensure a comprehensive assessment of innovative competence, multiple data collection methods were employed.

The quantitative component included structured questionnaires and diagnostic surveys designed to evaluate students' motivational orientation toward innovation and their readiness to engage in innovative professional activities. Knowledge tests were used to assess the cognitive dimension of innovative competence.

The qualitative component included pedagogical observations, individual and group interviews, and analyses of students' academic and project-based performance. These methods enabled the researchers to identify behavioural manifestations of innovative competence and obtain additional evidence regarding students' engagement in innovative activities.

The use of methodological triangulation enhanced the credibility of the findings by combining quantitative and qualitative sources of evidence.

Educational Intervention

The formative intervention was based on a comprehensive system of pedagogical conditions designed to foster innovative competence among future specialists in physical culture and sports.

The intervention incorporated the following components:

- Integration of digital educational technologies into the learning process.
- Implementation of STEAM-oriented educational activities.
- Project-based learning focused on authentic professional challenges.
- Interactive learning methods promoting collaboration and critical thinking.
- Interdisciplinary tasks aimed at developing creativity and innovation.
- Creation of an innovative digital educational environment supporting independent and collaborative learning.

Particular attention was devoted to developing students' innovative thinking, professional reflection, creativity, and readiness to use digital resources in future professional practice. The educational activities included digital learning platforms, multimedia resources, online collaboration tools, project assignments, discussions, workshops, and reflective exercises.

Students in the Control Group studied according to the traditional curriculum without the implementation of the proposed pedagogical conditions.

Data Analysis

The collected data were analysed using descriptive and inferential statistical methods. Frequency distributions and percentages were calculated to determine the distribution of respondents across the identified competence levels.

To assess the statistical significance of differences between the Experimental Group and the Control Group, Pearson's chi-square (χ^2) test was applied. The analysis compared the distributions of respondents according to motivational, cognitive, and activity-based criteria at the formative stage of the experiment.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The motivational criterion revealed statistically significant differences between the groups, $\chi^2(2, N = 220) = 34.33$, $p < .001$, Cramer's $V = .40$.

For the cognitive criterion, the analysis also demonstrated statistically significant differences, $\chi^2(2, N = 220) = 33.16$, $p < .001$, Cramer's $V = .39$.

The strongest differences were identified for the activity-based criterion, $\chi^2(2, N = 220) = 41.05$, $p < .001$, Cramer's $V = .43$.

The obtained effect sizes indicate moderate to relatively strong practical effects, confirming the effectiveness of the implemented pedagogical conditions in developing innovative competence among future specialists in physical culture and sports.

Ethical Considerations

The study was conducted in accordance with the ethical principles governing educational research. Participation was voluntary, and respondents were informed about the purpose and procedures of the study prior to data collection. All data were collected anonymously and processed confidentially. Participants had the right to withdraw from the study at any stage without negative consequences. The research procedures complied with institutional ethical standards for studies involving human participants.

Results and Discussion

Content and necessary innovations in the professional training of physical culture and sports specialists in order to form innovative competence in them.

Contemporary physical culture and sports education is increasingly influenced by digital transformation and the growing demand for innovation in professional practice. Consequently, the training of future specialists requires not only the acquisition of disciplinary knowledge and practical skills but also the development of innovative competence, adaptability, and the ability to effectively use digital technologies (Lin, 2018).

Current research highlights the need to modernize professional training through the integration of innovative teaching methods, digital resources, and technology-enhanced learning environments that stimulate students' cognitive and professional development. The transition from traditional educational models to innovation-oriented approaches necessitates corresponding changes in higher education curricula and instructional practices.

In this context, innovative competence represents an integrated professional characteristic that combines pedagogical thinking, professional orientation, creativity, and the ability to implement innovative solutions in practice. Therefore, the primary objective of professional training is not only to provide students with theoretical knowledge and practical skills but also to foster their readiness for continuous learning, adaptation to changing professional conditions, and application of progressive educational technologies.

The integration of innovative technologies into the educational process promotes personalized learning, supports the differentiation of training, enhances professional thinking, and contributes to the development of competencies required for

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

successful professional activity in the field of physical culture and sports (Belmonte et al., 2020).

The main requirements that a modern professional specialist in physical culture and sports must meet. The role of digitalization in the formation of innovative competence of future specialists in physical culture and sports.

The field of Physical Culture and Sports requires the preparation of competitive professionals capable of continuously developing their competencies and adapting to evolving professional demands. From this perspective, professional training should be grounded in a synergistic approach, which emphasizes learner autonomy, creativity, initiative, self-regulation, and active engagement in educational and professional development processes (Mohr & Townsend, 2026).

Accordingly, modern specialists in physical culture and sports are expected to demonstrate professional flexibility, innovative competence, creativity, and the ability to solve complex professional challenges. In this context, digitalization plays a crucial role in competence development, as contemporary educational technologies create new opportunities for communication, collaboration, individualized learning, and professional growth.

The integration of digital technologies into higher education enhances the quality of professional training by supporting competency-based, project-based, adaptive, and lifelong learning approaches. However, the effective use of digital tools depends on students' readiness to develop both digital competence and professional expertise, enabling them to respond successfully to the challenges of modern educational and sports environments (Gorozidis et al., 2020; Longakit et al., 2024).

The most common digital resources and the role of the STEAM approach in the educational process of training future physical education and sports specialists to form innovative competence.

The digitalization of professional training in physical culture and sports involves the use of diverse educational resources, including cloud-based applications, online learning platforms, synchronous and asynchronous communication tools, mobile health and fitness applications, interactive assessment systems, multimedia content creation tools, and digital movement-analysis technologies. These resources expand opportunities for personalized learning, collaboration, self-directed study, and professional skill development.

The effective integration of digital technologies supports students' adaptation to innovation-oriented educational environments and enhances their readiness for professional practice. An important complementary approach is STEAM-oriented learning, which promotes interdisciplinary thinking, creativity, problem-solving, and the application of knowledge in authentic contexts. In physical education and sports training, STEAM education facilitates the integration of scientific knowledge, technology, design, and physical activity, thereby contributing to the development of innovative competence among future specialists. The growing importance of interdisciplinary STEAM approaches in higher education has been emphasized in recent research (Leão Pereira & Lorente-Catalán, 2024).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Substantiation and experimental verification of the effectiveness of the proposed system and pedagogical conditions for the formation of innovative competence in future specialists in physical education and sports.

In the content of the innovative competence of the future specialist, we invested an integrated quality of personality, characterized by the ability to implement innovative technologies, cultivate creativity, and focus on the individual needs of students, their characteristics, and interests.

The study determined the structure of the innovative competence of students, which consists of components: motivational, professional, and innovative-activity, which are interdependent and interconnected, have a conditional nature, are determined by the specifics, and are formed comprehensively.

Innovations, creativity, and the development of creative thinking characterize the motivational component.

The professional component provides the student's professional sphere of activity in the field of pedagogical innovations, includes basic theoretical knowledge, focuses on the ability to organize their own innovative activities independently, and develops innovative skills.

The innovative-activity component covers creative and creative activities, the ability to make non-standard decisions, demonstrates the possibilities of the future specialist's emotional-volitional work, and forms an individual innovative style.

To assess the level of formation of innovative competence in future specialists, a diagnostic tool was developed, and the following criteria were characterized: motivational, cognitive, and activity.

The levels of formation of innovative competence were characterized as high, average, and low.

During the ascertaining experiment, the generalization of the obtained data according to all criteria allowed us to establish that at this stage of the experiment, no significant differences were established between the experimental and control groups (from 0.2% to 2.2%); a low level of formation of innovative competence was recorded in the vast majority of respondents in the control and experimental groups:

- A low level of formation of innovative competence is observed in the control group (64.6%) and the experimental group (62.6%).
- An average level of formation of innovative competence is observed in the control group (30.7%) and the experimental group (30.5%).
- A high level of development of innovative competence among higher education applicants is observed in the control group (4.7%) and the experimental group (6.9%).

The results of the ascertaining stage of the experiment showed that innovative competence among future specialists in physical culture and sports is insufficiently developed and requires the implementation of the developed system and the theoretically substantiated pedagogical conditions.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Experimental verification of the effectiveness of the developed system and pedagogical conditions for the formation of innovative competence in future specialists in physical culture and sports.

To foster innovative competence among future specialists in physical culture and sports, a comprehensive pedagogical system was implemented in the Experimental Group. The system was structured around several developmental stages, including motivation, professional training, adaptation, professionalization, and professional mastery, reflecting the progressive formation of professional identity and innovative competence throughout the educational process.

The intervention aimed to develop students' understanding of professional roles and responsibilities, innovative competence, self-improvement strategies, reflective practice, pedagogical creativity, and contemporary sports training technologies. Particular attention was given to strengthening professional orientation and preparing students for innovative activity in educational and sports contexts.

The expected outcomes included improving the quality of professional training, increasing students' innovative competence, enhancing readiness to use modern technologies, fostering innovative thinking, and promoting lifelong professional development.

The pedagogical system was based on four key conditions: the creation of an innovative digital educational environment, the development of readiness for innovative activity, the integration of innovation-oriented content into academic disciplines, and the enhancement of students' motivation for professional innovation. Methodologically, the intervention combined systemic, competence-based, subject-activity, axiological, contextual, and project-based approaches. Project activities played a particularly important role by engaging students in interdisciplinary tasks, problem-solving, communication, and analytical work, thereby promoting critical thinking and innovative competence development.

Innovative teaching practices included the use of digital educational technologies, interactive platforms, virtual simulations, online courses, and multimedia resources. These tools enhanced the flexibility of the learning process, supported individualized learning pathways, and increased students' motivation for independent work. In addition, STEAM-oriented learning emphasized the practical solution of real-world problems through interdisciplinary collaboration, experimentation, and creative inquiry.

The implementation of the pedagogical system also incorporated reflective activities, collaborative learning, discussions, workshops, debates, master classes, and project-based tasks. The formation of innovative competence was evaluated throughout a formative experiment comprising orientation, implementation, and assessment stages, designed to verify the effectiveness of the proposed pedagogical conditions.

Evaluation of the results of the experimental test of the developed system and pedagogical conditions for the formation of innovative competence.

At the formative stage of the experimental study, we conducted, using the same diagnostic methodology as at the ascertaining stage of the experiment, a re-diagnosis of the levels of formation of innovative competence of respondents: questionnaires, testing, analysis of the results of knowledge control, interviews (individual, collective), quantitative and qualitative analysis of the behavior of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

students and their activities, as well as the results of these actions carried out through observation.

In accordance with the developed criteria, indicators, and levels of students' innovative competence formation at the ascertaining stage of the experiment, the data obtained were analyzed. The main task of the formative experiment was to identify changes in the levels of formation of innovative competence and compare the results of respondents in the EG and CG.

The data obtained during the re-diagnosis were statistically analyzed using the Pearson χ^2 test. Data analysis allowed us to track changes in the levels of formation of innovative competence among respondents in higher education, reflecting their advancement.

Table 1.

Results of diagnostics of the levels of formation of innovative competence of respondents by motivational criterion at the formative stage of the experiment

Level	Experimental Group	Control Group
Low	10	45
Average	35	34
High	65	31

Results:

- $\chi^2(2) = 34.33$
- $p < .001$
- Cramer's $V = 0.40$

The results presented in Table 1 indicate substantial differences between the Experimental Group and the Control Group regarding the motivational component of innovative competence. In the Experimental Group, 65 students (58.9%) demonstrated a high level of motivational readiness for innovative activity, whereas only 31 students (28.2%) in the Control Group reached this level. Simultaneously, the proportion of respondents with a low level of motivation was considerably smaller in the Experimental Group (9.1%) than in the Control Group (40.9%).

The Pearson chi-square test revealed statistically significant differences between the groups, $\chi^2(2) = 34.33$, $p < .001$. The obtained effect size (Cramer's $V = .40$) indicates a moderate-to-large practical effect. These findings suggest that the implemented pedagogical system positively influenced students' motivation toward innovation, professional self-development, and the adoption of digital and STEAM-oriented educational practices.

Table 2.

Results of diagnostics of the levels of formation of innovative competence of respondents by the cognitive criterion at the formative stage of the experiment

Level	Experimental Group	Control Group
Low	9	42
Average	35	36
High	66	32

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Results:

- $\chi^2(2) = 33.16$
- $p < .001$
- Cramer's $V = 0.39$

The results shown in Table 2 demonstrate significant advantages of the Experimental Group in the cognitive dimension of innovative competence. A high level of cognitive competence was identified in 66 students (59.9%) of the Experimental Group compared with only 32 students (29.2%) in the Control Group. At the same time, the proportion of respondents with a low level of cognitive competence was markedly lower in the Experimental Group (8.3%) than in the Control Group (37.9%).

Statistical analysis confirmed the significance of these differences, $\chi^2(2) = 33.16$, $p < .001$. The effect size was moderate-to-large (Cramer's $V = .39$), indicating that the intervention had a meaningful impact on students' acquisition of knowledge related to innovative technologies, pedagogical innovations, and digital educational tools. The findings provide evidence that the proposed educational system effectively enhanced the cognitive foundations of innovative competence.

Table 3.

Results of diagnostics of the levels of innovative competence formation of respondents according to the activity criterion at the formative stage of the experiment

Level	Experimental Group	Control Group
Low	7	39
Average	28	38
High	75	32

Results:

- $\chi^2(2) = 41.05$
- $p < .001$
- Cramer's $V = 0.43$

The activity-based criterion produced the most pronounced differences between the groups. As shown in Table 3, a high level of innovative competence was achieved by 75 students (67.9%) in the Experimental Group, whereas only 32 students (29.2%) in the Control Group demonstrated comparable results. Moreover, the percentage of respondents with a low level of activity-based competence was substantially lower in the Experimental Group (6.5%) than in the Control Group (35.5%).

The Pearson chi-square test confirmed statistically significant differences between the groups, $\chi^2(2) = 41.05$, $p < .001$. The obtained effect size (Cramer's $V = .43$) represents the strongest effect among all assessed criteria. These results indicate that participation in digital, project-based, and STEAM-oriented activities significantly improved students' ability to apply innovative approaches in practical educational and professional contexts. Consequently, the implemented pedagogical conditions proved particularly effective in developing the behavioral and practical dimensions of innovative competence.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Pearson's chi-square test revealed statistically significant differences between the Experimental Group and the Control Group across all assessed criteria. For the motivational criterion, the difference was significant, $\chi^2(2, N = 220) = 34.33, p < .001$, with a moderate-to-large effect size (Cramer's $V = .40$). Similar results were obtained for the cognitive criterion, $\chi^2(2, N = 220) = 33.16, p < .001$, Cramer's $V = .39$, and for the activity-based criterion, $\chi^2(2, N = 220) = 41.05, p < .001$, Cramer's $V = .43$. These findings indicate that the implemented pedagogical system had a statistically significant and practically meaningful effect on the development of innovative competence among future specialists in physical culture and sports.

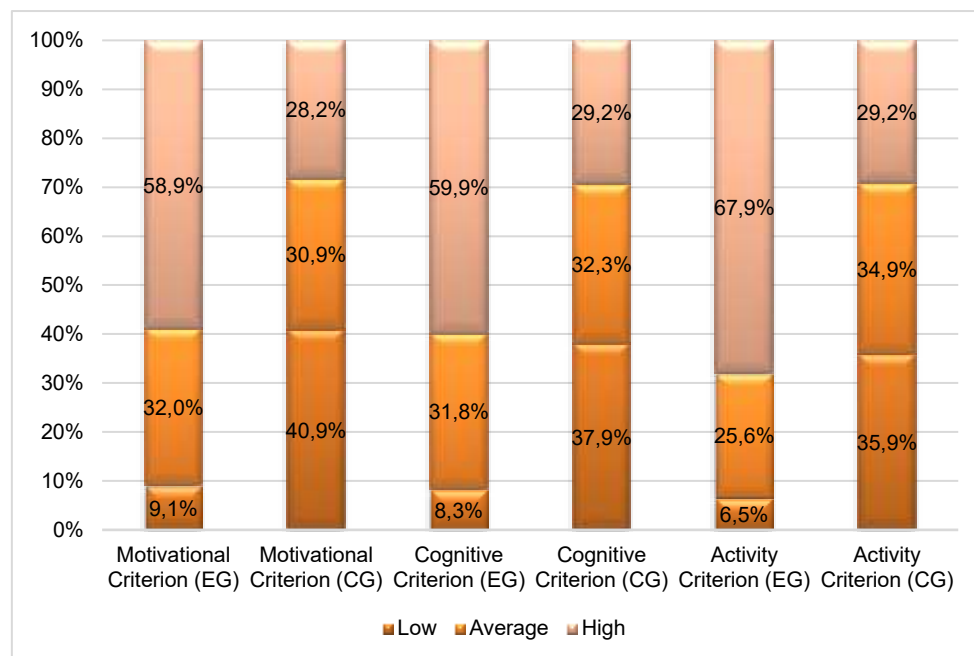


Figure 1. Levels of innovative competence formation among respondents according to motivational, cognitive, and activity criteria at the formative stage of the experiment.

The results demonstrated substantial differences between the Experimental Group (EG) and the Control Group (CG) across all assessed dimensions of innovative competence. According to the motivational criterion, 58.9% of students in the EG achieved a high level compared with 28.2% in the CG, while the proportion of students with a low level was considerably smaller in the EG (9.1%) than in the CG (40.9%). Pearson's chi-square test confirmed the statistical significance of these differences, $\chi^2(2, N = 220) = 34.33, p < .001$. The obtained effect size (Cramer's $V = .40$) indicates a moderate-to-large practical effect.

Similar tendencies were observed for the cognitive criterion. A high level of competence was recorded in 59.9% of EG participants and 29.2% of CG participants, whereas low-level indicators were found in 8.3% and 37.9% of students, respectively. The differences were statistically significant, $\chi^2(2, N = 220) = 33.16, p < .001$, with a moderate effect size (Cramer's $V = .39$).

The strongest differences were identified for the activity-based criterion. High-level competence was demonstrated by 67.9% of students in the EG compared with 29.2% in the CG. At the same time, only 6.5% of students in the EG remained at the low level, compared with 35.5% in the CG. Statistical analysis confirmed a significant

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

association between group membership and competence level, $\chi^2(2, N = 220) = 41.05$, $p < .001$. The effect size (Cramer's $V = .43$) indicates a relatively strong practical impact of the intervention.

Overall, the Pearson χ^2 analyses revealed statistically significant differences between the Experimental and Control Groups across all three criteria. The effect sizes ranged from .39 to .43, suggesting that the observed improvements were not only statistically significant but also educationally meaningful. These findings provide robust empirical support for the effectiveness of the proposed pedagogical system integrating digital technologies, STEAM-oriented learning, project-based activities, and innovation-focused educational practices in fostering innovative competence among future specialists in physical culture and sports.

The findings of this study demonstrate that the implementation of a comprehensive system of pedagogical conditions integrating digital technologies, STEAM-oriented learning, project-based activities, and an innovative educational environment contributed to significantly higher levels of innovative competence among students in the Experimental Group compared with those in the Control Group.

These results are consistent with the findings of Ghorbel et al. (2025) and Cáceres & Contreras Mu (2025), who reported that innovative student-centered approaches, particularly flipped-classroom models, positively influence learners' autonomy, critical thinking, and professional readiness. Similarly, the substantial improvements observed in the Experimental Group support the conclusions of González-Rivas et al. (2024), who demonstrated that active and experiential learning strategies contribute to higher levels of student engagement and competence development in physical education teacher training.

The present study also corroborates previous evidence regarding the educational potential of digital technologies. Maquera-Maquera et al. (2024) emphasized that immersive and technology-enhanced learning environments create favorable conditions for competency development, while Gorozidis et al. (2020) highlighted the role of digital collaborative environments in supporting professional learning and knowledge exchange. However, unlike these studies, which primarily focused on individual technological tools, the present research suggests that digitalization produces stronger educational outcomes when integrated within a broader pedagogical framework combining technological, methodological, and motivational components.

The findings further support the interdisciplinary perspective proposed by Leão Pereira & Lorente-Catalán (2024) and Leão Pereira et al. (2025), who argued that contemporary professional education should promote creativity, problem-solving, learner autonomy, and authentic engagement with real-world challenges. The higher competence levels demonstrated by students in the Experimental Group may be explained by the synergistic interaction of STEAM-oriented learning, project-based activities, and digital educational technologies, which provided multiple opportunities for active participation, interdisciplinary collaboration, and reflective practice.

The observed differences between the Experimental and Control Groups may also be explained by the cumulative effect of the pedagogical conditions implemented during the intervention. While previous studies, such as those conducted by Ghorbel et al. (2025), González-Rivas et al. (2024), and Maquera-Maquera et al. (2024), investigated the impact of individual educational innovations, the present study evaluated their combined implementation within a unified pedagogical system.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Consequently, students in the Experimental Group benefited simultaneously from digital resources, innovative teaching methods, project-based learning, and STEAM-oriented activities, which may have strengthened both motivational and behavioral dimensions of innovative competence.

Despite these positive outcomes, several methodological limitations should be acknowledged. First, the study was conducted within a specific disciplinary context involving future specialists in physical culture and sports, which may limit the generalizability of the findings to other academic fields. Second, although multiple assessment methods were employed, the measurement of innovative competence relied primarily on diagnostic instruments developed specifically for this study rather than internationally standardized scales. Third, the intervention was evaluated within a single implementation period; therefore, the long-term sustainability of competence development remains unclear. Fourth, the quasi-experimental design did not allow for random assignment of participants, which limits the strength of causal inferences regarding the effectiveness of the pedagogical intervention.

Conclusions

The findings of this study provide empirical evidence that the integration of digital educational technologies, STEAM-oriented learning, project-based activities, and an innovative educational environment contributes significantly to the development of innovative competence among future specialists in physical culture and sports. The implementation of the proposed system of pedagogical conditions resulted in substantially higher levels of innovative competence in the Experimental Group compared with the Control Group across motivational, cognitive, and activity-based dimensions. Statistical analysis confirmed the significance of these differences, demonstrating the effectiveness of the developed educational intervention.

The scientific contribution of the study lies in the conceptualization of innovative competence as a multidimensional construct comprising motivational, cognitive, and activity-based components and in the empirical validation of a comprehensive pedagogical system designed to foster its development. Unlike previous studies that primarily examined isolated educational technologies or teaching methods, this research evaluated the combined influence of digitalization, STEAM-oriented learning, and innovation-focused pedagogical conditions within a unified educational framework.

The results extend current knowledge regarding competency-based professional training in physical culture and sports by demonstrating that innovative competence can be systematically developed through intentionally designed educational environments rather than through the isolated use of technological tools. The findings support contemporary theoretical perspectives emphasizing the importance of integrating digital literacy, interdisciplinary learning, creativity, and active student engagement in higher education.

From a practical perspective, the proposed pedagogical system may be used by higher education institutions to modernize curricula for physical culture and sports programs. The incorporation of digital technologies, interdisciplinary projects, reflective learning activities, and innovation-oriented instructional strategies can enhance students' readiness for professional practice in rapidly changing educational and sports environments.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Several limitations should be acknowledged. First, the study involved participants from a limited educational context, which may restrict the generalizability of the findings. Second, innovative competence was assessed within the timeframe of a single academic intervention; therefore, long-term effects were not examined. Third, although multiple assessment methods were employed, future studies should further strengthen measurement procedures through the use of standardized and internationally validated instruments.

Future research should investigate the long-term sustainability of innovative competence development, compare the effectiveness of different digital and STEAM-oriented educational models, and examine the influence of individual pedagogical conditions on specific dimensions of innovative competence. Further studies may also explore the applicability of the proposed framework across different academic disciplines and educational contexts.

Bibliographic references

- Belmonte, J. L., Pozo Sánchez, S., Fuentes Cabrera, A., & Domínguez Campoy, N. (2020). The level of digital competence in education professionals: The case of Spanish physical education teachers. *Zona Próxima*, 33, 146–165. <https://www.redalyc.org/journal/853/85369305008/85369305008.pdf>
- Cáceres, P. G., & Contreras Mu, A. (2025). Flipped classroom: Innovation in online argumentative development of practical training in Physical Education. *Innovación Educativa*, 25(98), 10–24. <https://www.ipn.mx/assets/files/innovacion/docs/Innovacion-Educativa/Innovacion-Educativa-98/ie-98-5-completo-%282%29.pdf>
- Ghorbel, A., Trabelsi, O., Yaakoubi, M., Souissi, M. A., & Gharbi, A. (2025). Flipped classroom approach for gymnastics learning in physical education: A quasi-experimental study. *International Journal of Sports Science & Coaching*, 20(1), 300–312. <https://doi.org/10.1177/17479541241301382>
- González-Rivas, R. A., Enríquez, O. N., Martinen, R., Baena-Extremera, A., Zueck-Enríquez, M. D. C., & Gastélum-Cuadras, G. (2024). Including an adventure education training program in physical education teacher education programs. *Journal of Experiential Education*, 47(3), 358–379. <https://doi.org/10.1177/10538259231200583>
- Goroizidis, G. S., Tzioumakis, Y. S., Krommidas, C., & Papaioannou, A. G. (2020). Facebook group PETCoN (Physical Education Teacher Collaborative Network): An innovative approach to PE teacher in-service training: A self-determination theory perspective. *Teaching and Teacher Education*, 96, 103184. <https://doi.org/10.1016/j.tate.2020.103184>
- Jurat, V., Moga, C., Grigore, M. F., Carp, I., Ulăreanu, M. V., Drăgan, R. Ș., ... & Cieslicka, M. (2024). Development of specific competencies in gymnastics in specialized higher education. *Physical Education of Students*, 28(1), 4–15. <https://doi.org/10.15561/20755279.2024.0101>
- Leão Pereira, A. F., & Lorente-Catalán, E. (2024). Un estudio mixto sobre la satisfacción y frustración de las necesidades psicológicas básicas del alumnado de Educación Física en un centro innovador. *Retos*, 59, 64–74. <https://doi.org/10.47197/retos.v59.104115>
- Leão Pereira, A. F., Lorente-Catalan, E., & Anastácio Oliveira, T. C. (2025). Physical Education in the 21st century: An integrative review of its innovative characteristics. *SPORT TK-EuroAmerican Journal of Sport Sciences*, 14, 142. <https://doi.org/10.6018/sportk.611331>
- Lin, L.-Y. (2018). Exploration on innovative teaching and information technology integration in college physical education. In T.-T. Wu, Y.-M. Huang, R. Shadiev, L. Lin, & A. Istenič Starčič (Eds.), *Innovative Technologies and*

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Learning: First International Conference, ICITL 2018, Portorož, Slovenia, August 27–30, 2018, Proceedings (Lecture Notes in Computer Science, Vol. 11003, pp. 640–647). Springer. https://doi.org/10.1007/978-3-319-99737-7_69

- Longakit, J., Lobo, J., Tagare, R. J., Aliser, J., Colobio-Englatiera, B., Panganiban, T., Aquino, J. M., Rodriguez, D., Gazali, N., & Kurnaz, M. (2024). Investigating the effect of a 12-week game skill-based activity in physical education to enhance movement competence of students: a randomized trial. *Pedagogy of Physical Culture and Sports*, 28(6), 525–533. <https://doi.org/10.15561/26649837.2024.0607>
- Maquera-Maquera, Y. A., Condori, E. O., Gonzáles, L. Y. B., & Bermejo-Paredes, S. (2024). Tecnologías inmersivas y atención a la diversidad territorial en Educación Física. *Retos*, 54, 141–150. <https://doi.org/10.47197/retos.v54.102385>
- Mohr, D. J., & Townsend, J. S. (2026). Game on! Promoting holistic student development in sport education using a hybrid model approach. *Journal of Physical Education, Recreation & Dance*, 97(3), 7–15. <https://doi.org/10.1080/07303084.2025.2586026>
- Özer, Ö., Soslu, R., Devrilmez, E., Uyhan, O., Devrilmez, M., & Dogan, I. (2024). The effects of gymnastics training on flexibility and strength in children. *Science of Gymnastics Journal*, 16(2), 289–304. <https://easiv.kmu.edu.tr/server/api/core/bitstreams/49e67e4f-2a76-4ef4-92f9-82abb0867102/content>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Prácticas de aprendizaje digital y competencias de investigación: El impacto de las herramientas colaborativas y el Feedback en la educación superior

Digital learning practices and research competencies: The impact of collaborative tools and Feedback in higher education

Iryna Matiichyn¹  Olena Dmytriieva²  Volodymyr Yatsenko³  Vitalii Opanasenko⁴  Olena Samborska⁵ 

Afiliación autor:

¹ Candidate of Art Criticism, Associate Professor, Department of Vocal and Choral, Choreographic and Visual Arts, Drohobych Ivan Franko State Pedagogical University, Drohobych, Ukraine. irynam65@ukr.net

² PhD. in Cultural Research, Department of Music Theory and Instrumental Training, Drohobych Ivan Franko State Pedagogical University, Drohobych, Ukraine. olena.dmytriieva@gmail.com

³ Candidate of Pedagogical Sciences, Senior Researcher, Department of Geography and Economics, Institute of Pedagogy of the National Academy of Sciences of Ukraine, Kyiv, Ukraine. yatsenko_v@ukr.net

⁴ Candidate of Pedagogical Sciences, Associate Professor, Department of Vocational Education and Agricultural Production Technology, Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Hlukhiv, Ukraine. opanasenko80@gmail.com

⁵ PhD in Pedagogy, Associate Professor, Head of the Department of Technological and Professional Education and Decorative Arts, Khmelnytskyi National University, Khmelnytskyi, Ukraine. len4uk19911991@gmail.com

Recibido: 01/05/26

Aceptado: 13/06/26

Cómo citar:

Matiichyn, I., Dmytriieva, O., Yatsenko, V., Opanasenko, V., & Samborska, O. (2026). Digital learning practices and research competencies: The impact of collaborative tools and Feedback in higher education. *Revista Eduweb*, 20(2), 339-357. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.20>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

El estudio tuvo como objetivo determinar la efectividad del uso de herramientas digitales, así como de plataformas de gestión del aprendizaje, herramientas de colaboración y retroalimentación digital para el desarrollo de habilidades básicas de investigación. El estudio se realizó dentro del marco de un enfoque cuantitativo utilizando un diseño cuasiexperimental. La muestra incluyó 250 estudiantes. Se utilizó un cuestionario sobre competencias de investigación, una escala de intensidad de uso de prácticas de aprendizaje digital y una ficha de experto para evaluar tareas de investigación para recopilar datos. La confiabilidad de las herramientas se confirmó mediante el coeficiente alfa de Cronbach ($\alpha = 0,79-0,89$). Se indicó un aumento en el nivel de competencias de investigación después de la implementación de prácticas de aprendizaje digital ($t = 12,84$; $p < 0,001$; d de Cohen = $0,81$). Se encontró una relación positiva entre la intensidad de uso de herramientas digitales y el nivel de competencias de investigación ($r = 0,62$; $p < 0,001$). El análisis de regresión múltiple indicó que el predictor más significativo del desarrollo de competencias de investigación fue el uso de herramientas colaborativas y retroalimentación digital ($\beta = 0,41$). Las conclusiones confirmaron la eficacia de un entorno de aprendizaje digital organizado pedagógicamente para el desarrollo de competencias de investigación.

Palabras clave: aprendizaje semipresencial, educación superior, entorno de aprendizaje digital, prácticas de aprendizaje digital, redacción académica.

Abstract

The study aimed to determine the effectiveness of using digital tools, as well as learning management platforms, collaboration tools, and digital feedback for the development of basic research skills. The study was conducted within the framework of a quantitative approach using a quasi-experimental design. The sample included 250 students. A questionnaire on research competencies, a scale of intensity of use of digital learning practices, and an expert card for assessing research tasks were used to collect data. The reliability of the tools was confirmed by Cronbach's alpha coefficient ($\alpha = 0.79-0.89$). The indicated an increase in the level of research competencies after the implementation of digital learning practices ($t = 12.84$; $p < 0.001$; Cohen's $d = 0.81$). A positive relationship was found between the intensity of use of digital tools and the level of research competencies ($r = 0.62$; $p < 0.001$). Multiple regression analysis indicated

that the most significant predictor of the development of research competencies was the use of collaborative tools and digital feedback ($\beta = 0.41$). The conclusions confirmed the effectiveness of a pedagogically organized digital learning environment for the development of research competencies.

Keywords: academic writing, blended learning, digital learning environment, digital learning practices, higher education.

Introduction

In the current conditions of digital transformation of education, the formation of research competencies of education seekers has acquired special importance. The transition to a knowledge economy, the rapid development of digital technologies and the growing role of interdisciplinary approaches have led to the need to train specialists who would be able to reproduce knowledge and independently generate it, critically interpret and apply it in new contexts of digitalization. Therefore, research competencies were considered a key component of academic and professional training (Aliu et al., 2022). They ensured readiness for scientific activity, innovative thinking and making informed decisions. The digital educational environment has opened up new opportunities for the development of such competencies. The use of online platforms, learning management systems (LMS), collaboration tools, artificial intelligence and data analytics has significantly contributed to the activation of students' cognitive activity, expanding access to scientific resources and the formation of research skills in an interactive format (Leichsenring & Clauss, 2024; Mason et al., 2023). At the same time, the effectiveness of such tools depended on the pedagogical design of the educational process, in particular, the integration of research-oriented methods, problem-based learning, project activities and collective construction of knowledge (Osuna-Juárez & González-Castellano, 2023).

Despite a significant number of studies devoted to the digitalization of education and the development of research skills, many unresolved issues remain. First of all, there is a lack of empirically substantiated educational practices in the digital environment that are most effective for the formation of research competencies. Research that would combine pedagogical experiment with quantitative assessment of results was also limited. There was a shortage of scientific works that analyzed the impact of specific digital tools in combination with methodologically structured educational interventions.

Therefore, the scientific problem of the study was to determine the effectiveness of educational practices that would be aimed at developing research competencies of education seekers in a digital educational environment.

The purpose of the article is to empirically study the effectiveness of educational practices that were focused on the development of research competencies of education seekers in the digital environment, to identify the most effective pedagogical approaches and digital tools that contributed to this process.

RQ1: What is the level of research competencies of education seekers before and after the implementation of digital learning practices?

RQ2: Is there a relationship between the intensity of use of digital learning practices and the level of research competencies of education seekers?

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

RQ3: What components of the digital learning environment (shared tools, digital feedback, overall level of platform use) influence the development of research competencies?

Research hypotheses:

H1: The implementation of digital learning practices will increase the level of research competencies of education seekers.

H2: The frequency of use of shared digital tools, intensity of digital feedback, and overall level of digital platform use will be important predictors of the development of research competencies.

The proposed study had theoretical and practical significance. Theoretically, it expanded the understanding of the mechanisms of forming research competencies in the digital era, and practically, it proposed proven approaches to organizing the educational process that can be used in higher education institutions in the future.

Literature Review

Research competence: theoretical foundations and formation

In modern studies, the development of research competencies of scientists has been shown as one of the key outcomes of higher education, especially when the conditions of digitalization of the educational environment are taken into account (Pérez-Valls et al., 2023; Pérez Estébanez & Pastor Estébanez, 2025). Within the framework of the competency approach, research competencies are interpreted as an integrative formation that includes the ability to formulate a problem, search for and critically analyze information, interpret data, and present research results (for example, the role of social interaction and an activity-based approach in the formation of complex cognitive skills has been repeatedly emphasized).

Researchers also drew attention to the fact that an important characteristic of research competence is its interdisciplinary nature, since it consists of methodological literacy, analytical thinking, and the ability to work with data (Sposato, 2024). Of particular importance is the development of the skills to formulate research questions, build hypotheses, and choose adequate methods of data collection and analysis. Therefore, we can conclude that this competence acts as a metacompetence, which consists of cognitive, operational, and value factors on the path to the development of professional activity. However, as other scientists have noted, the skills of working with large data sets and the use of digital analysis tools have become significantly more active. Accordingly, the ability to select information and identify cognitive biases has begun to play a special role.

In these conditions, research competence requires high-quality mastery of knowledge and involvement of education seekers in practical research activities (Kulichenko et al., 2018; Kulichenko et al., 2023). In this system, it is important not only to carry out individual tasks, but also to include students in the full cycle: problem formulation, analysis and interpretation of data with subsequent reflection (Omrany et al., 2025). Such an approach will allow to form the logic of scientific knowledge and will contribute to the formation of sustainable strategies.

Effective approaches in this direction are problem-oriented learning, project activities, case method and research-oriented learning. These approaches require an active position of the seeker as a subject of knowledge. In addition, in these formats, independence in choosing research methods, working with uncertainty and

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

the need for reasoned justification of decisions taken are of particular importance.

The impact of digitalization on the formation of research competence

A significant number of modern works have focused on the potential of the digital educational environment for the development of such competencies. Research in the field of digital pedagogy and blended learning has demonstrated that the combination of traditional and digital forms of learning has significantly contributed to the development of critical thinking, autonomy, and research skills (Sposato, 2024; Zarceño García de Soriano et al., 2024). At the same time, the effectiveness of digital technologies largely depended on their pedagogically justified use (Austin Henry & Beserra, 2022). That is, it was not only about the level of technological equipment.

A separate area of research was related to the inquiry-based learning conception, which was considered one of the most effective approaches to developing research skills (Dembitska et al., 2024; Ma & Fang, 2023). It concerned digital tools that served as environments for information search, data organization, collaboration, and reflection. Studies have shown that the use of digital platforms, collaborative writing tools, and online feedback positively affected the quality of students' research activities (Omran et al., 2025; Santos et al., 2021).

In addition, scientists drew attention to the fact that immersive and simulation technologies had significant potential in the development of research competence. In particular, they make it possible to model complex, multifactorial research situations in a controlled educational environment. Their use also creates special conditions for practicing the skills of data analysis in real time, decision-making under conditions of limited information and time (Dembitska et al., 2024). In addition, such environments influence the formation of research reflection, and allow students to observe their own actions, evaluate their effectiveness and adjust behavioral strategies.

At the same time, scientists drew attention to the fact that an important element in this system is also the organization of feedback, which allows students to understand both the process and the results of their own research activities. Regular analytical reflection, discussion of results in a group and evaluation of alternative approaches allow the formation of critical thinking and the ability to argue (Ma & Fang, 2023).

Therefore, as can be seen, the use of interactive formats can ensure the mastery of research methods and form the autonomy of thinking.

At the same time, more critical positions on the digitalization of education were observed in the scientific literature. In particular, scientists emphasized that the use of digital tools in itself did not guarantee the development of research competencies and could be effective only under the conditions of structured pedagogical design, scaffolded support, and an active role of the teacher. Some studies also pointed to the risks of superficial knowledge acquisition and a decrease in the depth of analysis with excessive use of digital resources (Ramírez Heredia et al., 2025).

Thus, modern scientific discourse has shown that the digital educational environment has significant potential for the development of research competencies, but the effectiveness of this process was determined not by technologies as such, but by their integration into pedagogically designed educational practices. This logic became the theoretical basis for the study, which also aimed to eliminate a significant gap - the lack

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

of empirical measurements of the use of digital technologies.

Methodology

Research design

The study was conducted based on a quantitative approach using a quasi-experimental pre-test/post-test design with a comparison of results before and after the implementation of a model of specially formed educational practices in a digital environment. The chosen design made it possible to empirically assess changes in the level of research competencies of education seekers based on specially organized digital educational practices. Despite the use of a quasi-experimental pre-test/post-test design without a control group, this approach had a methodological justification. The formation of a control group was limited due to organizational and ethical factors, because all participants were involved in the educational process, in which digital learning practices were an integral part of the training courses.

To minimize threats to internal validity, particularly the maturation effect, several procedures were used. First, the duration of the intervention was limited to 8–10 weeks, which reduced the likelihood of significant changes that were not related to the influence of the studied practices. Second, the analysis was carried out considering control variables (age, level of education, previous research experience, and level of digital literacy). This approach made it possible to partially compensate for the absence of a control group. Third, the use of a combination of self-assessment and expert assessment increased the objectivity of the results.

The study considered the effectiveness of various activities and practices: working with digital platforms for searching and analyzing sources, conducting mini-research in an LMS environment, using collaborative academic writing tools, digital feedback forms, online discussions, electronic research diaries, and tools for visualizing and presenting results. The design used made it possible to combine the assessment of the initial level of research competencies with further analysis of changes after the intervention.

The independent variable was the implementation of a set of educational practices in a digital environment. The dependent variable was the level of development of research competencies of education seekers. The control variables included age, level of education, previous experience in research activities, and level of digital literacy.

Participants

The study involved 250 students from educational institutions in Ukraine. The sample was selected based on purposive sampling, involving individuals who studied in a digitally supported educational environment and participated in educational activities related to research work. The sample included undergraduate and graduate students. To ensure analytical representativeness, participants were divided by gender, age, level of education, and previous experience using digital tools in education. This approach also allowed us to explore the heterogeneity of the educational audience and reduce the risk of bias.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 1.
Characteristics of participants (N = 250)

Variable	Category	n	%
Gender	Female	148	59.2
	Male	102	40.8
Age	17–19 years	74	29.6
	20–22 years	109	43.6
	23 years and older	67	26.8
Level of education	Bachelor's degree	172	68.8
	Master's degree	78	31.2
Experience with digital learning tools	Low	52	20.8
	Medium	121	48.4
	High	77	30.8
Prior research experience	None / minimal	96	38.4
	Moderate	103	41.2
	Advanced	51	20.4

The study involved students from several higher education institutions in Ukraine, representing various majors (including humanities, social sciences, and technical fields). The sampling was purposive, which was due to the need to involve participants who studied in conditions of digital educational practices. At the same time, this approach limited the possibility of generalizing the results to the entire higher education system in Ukraine, which had to be taken into account when interpreting the data obtained.

Tools and validation

Various instruments were used to collect empirical data.

The questionnaires were adapted from existing structures and improved to reflect the context of digital learning environments, and some parts were developed by the authors.

The main instrument was a structured questionnaire that measured the level of development of research competencies. This questionnaire identified the following aspects:

- the ability to formulate a research problem;
- the ability to define a goal, objectives and hypotheses;
- the skills of searching, selecting and critically evaluating sources;
- the ability to analyze and interpret data;
- academic writing skills;
- the ability to present research results;
- reflection on one's own research activities.

The questionnaire items were rated on a five-point scale (1 – completely disagree; 5 – completely agree). The final score indicated the overall level of development of research competencies.

The scale of intensity of use of digital learning practices was to determine the frequency and intensity of participants' use of digital tools in research-oriented learning. It included blocks on:

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

use of LMS;
digital libraries and academic databases;
collaborative writing tools;
online communication and discussion tools;
digital platforms for data processing and visualization;
electronic feedback.

An important tool in the study was the expert card for evaluating research tasks. It was used to ensure the objectivity of self-assessment data, expert assessment of mini-research or research tasks completed by participants was used. This card was evaluated according to the criteria of research logic, quality of argumentation, correct use of sources, data analysis and quality of presentation of results.

A separate block of the toolkit contained a socio-demographic questionnaire, which included questions on age, gender, level of education, previous experience in research activities and level of digital literacy.

To ensure the methodological quality of the tool, a multi-stage validation was carried out. In particular, content validity was first ensured: the initial version of the questionnaire was developed based on an analysis of scientific literature on the structure of research competencies and the digital learning environment. After that, the tool underwent expert evaluation with the participation of 5–7 specialists in the field of pedagogy, educational technologies and research methodology. The experts assessed the relevance, clarity and compliance of the items with the research goal.

Subsequently, a pilot study was conducted on a small group of participants (for example, 25–30 people) who were not included in the main sample. Based on the results of the pilot study, the wording of the items was clarified and ambiguities were eliminated.

The reliability of the tools was determined using Cronbach's alpha coefficient. In particular, a value of $\alpha \geq 0.70$ was considered acceptable, $\alpha \geq 0.80$ was considered good. The obtained values ranged from 0.79–0.89. This indicated good internal consistency. The suitability of the data for factor analysis was confirmed by the Kaiser–Meyer–Olkin coefficient ($KMO = 0.87$) and the statistically significant result of the Bartlett test of sphericity ($\chi^2 = 2154.36$, $p < 0.001$).

The CFA results showed acceptable model quality:

$\chi^2/df = 2.38$, CFI = 0.93, TLI = 0.91, RMSEA = 0.054. These indicators correspond to the recommended threshold values.

Inter-expert consistency was determined for the expert assessment map. The value of Cohen's Kappa coefficient was 0.76. This indicated a high level of consistency of the estimates.

Research procedure

In order to increase the reproducibility of the study, the concept of “digital learning practices” was operationalized. Within the framework of the proposed article, this concept is considered as a structured set of pedagogical actions implemented using digital tools in the process of research-oriented learning.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 2.
Structure of digital learning practices within the intervention

Practice	Digital tools	Frequency	Expected result
Source search and analysis	Google Scholar, Scopus, цифрові бібліотеки	weekly	development of information literacy
Mini-research	LMS (Moodle/Canvas)	2–3 times per course	formation of research logic
Collaborative academic writing	Google Docs, Overleaf	continuously	development of academic writing skills
Online discussions	форуми LMS, Zoom, Teams	weekly	development of critical thinking
Digital feedback	LMS, Google Forms	after each assignment	reflection and correction of activities
Data visualization	Excel, Power BI, Canva	2–3 times	development of analytical skills
Electronic research diaries	Notion / LMS	continuously	development of reflection

All of these practices were implemented in a standardized format over 8–10 weeks with the same intensity and time frame for all participants, ensuring comparability of the results.

The study was conducted in several consecutive stages.

At the first stage, participants were informed about the purpose of the study, the principles of voluntary participation, confidentiality and anonymity of data. After obtaining informed consent, they filled out an entry questionnaire (pre-test), which allowed us to record the initial level of research competencies and the intensity of the use of digital teaching practices.

At the second stage, an educational intervention was implemented, which required the systematic use of digital teaching practices for 8–10 weeks. The intervention included:

implementation of research mini-projects;
search and critical analysis of sources in digital databases;
joint writing of texts in cloud environments;
participation in thematic forums and discussions;
use of digital tools for collecting, processing and visualizing data;
receiving formative feedback from the teacher via electronic platforms.

Further, after the intervention, a final evaluation (post-test) was conducted using the same or equivalent instruments. Additionally, expert evaluation of the completed research tasks was implemented. In order to minimize methodological risks, all participants worked in comparable organizational conditions. At the same time, digital learning activities had a unified structure, time limits and evaluation criteria.

Data analysis

Data processing was implemented using the SPSS statistical software.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

In particular, the descriptive statistics method was initially used, on the basis of which the mean values, standard deviations, minimum and maximum values were calculated.

Before conducting the inferential analysis, assumptions were made regarding the normality of the distribution and homogeneity of variances using the Shapiro–Wilk and Levene’s tests. In order to assess the changes between pre-test and post-test, it is advisable to use:

paired t-test - if the distribution is close to normal;
Wilcoxon test - if the data do not meet the parametric assumptions.

In order to determine the role of digital learning practices on the development of research competencies with the control of background variables, the following were used:

multiple linear regression analysis;
ANCOVA, if it is necessary to compare the final indicators with the control of pre-test results;
Pearson or Spearman correlation analysis to determine the relationship between the intensity of use of digital tools and the level of research competencies.

Statistical significance was established at the $p < 0.05$ level. Also calculate the effect size: Cohen’s d, partial eta squared (η^2) and R^2 .

Overall, the study was created in compliance with the basic ethical principles of pedagogical and social research: voluntary participation, informed consent, confidentiality, anonymity and the right of participants to refuse participation at any stage. The collected data were used exclusively for scientific purposes.

It is important to note that the empirical data were generated based on a combination of self-assessment and external expert assessment. The main data set (about 70%) was obtained from the questionnaire. The other 30% were the results of expert assessment of completed research tasks. Therefore, this made it possible to combine the subjective perceptions of education seekers about their own competencies with a more objective assessment of their real educational results. To check the consistency of the results, a correlation analysis was performed between the indicators of self-assessment and expert assessment. The results obtained indicated the presence of a statistically significant positive relationship between these indicators. Under such circumstances, confirmation of the validity of the instruments used was obtained, and the risks of bias associated with self-reporting were reduced.

Results and Discussion

In the first stage, a comparative analysis of the means and standard deviations before (pretest) and after (posttest) was carried out. Subsequently, a paired t-test was used to test the statistical significance of the differences between the two dimensions. A positive trend was observed in all the main components of research skills. The greatest improvement was observed in the following components: searching and critical analysis of sources, academic writing, and presentation of research results. The overall integral indicator of research competencies also increased significantly after the intervention (see Table 3).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 3.

Descriptive statistics of research competency indicators before and after the intervention

Research Competence Component	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD
Formulation of Research Problem	3.08	0.63	3.69	0.58
Statement of Goal, Objectives and Hypotheses	3.11	0.60	3.74	0.55
Search and Critical Analysis of Sources	3.19	0.57	3.88	0.52
Data Analysis and Interpretation	3.05	0.61	3.70	0.56
Academic Writing	3.14	0.59	3.83	0.51
Presentation of Research Results	3.09	0.62	3.79	0.54
Reflection on Research Activity	3.17	0.56	3.82	0.50
Overall Score	3.12	0.54	3.78	0.49

As shown in Table 3, the mean values after the intervention exceeded the corresponding values before the intervention for all the components studied. The highest post-test score was recorded for the component "Searching and Critically Analyzing Sources" (M = 3.88; SD = 0.52). At the same time, the lowest, although also higher than the pre-test, was found for the component "Formulating a Research Problem" (M = 3.69; SD = 0.58). The total score increased from 3.12 to 3.78 (see Figure 1). Such data indicated an increase in the research competencies of the participants.

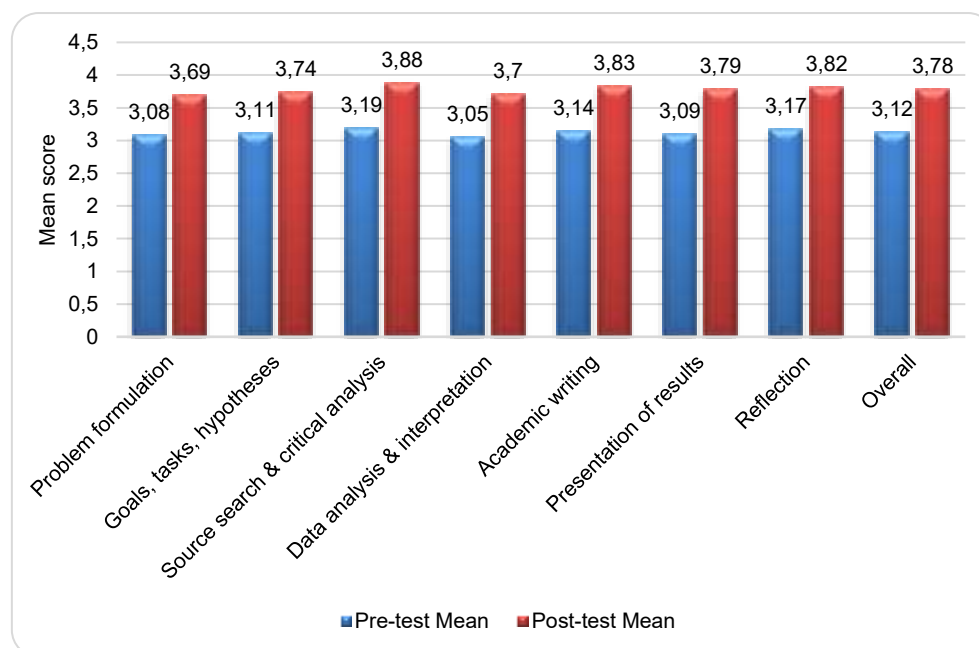


Figure 1. Comparison of mean values of research competency components before (pre-test) and after (post-test) implementation of digital practices.

At the same time, a paired t-test was conducted to check whether the differences found were statistically significant. The results are presented in Table 3. The results of the paired t-test showed that the differences between pre-test and post-test are significant for all components of research competencies ($p < 0.001$). The largest

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

changes were recorded for the components “Presentation of research results” and “Academic writing”.

The graphical representation of the data in Figure 1 demonstrates the positive dynamics of the development of research competencies of education seekers after the implementation of digital learning practices. Moreover the post-test values exceeded the corresponding pre-test indicators for all components.

Table 4.
Paired t-test results for research competency indicators

Indicator	Mean difference	t	df	p	Cohen's d
Formulation of the research problem	0.61	10.42	249	<0.001	0.66
Statement of the goal, objectives and hypotheses	0.63	10.95	249	<0.001	0.69
Search and critical analysis of sources	0.69	11.84	249	<0.001	0.75
Analysis and interpretation of data	0.65	10.88	249	<0.001	0.69
Academic writing	0.69	11.97	249	<0.001	0.76
Presentation of research results	0.70	12.11	249	<0.001	0.77
Reflection on research activity	0.65	11.02	249	<0.001	0.70
Overall indicator	0.66	12.84	249	<0.001	0.81

The overall integral indicator also indicated a statistically significant increase ($t = 12.84$; $p < 0.001$). The obtained value of Cohen's $d = 0.81$ indicated a large effect size. Therefore, the implemented digital teaching practices had a positive impact on the development of research competencies of education seekers.

The study also conducted a correlation analysis, covering general indicators and main components of the digital learning environment and research competencies. This approach made it possible to establish the fact of the existence of a connection and to detail its structure.

Before conducting the analysis, the assumptions regarding the normality of the distribution (Shapiro–Wilk) were checked, which did not reveal statistically significant deviations ($p > 0.05$). The Pearson correlation coefficient was then applied (see Table 5).

Table 5.
Matrix of correlations between digital learning practices and elements of research competencies

Variables	1	2	3	4	5	6	7	8
1. Digital practices (overall)	1							
2. Collaborative tools & feedback	0.71**	1						
3. LMS & platform use	0.66**	0.63**	1					
4. Problem formulation	0.48**	0.51**	0.42**	1				
5. Goals & hypotheses	0.52**	0.55**	0.47**	0.64**	1			
6. Source analysis	0.67**	0.69**	0.61**	0.58**	0.63**	1		
7. Data analysis	0.59**	0.62**	0.54**	0.56**	0.60**	0.68**	1	
8. Academic writing & presentation	0.64**	0.68**	0.57**	0.53**	0.61**	0.66**	0.72**	1

Note: $p < 0.001$

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

As can be seen from Table 5, all correlation coefficients are positive and significant. Thus, it is clear that there is a systemic relationship between digital teaching practices and the development of research competencies.

The strongest relationships were recorded between the use of collaborative tools & feedback and source analysis ($r = 0.69$), the use of the same tools and academic writing ($r = 0.68$), the general level of digital practices and source analysis ($r = 0.67$).

This made it possible to determine that it is interactive and collaborative digital tools that have the greatest impact on the formation of research skills.

At the same time, the least pronounced, although between digital practices and the formulation of the research problem ($r = 0.48$). This indicated the complexity of developing this competence.

To determine which components of the digital learning environment have the greatest impact on the development of students' research competencies, a multiple linear regression analysis was performed, which allowed us to determine the contribution of individual components of digital learning practices to explaining the variation. The multicollinearity of the independent variables was then tested. The VIF values did not exceed 2.1. Therefore, there were no critical multicollinearity problems. The linearity and homoscedasticity of the residuals were also tested, which met the statistical assumptions (see Table 6).

Table 6.
Results of multiple linear regression analysis

Predictor	B	Std. Error	Beta (β)	t	p-value
Collaborative tools & feedback	0.47	0.08	0.41	5.88	<0.001
LMS & platform use	0.21	0.07	0.23	3.12	0.002
Digital interaction intensity	0.18	0.06	0.19	2.95	0.004
Age (control)	0.05	0.06	0.06	0.84	0.401
Level of education (control)	0.03	0.05	0.04	0.61	0.543
Digital experience (control)	0.07	0.06	0.08	1.12	0.264

Note: R^2 0.48; Adjusted R^2 0.46; F 38.91; df (6, 243); p -value <0.001

Therefore, the model is significant ($F = 38.91$, $p < 0.001$) and explained 48% of the variation in the level of research competencies.

The results of the regression analysis indicated that the most significant predictor of the development of research competencies is the use of collaborative tools and digital feedback ($\beta = 0.41$, $p < 0.001$). This may indicate that the active involvement of students in collaborative environments and systematic feedback significantly enhance the formation of research skills.

The overall level of use of digital platforms (LMS) was also an important predictor ($\beta = 0.23$, $p = 0.002$). Separately, the intensity of digital interaction had a significant impact ($\beta = 0.19$, $p = 0.004$), which emphasizes the role of communication, discussion and active participation in the learning process. At the same time, control variables (age, education level, previous digital experience) did not have a statistically significant impact (see Figure 2).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

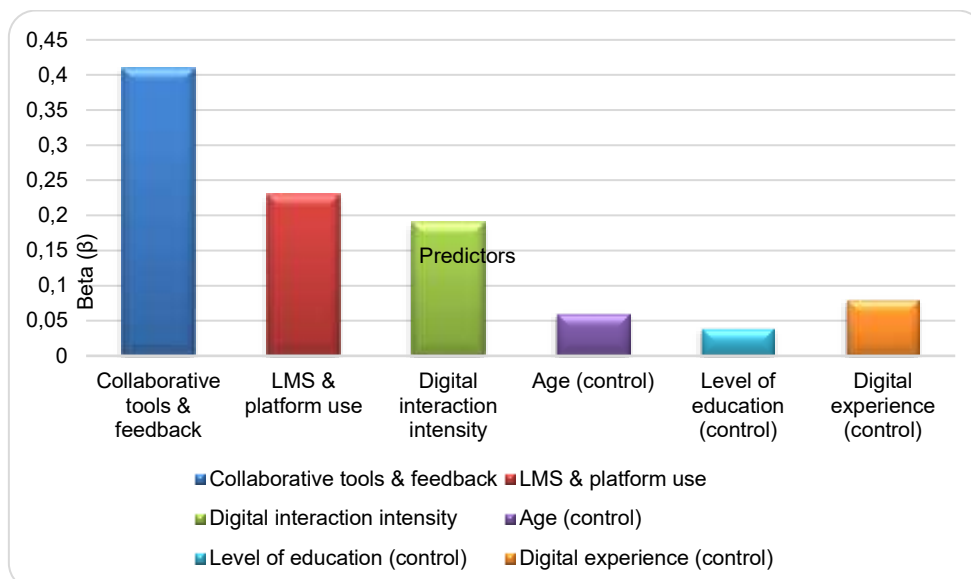


Figure 2. Standardized regression coefficients (β) of predictors of research competence development.

The graphical representation of the standardized regression coefficients (Figure 2) clearly indicated the relative strength of the influence of individual components of the digital learning environment. As can be seen from figure 2, the largest contribution to explaining the variation in the dependent variable is the use of collaborative tools and digital feedback. This indicated their important role in the formation of research skills.

Discussion

The results obtained showed that the implementation of digital learning practices is accompanied by a statistically significant increase in the level of research competencies of education seekers by the general integral indicator and by individual components. Such dynamics are generally consistent with modern scientific approaches, according to which digital and blended learning may not be effective in itself. Therefore, it is specifically designed to develop higher cognitive skills, in particular critical thinking, creativity, analytical work with information and reflection (Sohail & Gupta, 2024). Also, according to some scientists, research competence is important for solving a wide range of educational and life tasks. Therefore, it should be formed on an interdisciplinary basis as a specially structured set of qualities that allow students to effectively participate and act in various life situations. In this sense, our results supported the conclusions of other scientists that the most promising for the development of higher-order thinking skills were blended and flipped formats (Alam & Mohanty, 2023; Chovriy et al., 2025). At the same time, fully online learning did not always demonstrate better results.

Positive changes in the proposed study are especially noticeable in the components related to the search and critical analysis of sources, data analysis, academic writing and presentation of results. This is well explained in the modern literature on inquiry-based learning (Bojórquez-Roque et al., 2024; Hattab, 2023). In particular, a systematic review of the roles of digital technologies in IBL demonstrated that digital tools most often functioned as means of accessing content, collecting data, organizing ideas, exchanging information, and receiving feedback (Filippou et al., 2025; Kuzminska et al., 2021). It is this functional multicomponent

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

nature of the digital environment that may explain why the greatest gains in our sample were not observed in an isolated skill, but in several interconnected components of research activity.

The proposed results are also consistent with recent empirical evidence on the relationship between digital competence and educational achievement. For example, studies have shown that students' overall digital learning competence is positively associated with academic performance (Inamorato dos Santos et al., 2023; Maricato et al., 2026). The most notable contributions were made by technical, managerial and assessment components. This is important for interpreting the data obtained because digital practices also served as a channel for accessing materials, and became an environment for self-regulation, assessment and organization of research work (Ismail et al., 2026; Spante et al., 2018; Polyezhayev et al., 2024). Therefore, the proposed research results supported the theory that the development of research competences in the digital environment did not occur solely due to the availability of platforms, but as a result of the formation of skills for managing one's own educational and research activities (Ashraf et al., 2022).

Of particular note is the increase in academic writing and presentation of research results. In this respect, the proposed findings are consistent with studies that have highlighted the role of digital self-efficacy, genre awareness, collaborative writing and reflective revision in the formation of academic writing competence. In particular, recent studies have shown high explanatory power of a model that combines digital self-efficacy, collaborative writing and reflective editing in the framework of academic writing competence (de Alwis et al., 2025). This correlated well with the results obtained: improvement in writing was one of the most noticeable effects of the digital intervention, which was probably related to the combination of collaborative work, gradual text revision and regular feedback.

A similar logic has been supported by other researchers. Systematic reviews have shown that online peer assessment is associated with both cognitive outcomes and behavioral and affective consequences: increased engagement, communication, teamwork, motivation, self-esteem and autonomy (Palamar et al., 2023). At the same time, the authors emphasized that the effect depended on the characteristics of the students, the design of the tasks, the platform and the technological support (Sliwka et al., 2023). This was well explained by the data obtained: the positive impact of digital practices probably arose not simply due to the use of technology. Rather, it was due to the pedagogically structured application in the system of tasks, which combined collaborative work, formative feedback and step-by-step research activities. At the same time, the results obtained should not be interpreted as evidence that any expansion of digitalization would automatically improve research skills. A more cautious position has been traced in the scientific literature (Lidolf & Pasco, 2020; Zhao et al., 2021). In particular, several reviews have emphasized that digital tools could enhance the quality of writing, the structure of the presentation and the availability of support. However, their excessive or uncritical use can form a dependence on external prompts and weaken the development of one's own critical thinking and creativity. Therefore, the results of the proposed study should be interpreted in line with the concept of pedagogically guided digital support, where the key elements were dosage, scaffolded feedback, a clear structure of tasks, and the reflective activity of students.

Another important aspect was that in the proposed study, less pronounced growth was observed in the components that were related to the formulation of the research problem. This also did not contradict modern scientific ideas. Modern scientists

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

emphasized that online and digital formats had the potential to develop higher-order thinking skills (Kurebay et al., 2023; Boichenko et al., 2023). However, this potential was realized unevenly for different types of cognitive operations; the most complex stages, which were related to the formulation of the problem, conceptualization, and original research design, usually required more intensive teaching support (Sillat et al., 2021; Turabay et al., 2023; Pichkur et al., 2023). Accordingly, the results obtained gave reason to assume that it was precisely for the development of problematization, construction of research logic and formation of hypotheses that digital tools should be combined with more targeted mentoring by the teacher. Overall, the study supported the modern scientific position, according to which the digital environment was a productive resource for the development of research competencies if it was integrated into learning as a space for searching for sources (Guillén-Gámez et al., 2021; Colás-Bravo et al., 2021). At the same time, the proposed results also clarified the following position: the greatest effect was observed where digital tools were supported by specific research actions and interactions. Therefore, the obtained findings are considered as an argument in favor of the transition from “digitalization as technical equipment” to “digitalization as pedagogical design of research-based learning”.

Thus, hypothesis H1, which predicted that the implementation of digital learning practices would improve the level of research competencies of education seekers, was confirmed. The results of the paired t-test indicated significant differences between pre- and post-test scores for all components of research competencies ($p < 0.001$). The effect size value (0.81) indicated a strong practical effect of the intervention.

Hypothesis H2 was also confirmed. The results of the correlation analysis indicated a moderately positive relationship between the variables ($r = 0.62$, $p < 0.001$). This indicated the systemic nature of the influence of the digital environment.

In addition, the results of the multiple regression analysis allowed us to clarify the structure of this influence: the most significant factors were the use of shared digital tools and feedback ($\beta = 0.41$, $p < 0.001$), the overall level of use of digital platforms ($\beta = 0.23$, $p = 0.002$). The control variables did not demonstrate a statistically significant influence.

Despite the significant results obtained, the study had certain limitations that should be taken into account when further interpreting the data. First, the quasi-experimental design used without a control group limited the possibility of unambiguously establishing cause-and-effect relationships. Second, some data were obtained using self-assessment tools, which could be accompanied by the effect of social desirability or subjective inflation of the results. Third, the study was conducted on a relatively large sample of participants, which may limit the possibility of generalizing the results to other educational contexts. Furthermore, the use of purposive sampling limited the representativeness of the results, so their transfer to the broader student population required caution.

Conclusions

Therefore, the proposed results demonstrated that the implementation of digital learning practices was accompanied by a statistically significant increase in the level of research competencies by the general integral indicator and by individual components. The most pronounced effect was recorded in the area of searching and critical analysis of sources, academic writing and presentation of research results. A moderately strong positive relationship was found between the intensity of use of digital learning practices and the level of research competencies. This indicated the

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

systemic nature of the influence of the digital educational environment.

The results of multiple regression analysis demonstrated: the most significant predictors of the development of research competencies were the use of shared digital tools and feedback, the overall level of use of digital platforms.

At the same time, the smallest growth was recorded for the "Problem Formulation" component. Thus, identifying scientific contradictions and formulating research questions is one of the most difficult components of research competence. Therefore, the use of digital educational platforms in itself will not provide sufficient conditions for the effective development of research problem-setting skills. To increase the level of formation of this competence, it is advisable to integrate specialized educational activities into the educational process that are aimed at the formation of research thinking: analysis of real and simulated problem situations, case methods, project-research tasks, exercises in formulating research questions and hypotheses, as well as collective discussion and expert review of research ideas. In addition, systematic mentoring of students, consisting of individual consultations, providing feedback on the quality of formulated research problems, and support at the stages of research design, can play an important role.

In general, the study confirmed that the effectiveness of the digitalization of education was determined not only by the availability of technologies, but also by their pedagogically justified integration into the research-oriented educational process. The digital environment has been a productive tool for developing research competencies, if it is used as a space for active, reflective and collaborative learning activities. The results obtained could be used to improve educational programs, develop digital courses and form strategies for developing research competencies in a modern educational environment.

The results also opened up a number of promising directions for further scientific research in the field of developing research competencies in the digital educational environment. First, it would be advisable to conduct research using an experimental design with a control group, which would allow us to more clearly establish the cause-and-effect relationships between the use of digital educational practices and the development of research competencies.

Bibliographic references

- Alam, A., & Mohanty, A. (2023). Educational technology: Exploring the convergence of technology and pedagogy through mobility, interactivity, AI, and learning tools. *Cogent Engineering*, 10(2). <https://doi.org/10.1080/23311916.2023.2283282>
- Aliu, J., Aghimien, D., Aigbavboa, C., Oke, A., Ebekozen, A., & Temidayo, O. (2022). Empirical Investigation of Discipline-Specific Skills Required for the Employability of Built Environment Graduates. *International Journal of Construction Education and Research*, 1–20. <https://doi.org/10.1080/15578771.2022.2159589>
- Ashraf, R., Khan, M. A., Khuhro, R. A., & Bhatti, Z. A. (2022). Knowledge creation dynamics of technological forecasting and social change special issues. *Technological Forecasting and Social Change*, 180, 121663. <https://doi.org/10.1016/j.techfore.2022.121663>
- Austin Henry, R., & Beserra, B. (2022). Neoliberalism and Higher Education in Latin America. *Latin American Perspectives*, 49(3), 3-17. <https://doi.org/10.1177/0094582x221084299>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Boichenko, M., Churychkanych, I., Kulichenko, A., Shramko, R., & Rakhno, M. (2023). Mind maps to boost the learning of English as L2 at higher education institutions in Ukraine. *Amazonia Investiga*, 12(70), 229–240. <https://doi.org/10.34069/AI/2023.70.10.21>
- Bojórquez-Roque, M. S., Garcia-Cabot, A., Garcia-Lopez, E., & Oliva-Córdova, L. M. (2024). *Digital competence learning ecosystem in higher education: A mapping and systematic review of the literature*. IEEE Access, 1. <https://doi.org/10.1109/access.2024.3416906>
- Chovriy, S., Havrylenko, A., Kostolovych, M., Derkach, O., & Hrebenyk, T. (2025). Designing the digital environment of higher education for the quality training of specialists. *Revista Eduweb*, 19(3), 284–302. <https://doi.org/10.46502/issn.1856-7576/2025.19.03.18>
- Colás-Bravo, P., Conde-Jiménez, J., & Reyes-de-Cózar, S. (2021). Sustainability and Digital Teaching Competence in Higher Education. *Sustainability*, 13(22), 12354. <https://doi.org/10.3390/su132212354>
- de Alwis, A., Shrestha, A., & Sarker, T. (2025). Exploring Governance for accreditation in the education sector using blockchain technology: a systematic literature review. *Discover Education*, 4(1). <https://doi.org/10.1007/s44217-025-00449-y>
- Dembitska, S., Kuzmenko, O., Savchenko, I., Demianenko, V., & Hanna, S. (2024). Digitization of the Educational and Scientific Space Based on STEAM Education. In *Towards a Hybrid, Flexible and Socially Engaged Higher Education* (pp. 329–337). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-53022-7_34
- Filippou, K., Acquah, E. O., & Bengs, A. (2025). Inclusive policies and practices in higher education: A systematic literature review. *Review of Education*, 13(1). <https://doi.org/10.1002/rev3.70034>
- Guillén-Gámez, F. D., Cabero-Almenara, J., Llorente-Cejudo, C., & Palacios-Rodríguez, A. (2021). Differential Analysis of the Years of Experience of Higher Education Teachers, their Digital Competence and use of Digital Resources: Comparative Research Methods. *Technology, Knowledge and Learning*, 27, 1193–1213. <https://doi.org/10.1007/s10758-021-09531-4>
- Hattab, H. W. (2023). An Empirical Investigation of the Effectiveness of Online Entrepreneurship Education among University Students In Egypt. *International Journal of Innovation in Education*, 8(1), 1. <https://doi.org/10.1504/ijie.2023.10051279>
- Inamorato dos Santos, A., Chinkes, E., Carvalho, M. A. G., Solórzano, C. M. V., & Marroni, L. S. (2023). The digital competence of academics in higher education: is the glass half empty or half full? *International Journal of Educational Technology in Higher Education*, 20(1). <https://doi.org/10.1186/s41239-022-00376-0>
- Ismail, M.N., Duan., & Wahid, K.A. (2026). Factors influencing vocational education teachers' digital competencies: A systematic literature review. *Environment and Social Psychology*, 11(1). <https://doi.org/10.59429/esp.v11i1.4102>
- Kurebay, B., Seitenova, S., Khassanova, I., Kazetova, A., Bayukanskaya, S., & Mailybaeva, G. (2023). Competence of primary school teachers in the use of internet resources. *International Journal of Education in Mathematics, Science and Technology*, 11(4), 964–980. <https://doi.org/10.46328/ijemst.3466>
- Kulichenko, A. K., Sotnik, T. V., & Stadnychenko, K. V. (2018). Electronic portfolio as a technique of developing creativity of a foreign language teacher. *Information Technologies and Learning Tools*, 66(4), 286–304. <https://doi.org/10.33407/itlt.v66i4.2178>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Kulichenko, A., Shramko, R., Rakhno, M., & Polyezhaev, Y. (2023). Two-dimension educational resistance in the modern Ukrainian tertiary educational establishment. *Apuntes Universitarios*, 13(1), 474–493. <https://doi.org/10.17162/au.v13i1.1351>
- Kuzminska, O., Morze, N., Varchenko-Trotsenko, L., Boiko, M., & Prokopchuk, M. (2021). Digital Competence of Future Researchers: Empirical Research of PhD Students of Ukrainian University. In *DHW 2021: Digital Humanities Workshop*. ACM. <https://doi.org/10.1145/3526242.3526258>
- Leichsenring, A., & Clauss, A. (2024). Competence-Oriented Qualification in Digital Community Management. In *Towards a Hybrid, Flexible and Socially Engaged Higher Education* (pp. 169–180). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-52667-1_18
- Lidolf, S., & Pasco, D. (2020). Educational Technology Professional Development in Higher Education: A Systematic Literature Review of Empirical Research. *Frontiers in Education*, 5. <https://doi.org/10.3389/feduc.2020.00035>
- Ma, K., & Fang, B. (2023). Exploring Generation Z's expectations at future work: the impact of digital technology on job searching. *European Journal of Training and Development*, 48(9), 933–953. <https://doi.org/10.1108/ejtd-05-2023-0076>
- Maricato, D., Aquino, J., & Jóhannesson, G. T. (2026). Pedagogical practices in tourism higher education: a systematic literature review. *Frontiers in Sustainable Tourism*, 4. <https://doi.org/10.3389/frsut.2025.1720759>
- Mason, J., Cieri, K., & Spurr, C. (2023). Problematising »Cultural Competence« in the Digital Environment. In *Digital Teaching and Learning in Higher Education* (pp. 33–48). transcript Verlag. <https://doi.org/10.14361/9783839462768-003>
- Omrany, H., Al-Obaidi, K. M., Ghaffarianhoseini, A., Chang, R.-D., Park, C., & Rahimian, F. (2025). Digital twin technology for education, training and learning in construction industry: implications for research and practice. *Engineering, Construction and Architectural Management*, 33(3), 1836–1870. <https://doi.org/10.1108/ecam-10-2024-1376>
- Osuna-Juárez, A., & González-Castellano, N. (2023). Understanding professors' and students with disabilities' perceptions of inclusive higher education: a systematic literature review. *European Journal of Special Needs Education*, 39(5), 774–788. <https://doi.org/10.1080/08856257.2023.2294238>
- Palamar, S., Nezhyva, L., Brovko, K., & Bodnenko, D. (2023). Digital Technologies as a Means of Forming Subject-Methodical Competence Future Primary School Teachers. In *Information and Communication Technologies in Education, Research, and Industrial Applications* (pp. 336–347). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-48325-7_26
- Pérez Estébanez, R., & Pastor Estébanez, M. (2025). Shaping the Future Through Business Education: Teaching Business Administration for Sustainable Higher Education. *Administrative Sciences*, 15(8), 325. <https://doi.org/10.3390/admsci15080325>
- Pérez-Valls, M., Sánchez, B. P., & Morgado, A. (2023). Teaching and learning. In *Digital competence in higher education: A European perspective*. (pp. 115–136). Dykinson. <https://doi.org/10.2307/jj.5076296.10>
- Pichkur, M. O., Poluden, L. I., Demchenko, I. I., & Sotska, H. I. (2023). Digital footprints monitoring of higher art education applicants training. *Information Technologies and Learning Tools*, 94(2), 128–149. <https://doi.org/10.33407/itlt.v94i2.5205>
- Polyezhaev, Y., Terletska, L., Kulichenko, A., Vorobiova, L., & Snizhko, N. (2024). The role of web applications in the development of multilingual competence

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- in CLIL courses in higher education. *Revista Eduweb*, 18(3), 106–118. <https://doi.org/10.46502/issn.1856-7576/2024.18.03.9>
- Ramírez Heredia, R. C., Franco Lazarte, E. G., & Carcausto-Calla, W. (2025). Factors Influencing the Development of Digital Competencies in Higher Education Teachers in Latin America: A Systematic Review. *Journal of Educational and Social Research*, 15(1), 104. <https://doi.org/10.36941/jesr-2025-0009>
- Santos, C., Pedro, N., & Mattar, J. (2021). Digital competence of higher education professors. *Obra digital*, (21), 69–92. <https://doi.org/10.25029/od.2021.311.21>
- Sillat, L. H., Tammets, K., & Laanpere, M. (2021). Digital Competence Assessment Methods in Higher Education: A Systematic Literature Review. *Education Sciences*, 11(8), 402. <https://doi.org/10.3390/educsci11080402>
- Sliwka, A., Klopsch, B., Beigel, J., & Tung, L. (2023). Transformational leadership for deeper learning: shaping innovative school practices for enhanced learning. *Journal of Educational Administration*, 62(1), 103–121. <https://doi.org/10.1108/jea-03-2023-0049>
- Sohail, M., & Gupta, S. (2024). Analysing challenges for Information and Research Literacy skills using an integrated approach of Delphi and Best-worst method. *Journal of Decision Systems*, 1–26. <https://doi.org/10.1080/12460125.2024.2331639>
- Spante, M., Hashemi, S. S., Lundin, M., Algers, A., & Wang, S. (2018). Digital competence and digital literacy in higher education research: Systematic review of concept use. *Cogent Education*, 5(1), 1519143. <https://doi.org/10.1080/2331186x.2018.1519143>
- Sposato, M. (2024). Developing Digital Leadership Skills for AI-Driven Research Environments. In *Advances in Educational Technologies and Instructional Design* (pp. 235–254). IGI Global. <https://doi.org/10.4018/979-8-3693-0884-4.ch010>
- Turabay, G., Mailybaeva, G., Seitenova, S., Meterbayeva, K., Duisenbayev, A., & Ismailova, G. (2023). Analysis of intercultural communication competencies in prospective primary school teachers' use of internet technologies. *International Journal of Education in Mathematics, Science and Technology*, 11(6), 1537–1554. <https://doi.org/10.46328/ijemst.3795>
- Zarceño García de Soriano, A. J., Agreda Montoro, M., & Ortiz Colón, A. M. (2024). Digital Teaching Competence and Educational Inclusion in Higher Education. A Systematic Review. *Electronic Journal of e-Learning*, 22(1), 31–45. <https://doi.org/10.34190/ejel.22.1.3139>
- Zhao, Y., Pinto Llorente, A. M., & Sánchez Gómez, M. C. (2021). Digital competence in higher education research: A systematic literature review. *Computers & Education*, 168, 104212. <https://doi.org/10.1016/j.compedu.2021.104212>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Integración de las TIC en la enseñanza de las disciplinas de comunicación social: enfoques pedagógicos y metodológicos

ICT integration in teaching social communication disciplines: Pedagogical and methodological approaches

luksel Gaiana¹ Tetiana Hyrina² Oleksii Sytnyk³ Anzhelika Dosenko⁴ Olha Bykova⁵

Afiliación autor:

¹ Professor of the Department of Journalism, Volodymyr Vernadskiy Taurida National University, Kyiv, Ukraine.

gayanayuksel@gmail.com

² Head of the Department of Social Communications, Philology and Culture, State Tax University, Irpin, Ukraine.

hirinatetyana@gmail.com

³ Associate Professor at the Department of Editorial and Publishing Technologies and Production Taras Shevchenko National University of Kyiv, Kyiv, Ukraine.

sytnyk@knu.ua

⁴ The head of the Department of Journalism, Volodymyr Vernadskiy Taurida National University Kyiv, Ukraine.

Dosenko.anzhelika@tnu.edu.ua

⁵ Associate Professor at the Department of Publishing and Editing, National Technical University of Ukraine "Igor Sikorsky Polytechnic Institute", Kyiv, Ukraine.

bykova.olha@edu.kpi.ua

Recibido: 04/04/26

Aceptado: 11/06/26

Cómo citar:

Gaiana, I., Hyrina, T., Sytnyk, O., Dosenko, A., & Bykova, O. (2026). ICT integration in teaching social communication disciplines: Pedagogical and methodological approaches. *Revista Eduweb*, 20(2), 358-377. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.21>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

Este trabajo de investigación utiliza un diseño de métodos mixtos para investigar la integración de las TIC en la enseñanza de disciplinas de comunicación social. Se empleó una encuesta, entrevistas semiestructuradas y un análisis de documentos para recopilar información de 120 participantes (58 docentes y 62 estudiantes) en cinco universidades. Se pusieron a prueba tres hipótesis basadas en TPACK, constructivismo, conectivismo, DigComp y la Taxonomía Digital de Bloom. Los resultados mostraron que los sistemas de gestión del aprendizaje y las herramientas de videoconferencia son las más utilizadas, mientras que las plataformas de radio digital y las aplicaciones de IA no se utilizan con tanta frecuencia. Existen altas correlaciones positivas que indican que la frecuencia de uso de las TIC ($r=0,564$), las prácticas pedagógicas constructivistas ($r=0,598$) y la claridad del marco metodológico ($r=0,473$) están vinculadas con la eficacia instruccional percibida. Las deficiencias en infraestructura y tiempo son los principales problemas que surgen y están correlacionadas positivamente con las oportunidades de innovación ($r=0,418$). Entre los temas cualitativos identificados se encuentran la autenticidad profesional en la integración de las TIC, el conocimiento metodológico tácito y la ambivalencia hacia la IA. La investigación ofrece implicaciones teóricas y sugerencias prácticas para docentes y centros educativos.

Palabras clave: Plataformas digitales, integración de las TIC, educación en medios de comunicación, Inteligencia Artificial, periodismo radiofónico.

Abstract

This research paper uses a mixed methods design to investigate the ICT integration in the teaching of social communication disciplines. A survey, semi-structured interviews and an analysis of documents were used to gather information on 120 respondents (58 faculty and 62 students) in five universities. Three hypotheses were tested based on TPACK, constructivism, connectivism, DigComp and Bloom Digital Taxonomy. The findings have shown that Learning Management Systems and Video Conferencing tools are used the most, and the digital radio platforms and AI applications are not used that often. There are high positive correlations that indicate that ICT use frequency ($r=0.564$), constructivism pedagogical practices ($r=0.598$) and clarity of methodological framework ($r=0.473$) are linked with perceived instructional effectiveness. Deficits in infrastructure and time are the main problems that arise and they are positively correlated with the opportunities of innovation ($r=0.418$). Such qualitative themes are professional authenticity in ICT integration, tacit methodological knowledge,

and ambivalence to AI. The research has theoretical implications and practical suggestions to teachers and schools.

Keywords: Artificial Intelligence, digital platforms, ICT integration, media education, radio journalism.

Introduction

The rapid digitalization of higher education altered the way academic instructions in different fields are delivered (Bitar & Davidovich, 2024). It is particularly crucial with respect to social communication disciplines such as journalism, PR, advertising, and media studies, which prepare students to work in digital-oriented professions (Bondarchuk et al., 2026). The usage of ICTs such as learning management systems, social media, digital audio workstations and AI-content tools in education has become the focus of usage and critical analysis (Tokmakov et al., 2025). Whereas, the radio stations and podcasting platforms by students are experiential learning laboratories where communication students learn the practical audio production and broadcasting skills. The use of ICT in these disciplines is not a change of technology, but the redefinition of the teaching and learning paradigms (Vandeyar & Adegoke, 2024). The use of artificial intelligence tools, such as generative AI to create content and automated fact-checking, is transforming journalism and communication education around the world.

The Technological Pedagogical Content Knowledge (TPACK) approach connects technology, pedagogy and content, which are the elements that have to be combined by teachers in order to incorporate ICT. This paradigm applies pedagogical strategies such as collaborative learning, flipped classes, and experiential learning to establish the effect of technological aids on learning as to whether they improve or transform learning (Adhami & Taghizadeh, 2024). Such methods as instructional design frameworks, assessment methods, and activity structures organizing technology-enhanced learning are also significant (Abuhassna & Alnawajha, 2023). Effective ICT integration in teaching social communication enhances student participation, real-world professional training, and digital skills that are relevant in the industry (Gopinathan et al., 2022; Sharma et al., 2024). The instructional value of technology posits constructivist theory that the technology is useful in instruction because it assists and facilitates knowledge construction as opposed to delivering material passively.

The gaps between the technological availability and pedagogical use of technology in communication education have been reported in the recent scholarship (Shruthi et al., 2025; Valverde-Berrocoso et al., 2022). Although the digital tools are proliferated, journalism programs do not have any cohesive methodological approach to the implementation of technology in the programs. On the same note, studies on PR education show incongruent compatibility between digital needs in the industry and teaching (Moise & Chmiel, 2026). The core problem addressed by this study is twofold. First, limited empirical research has systematically examined the pedagogical approaches that characterize effective technology integration in social communication disciplines. Second, even fewer studies have investigated the methodological frameworks that structure such integration. Consequently, educators lack evidence-based guidance for curriculum development and instructional design tailored to journalism, public relations, media studies, and related disciplines. The given research fills this gap as it studies particular ICT tools and platforms adopted into social communication teaching, explores pedagogical strategies and methodological models that promote their successful use, and discusses the challenges and opportunities teachers face during the process.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

This study pursues the following objectives, grounded in its dual focus on pedagogy and methodology:

- To identify Information and Communication Technology tools and digital platforms integrated into social communication teaching and examine their perceived effectiveness as reported by faculty and students.
- To examine pedagogical approaches and methodological frameworks supporting Information and Communication Technology-enhanced instruction in social communication courses.
- To analyze challenges and opportunities in Information and Communication Technology integration with implications for pedagogical and methodological practice.

The research aims at investigating the adoption of Information and Communication Technologies in teaching social communication subjects at the tertiary level. The following research questions guide the study.

- What Information and Communication Technology tools and digital platforms are most perceived as effectively integrated into the teaching of social communication disciplines in higher education?
- What pedagogical approaches and methodological frameworks best support Information and Communication Technology-enhanced instruction in social communication courses?
- What challenges and opportunities do educators face when implementing Information and Communication Technology in social communication discipline teaching?

This study has numerous higher education stakeholders that can gain in a philosophical and practical way. It is a poorly studied field of social communication that employs TPACK, constructivism, and connectivism. There is evidence-based guidance about using ICT devices and platforms, successful teaching strategies, and powerful methodological practices of journalism, PR, media studies, and courses in this field. The research assists the curriculum developers in incorporating digital competency. It assists institutional policymakers in the development of faculty and resources. The initiative is a union of both technology and pedagogy to equip the students with digital communication careers and to be able to satisfy the industry expectations.

Theoretical Framework or Literature Review

The proposed study is based on five complementary theoretical models that shed light on the pedagogical and methodological aspects of ICT integration in the social communication education. Table 1 will be a brief overview of the unique contribution of each framework to this study.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 1.
Theoretical Frameworks and Their Roles in the Study

Framework	Key Focus	Role in This Study
TPACK (Weisberg & Dawson, 2023)	Intersection of technology, pedagogy, and content knowledge	Leads the process to identify ICT tools (Section 2.1) and reports survey items on the practices of technology integration.
Constructivism (Umar et al., 2023)	Active knowledge construction through experience and social interaction	Instructs the discussed pedagogical approaches (Section 2.2) and defines interview questions about the teaching practices.
Connectivism (Aliyeva et al., 2023)	Learning through networks and digital information sources	Offers theoretical framework to the role of social media and digital platforms as learning networks in communication education.
DigComp 2.2 (Riina et al., 2022)	Digital competence framework for citizens	Instructs the evaluation of digital capabilities and dictates the survey questions about ICT skills.
Bloom's Digital Taxonomy (Khokhar, 2025)	Mapping cognitive processes to digital tools	Offers guidelines on assessment of ICT tools in supporting various levels of learning (remembering to creating).

Source: Compiled by the authors
Note: Each framework serves a distinct analytical purpose in the study

ICT Resources and platforms in teaching social communication

The first target is to identify and evaluate the social communication teaching tools and platforms using the ICT tools. Research shows that there is integration of content management systems and social media into journalism education products, but this is largely “disorganized and pedagogically underdeveloped” (Garachkovska et al., 2022). There is little empirical evidence that social media monitoring and content creation software are educationally effective, and this software is now a part of PR programs.

For the digital media production courses, the most common software includes Adobe Creative Suite, digital audio workstations (DAWs), and video editing applications, with the goal of reaching a professional level of competence (Reuter, 2022). Communication program surveys indicate that the effectiveness of the use of these tools is hindered because of the cost of the licenses, lack of faculty training, and poor infrastructure. It is not common to explicitly teach a communication curriculum that includes AI, nor are there many AI literacy policies or pedagogical models in most communication programs (Noain-Sánchez, 2022).

Social communication students find radio and podcasting stations to be experiential learning labs in which they learn to produce audio products, engage audiences, and learn broadcast ethics (Mwangi, 2025). New advances in social media, streaming and digital audio workstations have revolutionized campus radio into a multi-platform content hub (Dowling, 2025). This development makes student radio not only a vehicle of dissemination of information but a multifaceted pedagogical instrument that enables students to think critically, work in teams, and develop digital literacy -

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

skills that are pivotal to working in the modern communication sector (Eswaran, 2024). AI-based analytics allow students to comprehend the audience behavior and engagement patterns and connect the theoretical understanding of the subject.

Methodologies and Pedagogies

The second goal investigates pedagogies and approaches to teaching social communication with the application of ICT. The research shows that ICT research in social studies is mainly reflective of perceptions (not learning outcomes) (Torres Madronero & Torres-Madronero, 2025). This is a huge topic for communication education because digital skills are a key component of practitioners' professional development (Stevens, 2025). Similarly, radio journalism training has also included the use of digital audio workstations, streaming and integration of social media that equip students to work in converged media settings.

Journalism education combines theory and practice in project-based learning, creating digital content for real audiences (Fowler-Watt, 2023). The concept of PR education emphasizes on a collaborative approach and the use of social media simulations to help students virtually experience stakeholder engagement (Toledano & Avidar, 2016). Digital video and audio production courses enable media production students to build professional portfolios and technical skills.

Despite this, teachers express their support for constructivist approaches but do not have specific methodological models on how to integrate ICTs. Journalism faculty use technology to aid their active learning, but can't explain their theories (Sitthiworachart et al., 2022). The use of AI in communication programs involves the technical training and ethical guidelines to tackle misinformation, bias, and academic honesty.

IT Integration Problems and Opportunities

The third goal is to analyse pedagogical problems and prospects of using ICT in social communication. ICT integration in resource constrained institutions is hampered by hardware limitations, weak internet connectivity, and inadequate software. Time constraints are also a major constraint: faculty members do not have sufficient time to learn how to use new technologies and implement ICT-integrated curricula (Fanguy et al., 2023). Journalism faculty are against AI tools for similar reasons as the larger issues with communication education around insufficient training and unclear policies (Fernández-Barrero et al., 2024).

Positive institutional conditions enable innovation, although the challenges are there. Journalism schools with separate academic digital media courses show that investments in infrastructure and faculty training can lead to a more sophisticated methodological approach that can equip students for change in the industry (De Juana-Espinosa et al., 2023). Specialized audio production programs provide students with targeted resources, enabling them to produce professional-quality audio content and better preparing them for industry needs (Mehendale, 2024). A comparative study between Brazil and Romania identified the high lack of infrastructure as a challenge, while COVID-19 pandemic has driven the use of ICT and facilitated curriculum reform (da Rosa et al., 2025).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Contributions and Research Gap

In this study, the authors make three unique contributions to the current literature. In the first place, previous studies have looked at the integration of ICT in general education settings, but there is little empirical research devoted to the social communication disciplines (journalism, public relations, media studies and advertising). This study seeks to bridge this gap with the discipline-specific evidence provided by ICT tools, pedagogical approaches and methodological frameworks that are uniquely relevant to communication education.

Second, this study is a mixed methods design (explanatory sequential) that combines quantitative and qualitative methods, and the majority of previous studies only used quantitative or qualitative methods. In this way, there is a possibility to generalize the findings and also to gain a deeper insight into the ways and reasons of ICT integration in social communication teaching.

Third, this study uniquely investigates the less-studied connection between perceived instructional effectiveness with the clarity of methodological frameworks which inform ICT integration. Much of the existing research has been on the adoption rate of tools without examining the pedagogical and methodological aspects that enable them to be integrated successfully. This study is a novel contribution both in TPACK and connectivism literature in the field of communication education by recognizing the difference between endorsement of constructivist pedagogy and the implicit pedagogical frameworks.

From the above literature review, research gap and distinctive contributions, the following hypotheses are developed to address the research questions and objectives of this study:

H1: Information and Communication Technology tools and digital platforms integration is positively associated with perceived instructional effectiveness in social communication teaching.

H2: Pedagogical approaches and methodological frameworks significantly predict successful Information and Communication Technology-enhanced instruction in social communication courses.

H3: Challenges in Information and Communication Technology integration are positively correlated with opportunities for curriculum innovation when supportive institutional mechanisms exist.

Methodology

Research Design

The research used mixed methods explanatory sequential design, both quantitative and qualitative methods were used to examine the research thoroughly, especially regarding the subject of the research being studied, namely the integration of ICT in the teaching of social communication disciplines. The design incorporated breadth via a larger sample of survey data, then depth via qualitative interviews and document analysis with subsamples. The quantitative data collection and analysis was carried out before the qualitative data collection so that the qualitative results can explain and elaborate on the quantitative data.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Objectives, Methodology, and Analytical Framework

The research was carried out in Ukraine in five state and private universities, that provide journalism, public relations, media studies, advertising, and communication studies degrees. Institutions were chosen for the following reasons: (a) documented interest in the integration of ICT; (b) programme diversity (three public and two private universities); (c) geographic spread (urban and regional).

A sample size n of 84 was calculated from a power analysis with G*Power for correlation analysis with medium effect size ($r = 0.30$), $\alpha = 0.05$ and power = 0.80.

The sample size of 120 obtained was thus adequate.

In quantitative strand, a total of 120 respondents (58 faculty, 62 students) were taken from the five universities. Students were recruited by class announcements and faculty through departmental e-mail. Each of 120 respondents answered the survey instrument.

Purposive subsamples were selected from respondents of the survey for the qualitative strand. A total of 20 faculty members from four universities were selected based on their experiences with the use of ICT (at least two years), and their disciplines representation and were interviewed semi-structuredly. Three programs were chosen for detailed documentation, depending on the availability of curriculum and the maturity of the program.

Data Collection Instruments

Three instruments were used. A structured survey was used to measure the frequency, types and perceived effectiveness of the use of ICT tools, first. The questionnaire contained 6 parts: demographic information, inventory of ICT tools, pedagogical approaches, perceived effectiveness, challenges and opportunities, and open-ended reflections. Composites were created using items on a Likert scale (Perceived Effectiveness, Challenge Recognition, Pedagogical Approach, Methodological Clarity). The reliability of the items was determined by means of Cronbach's alpha as follows: Perceived Effectiveness ($\alpha = 0.87$), Challenge Recognition ($\alpha = 0.84$), Pedagogical Approach ($\alpha = 0.82$), Methodological Clarity ($\alpha = 0.79$). The full survey was deployed after a pilot study on 10 faculty members was conducted.

Second, a semi-structured interview guide was used to capture the experiences of the faculty on using ICTs, what they believed, the pedagogical approach, and the challenges experienced. Probes provided rich information on tools and teaching practices.

Finally, an analysis of documents was conducted to analyse ICT integrated curriculum and course materials of selected programmes. Syllabi, lesson plans, description of assignments and assessment rubrics were systematically coded and analyzed.

Procedures

The data collection process was carried out in three stages, spanning a period of 4 months from September to December 2024. The survey (Phase One) was four weeks, interviews (Phase Two) three weeks, and document collection (Phase

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Three) three weeks, all of which overlapped to allow for data preparation and analysis.

The questionnaire was sent electronically to five universities through Qualtrics (Phase One: Survey, Weeks 1-4). Deliveries were made by institutional contacts via departmental email lists. There were two follow-up reminders at two-week intervals. The consent to access the survey was obtained electronically. This survey was left open for 4 weeks and received a total of 120 complete responses.

Patterns identified through the preliminary analysis of the survey were then explored during phase two – Interviews (weeks 5-7). Twenty faculty members were contacted who were willing to be interviewed. Semi structured interviews were held, 20 were done on Zoom, 5 in-person (with participants' consent and recorded and transcribed exactly as spoken). Interviews lasted 45–60 minutes. Field notes were taken.

During Phase Three (Weeks 8-10), curriculum documents were gathered from three programs: course syllabi ($n = 24$), lesson plans ($n = 18$), assignment descriptions ($n = 35$), and assessment rubrics ($n = 22$). All the materials were documented and ready to be analyzed.

Data Analysis

The data were analysed using SPSS version 28 which was a quantitative data analysis. Demographic characteristics and the use of ICT tools were summarized by descriptive statistics (frequencies, means and standard deviations) as were perceived effectiveness ratings. Pearson correlation coefficients were used to explore correlations between the use of ICTs and pedagogical approaches, methodological clarity and the perceived effectiveness. Independent samples t-test was used to compare faculty and student views. Assumptions of parametric test (normality & homogeneity of variance) were checked and met. A p-value of < 0.05 was considered significant.

Thematic analysis was employed to analyze the qualitative data, which consisted of the six stages: familiarization, initial coding in NVivo 14, theme search, thematic review, thematic definition and final analysis as recommended (Kushnir, 2025). Inter-coder reliability was achieved by having two researchers transcribe 20% of the interviews independently, which resulted in a κ of 0.84. For member checking, the results of the preliminary analysis were presented to three interview participants to check the accuracy of the interpretation.

Ethical Considerations

This study has been approved by the Institutional Review Board of the first author's university (Protocol #EDU-2024-045). Informed consent was obtained from all participants. All the identifiable data were anonymized and participants were given pseudonyms for confidentiality. The data were kept in password protected servers which were only accessible by the research team. Participants were informed that they are free to drop out anytime without repercussions.

Limitations

There are a number of restrictions to note. The results of this purposed sampling technique do not necessarily extrapolate to other contexts outside of Ukraine. Social desirability bias can be an issue in self-report data. A cross-sectional design collects data at one point in time, thus capturing the ICT integration at one time. Confounding

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

variables may be caused by differences in infrastructure between institutions. If students are involved on a voluntary basis, this can result in a sample of the only students who are interested in learning about ICT integration. Despite these constraints, the mixed methods design and data sources triangulation contributes to the credibility and trustworthiness.

Results

The results of the data collection process, which is presented in this section, are based on the mixed methods data collection procedures that are outlined in the methodology. The findings are summarized based on the three research questions and hypotheses. The evidence of quantitative data will be introduced by descriptive and inferential statistics, then qualitative data will be provided in the form of interviews and document analysis. All the statistical data were examined with SPSS 28, and the p-value was determined as $p < 0.05$. Parameters tests (normality, homogeneity of variance) were tested and satisfied before analysis.

Table 2 shows the demographic data of 120 respondents of the survey (58 faculty, 62 students) in five universities in Ukraine.

Table 2.
Demographic Characteristics of Survey Respondents

Characteristic	Category	Frequency (n)	Percentage (%)
Role	Faculty	58	48.3
	Student	62	51.7
Discipline	Journalism	35	29.2
	Public Relations	28	23.3
	Media Studies	32	26.7
	Advertising	15	12.5
	Communication Studies	10	8.3
Gender	Male	52	43.3
	Female	68	56.7
Institution Type	Public University	72	60
	Private University	48	40

Source: Survey Data

Note: The sample was balanced in terms of faculty (48.3%) and students (51.7%). Most of the disciplinary representation was represented by Journalism (29.2%), Media Studies (26.7%), and Public Relations (23.3%)

The selection criteria for the participants were: (a) faculty should be at least one year teaching social communication courses, (b) the student should have been engaged in studies for at least one semester in a social communication program, (c) the institution should have a degree program in either journalism, public relations, media studies, advertising or communication studies.

The selection process was three steps as given in tabe 2. First, five universities (three public, two private) in urban and regional settings in Ukraine were selected for their exemplary work in integration of ICT. Second, faculty were recruited by invitation via Departmental e-mail and students by invitation in the classroom. Third, after receiving 145 expressions of interest, 120 participants (58 faculty, 62 students) who met the inclusion criteria were chosen, ensuring representation across disciplines and roles.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The sample represents faculty and students of Ukrainian higher education institutions with social communication programs. The findings however, are not statistically generalizable to other populations because of the purposive sampling method and the focus on one country (Ukraine). Rather, the results provide analytical generalizability, meaning that they yield theory building and practice implications that can be generalized to similar institutional settings.

Table 3.
ICT Tools Usage and Pedagogical Practices

ICT Tools and Pedagogical Practices	Mean (M)	SD
ICT Tools Usage Frequency		
Learning Management Systems	4.42	0.68
Video Conferencing Tools	4.38	0.72
Social Media Platforms	4.12	0.84
Collaborative Tools	3.98	0.91
AI-Powered Tools	3.76	1.02
Content Creation Tools	3.68	1.08
Podcasting Platforms	3.42	1.21
Video Production Tools	3.28	1.18
Digital Radio/Streaming Tools	2.86	1.32
Quiz and Interactive Tools	2.74	1.24
Pedagogical Practices		
Facilitate collaborative learning	4.28	0.74
Active knowledge construction	4.16	0.82
Connect with real-world practices	4.08	0.88
Project-based and experiential learning	3.96	0.94
Systematic alignment with objectives	3.84	1.02
Clear methodological framework	3.62	1.14
Employ AI tools for teaching	3.48	1.21
Integrate radio/podcasting tools	3.12	1.34

Source: Survey Data

Note: ICT tools usage frequency scale: 1=Never to 5=Very Often. Pedagogical practices scale: 1=Strongly Disagree to 5=Strongly Agree.

According to Table 3, Learning Management Systems (M=4.42) and Video Conferencing Tools (M=4.38) were most frequently used, while Digital Radio/Streaming Tools (M=2.86) and Quiz Tools (M=2.74) were least used. Pedagogically, collaborative learning (M=4.28) and active knowledge construction (M=4.16) received the highest endorsement, whereas methodological framework clarity (M=3.62) and radio/podcasting integration (M=3.12) scored lowest. Additionally, the results of the surveys have shown that AI-based tools (M=3.76, SD=1.02) were moderately adopted, with faculty members being both eager and worried about using them in their classrooms. Moreover, data also indicated that one of the least used technologies was digital radio and streaming tools (M=2.86, SD=1.32) and podcasting platforms (M=3.42, SD=1.21) although all of these technologies were relevant to the profession.

Pearson correlation coefficients were calculated to test Hypotheses 1 and 2 in the test of relationships between the frequency of ICT use, the scores of pedagogical approaches, methodological clarity, and perceived effectiveness. The correlation matrix in the form of a heatmap is given in Figure 1.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

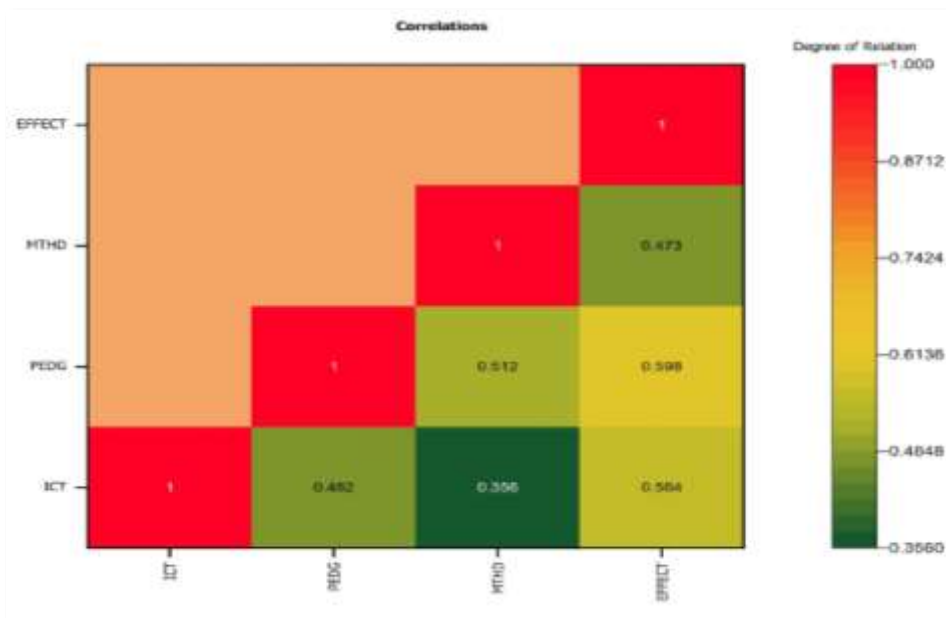


Figure 1. Correlation Heatmap of ICT Integration Variables.

Source: Survey Data

Note: ICT stands for ICT usage frequency, MTHD for Methodological Clarity, PEDG for Pedagogical Approach and EFFECT is for Perceived Effectiveness

ICT usage frequency had a positive correlation with perceived effectiveness ($r = 0.564$, which corresponds to Hypothesis 1 as Figure 1 shows. Pedagogical approach scores were also related to perceived effectiveness ($r = 0.598$), and methodological clarity related to both pedagogical approaches ($r = 0.512$) and perceived effectiveness ($r = 0.473$) which proved Hypothesis 2.

Faculty and student views were compared in independent samples t-tests. Table 4 presents the results.

Table 4.

Faculty and Student Perspectives on ICT Integration

Variable	Faculty Mean (SD)	Student Mean (SD)	t-value	p-value
ICT Tools Usage Frequency	4.02 (0.68)	3.84 (0.74)	2.14	0.034*
Perceived Effectiveness	4.18 (0.62)	3.92 (0.78)	2.42	0.017*
Challenge Recognition	3.96 (0.72)	3.68 (0.84)	2.28	0.024*

Note: $p < 0.05$

Source: Survey Data

Table 4 demonstrates statistically significant differences in faculty and student approaches towards all three measures. The faculty indicated greater frequency of ICT usage, perceived effectiveness, and more challenge acute perception than students ($p < 0.05$, all).

Table 5 displays the average challenge ratings and the correlation of challenges and opportunities.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Table 5.
Challenges and Opportunities in ICT Integration

Challenge	Mean (M)	SD
Insufficient ICT infrastructure	4.18	0.86
Limited time to learn new technologies	4.06	0.92
Lack of faculty training	3.94	1.04
Rapidly changing technologies	3.88	0.98
Insufficient funding	3.82	1.12
Students' limited digital literacy	3.68	1.08
Lack of clear institutional policies	3.54	1.18
Concerns about AI misuse	3.42	1.24
Limited radio/podcasting integration	3.28	1.32
Correlation	r-value	p-value
Challenges × Opportunities	0.418	0.001**

Source: Survey Data

Note: Challenge scale: 1=Not a Challenge to 5=Very Significant Challenge.
** $p < 0.01$.

As Table 5 indicates, the most challenging ones were inadequate infrastructure (M=4.18) and time (M=4.06). Hypothesis 3 is supported by the positive relationship between challenges and opportunities ($r = 0.418$, $p < 0.01$).

Five universities were interviewed with 20 faculty members in semi-structured interviews. Interpretation of interviews transcripts using thematic analysis showed that there were four themes. Table 6 provides a summary of the themes and the quotation used to support them and their frequency of occurrence.

Table 6.
Qualitative Themes from Faculty Interviews

Theme	Description	Frequency (n)	Example Quotation
Theme 1: Professional Authenticity	ICT tools valued for simulating real-world professional environments	15 (75%)	"Social media platforms aren't just teaching tools—they're the actual tools students will use professionally. When they manage a Twitter feed for class, they're building portfolio pieces." (Journalism Faculty, #7)
Theme 2: Tacit Methodological Knowledge	Faculty demonstrate sophisticated ICT integration but cannot articulate explicit frameworks	12 (60%)	"I know what works, but I haven't formalized it into a framework. It's more intuitive—I try things, see what engages students, and adjust." (Media Studies Faculty, #12)
Theme 3: AI Ambivalence	Educators recognize AI's potential but express concerns about academic integrity	14 (70%)	"AI like ChatGPT is both exciting and terrifying. It can help students generate ideas and refine writing, but we're still figuring out academic integrity guidelines." (PR Faculty, #5)
Theme 4: Radio/Podcasting as Revitalized Pedagogy	Audio journalism teaching has evolved from traditional radio to digital podcasting	8 (40%)	"Radio isn't dead—it's evolved into podcasting. Teaching audio journalism now means teaching digital production, distribution, and audience analytics." (Journalism Faculty, #3)

Source: Interview Data

Note: Frequencies indicate the number of faculty members (out of 20) who mentioned each theme. Percentages calculated as $(n/20) \times 100$.

Three programs (two publicly based, one privately based) curriculum documents were examined, such as course syllabi ($n=24$), lesson plans ($n=18$), assignment

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

descriptions (n=35) and assessment rubrics (n=22). Table 7 presents the findings. At the qualitative level, interviews with faculty members showed that they are aware of the possibilities of AI in terms of individual learning and automated evaluation but are still unsure about the institutional policies that govern the utilization of AI.

Table 7.
Document Analysis of ICT Integration in Curricula

Document Type	Findings	Examples
Course Syllabi	18 of 24 syllabi (75%) explicitly mentioned ICT tools; 6 (25%) had no ICT reference	"Students will use Adobe Audition for audio production" (Program A); "Weekly blog posts on WordPress" (Program B)
Lesson Plans	12 of 18 lesson plans (67%) included ICT-based activities; 6 (33%) relied on traditional lecture	"Students record podcast segments in groups" (Program A); "Analyze social media campaign case studies" (Program C)
Assignments	28 of 35 assignments (80%) required ICT use; 7 (20%) were text-based only	"Create a 10-minute podcast episode" (Program A); "Develop a PR campaign using Canva and Hootsuite" (Program B)
Assessment Rubrics	14 of 22 rubrics (64%) included criteria for digital competencies; 8 (36%) did not	"Audio quality, editing proficiency, and storytelling structure" (Program A)

Source: Document Analysis (2024)

As the analysis of the documents in Table 7 showed, programs that included specific courses on digital media (Program A) reflected more systematic integration of ICT, and ICT became explicit in the syllabi, assignments, and grading rubrics. Those programs, whose digital courses were not implemented, demonstrated a disjointed ICT integration, with the tools listed in the assignments, but not correlated with the learning goals and evaluation standards (Turchyn et al., 2023). Furthermore, document analysis showed that programs that had specific audio production facilities showed greater systematic incorporation of radio and podcasting tools in curricula.

Discussion

The present study deals with pedagogical and methodological aspects of the integration of ICT in the social communication disciplines of teaching. Below, the results are presented and interpreted in terms of the three research questions and hypotheses and relate explicitly to the theories presented in Table 1.

The use of ICT Tools and Platforms (RQ1, H1)

The use of basic tools (Learning Management Systems and video conferencing) was seen as most common whereas use of specialized tools (digital radio platforms and AI applications) was least common, which aligns with the TPACK model (Mishra & Koehler, 2006). TPACK theorizes that for technology to be well integrated, all three knowledge bases technological, pedagogical, and content must interact. The low use of specialized tools indicates that teachers might have technological knowledge of the tools but not pedagogical knowledge for the meaningful use of the tools in social communication curricula. This interpretation is confirmed by qualitative

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

interviews held, where faculty members identified inadequate training and poor facilities as being the main barriers.

This trend is also described in the DigComp 2.2 (Vuorikari et al., 2025; Kurebay et al., 2023). Content creation and problem-solving are listed as sophisticated digital skills in the framework. Underutilization of digital radio and podcasting tools ($M=2.86$, $M=3.42$) indicates a lack of proficiency in using these skills by faculty, which highlights the need for professional development. The results of the correlation analysis of the frequency of using ICT with perceived teaching-learning effectiveness are $r=0.564$, $p<0.01$, which leads to the acceptance of the H1 hypothesis, where it proves that the use of ICT tools by teachers enables them to perceive better teaching-learning outcomes (Boichenko et al., 2023; Jiménez-Sierra et al., 2023).

Pedagogical Approaches and Methodological Frameworks (RQ2, H2)

A positive score for collaborative learning $M=4.28$, active knowledge construction $M=4.16$ is in keeping with the Constructivist Learning Theory which asserts that learners construct knowledge by interacting with the environment and others. The low score for methodological framework clarity ($M=3.62$), however, shows that there is a big problem: teachers engage in constructivist practices in a more intuitive manner than they can explain explicit frameworks.

The gap can be addressed using Bloom's Digital Taxonomy (Churches, 2010). The taxonomy is a tool that helps map ICT tools with cognitive levels ranging from remembering to creating. The results show that teachers are mostly using ICT tools for lower order thinking skills (collaboration and construction of knowledge) and not so much for higher order thinking skills for creative production (digital radio, podcasting and video production). This is the reason why there is a low adoption of production tools which are more professional. The significant correlation between pedagogical approaches and their effectiveness ($r=0.598$, $p<0.01$) and that of methodological clarity and effectiveness ($r=0.473$, $p<0.01$) confirms H2 (Sánchez et al., 2023).

Challenges and Opportunities (RQ3, H3)

Infrastructure deficits ($M=4.18$) and timetables ($M=4.06$) are identified as major problems and these are interpreted using the Connectivism that explains that learning in digital learning environment needs networks of information sources. Lack of infrastructure harms these networks, decreasing opportunities for networked and collaborative learning (Aliyeva et al., 2023). The correlation between challenges and opportunities is positive, with an r value of 0.418 and p value of <0.01 , thus supporting H3 which indicates that barriers in the presence of institutions can stimulate innovation.

Qualitative results showed that faculty in institutions that had invested in training and facilities came out with innovative practices. Programs that had a special digital media course (Program A, Table 7) showed systematic integration of ICT, where the integration of ICT was made explicit in the syllabus, assignments, and rubrics. This is considered to be consistent with the DigComp 2.2 focus on the support of the development of digital competence in the organization. The results are consistent with the international research on communication education. The use of constructivist practices is based on research in journalism education that found project-based learning is able to connect theory and practice to journalism education (D'Elia et al., 2025). The low level of use of special tools in the production of media

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

shows a similar pattern compared to media production education research (Jaakkola, 2022). This opposition between constructivist acceptance and implicit frameworks is aligned with the comparison studies conducted in Brazil (Ramírez et al., 2025). The ambivalent attitude towards AI integration across the globe is reflected in the moderate score for AI adoption by faculty ($M=3.48$) and the moderate score for AI concerns with academic integrity in this study. Moreover, academic programs offering specialized audio production resources and education enable students to create content of the highest quality, which narrows the divide between school training and industry requirements.

Theoretical Implications

This study builds upon TPACK by showing how the concept of professional authenticity in the integration of ICTs in the context of constructivist learning environments is specifically unique to communication education. It builds on Connectivism by demonstrating the ways in which social media can be used as a professional networking and portfolio creation tool, tailored to journalism and PR. It also brings an element to DigComp 2.2 which highlights the need to communicate pedagogical reasoning – a tacit element that has been less emphasized in digital competence in the field of communication education. It uses Bloom's Digital Taxonomy for communication education, showing the use of ICT tools at the level of different cognitive processes (Chapman & Montecinos, 2025; Plaza De La Hoz et al., 2024).

Practical Implications

Educators should focus on ICT tools that are professionally relevant, representative of industry practice, and capture effective practices for integrating ICT in the classroom, as a way to make tacit knowledge explicit. Institutions should allocate resources for communication-specific infrastructure, including audio production space, designate time for faculty development for the use of AI, and implement policies encouraging ethical use of AI. Digital competencies should be integrated systematically in the curriculum through the syllabus, assignments, and rubrics (Cabero-Almenara et al., 2021), (Degen & Gleiss, 2025).

Unexpected Findings

Two unwarranted discoveries came to light. First, although there was talk around the world, AI tools were only used to a moderate extent ($M=3.76$) amongst faculty, who had shown interest in their potential benefits, but questioned about the issue of academic integrity and the lack of academic policy. Second, there are substantial perceptual differences between faculty and students (Table 4) that indicate faculty may have an inflated view of integration or student expectations may be greater, underscoring the need for students to play a part in the technology planning process.

Conclusion

This study examined ICT integration in teaching social communication disciplines, focusing on pedagogical and methodological approaches across five Ukrainian universities. The findings show that simple tools, such as Learning Management Systems (LMS) and video conferencing, were used more often, while more advanced tools such as digital radio platforms and AI tools were less frequently employed. The positive correlation between the frequency of ICT use and the instructional effectiveness indicates that from faculty and student perspectives, the

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

more frequently ICTs are used, the more effective and fruitful the teaching-learning process becomes. Constructivist pedagogical practices, particularly collaborative learning and active knowledge construction, demonstrate the strongest relationship with perceived effectiveness. However, explicit methodological frameworks guiding ICT integration remain underdeveloped, with educators relying on intuitive rather than formalized approaches. Infrastructure deficits, limited time, and insufficient training emerge as significant challenges, yet these correlate positively with opportunities for curriculum innovation when supportive institutional conditions exist. Notable perceptual differences between faculty and students suggest incorporating student perspectives in technology planning.

The scientific novelty of this study lies in three specific contributions. First, it extends TPACK by demonstrating that professional authenticity in ICT integration, where students use industry-standard tools within authentic professional contexts, creates constructivist learning environments uniquely suited to communication education. Third, it contributes to DigComp 2.2 by identifying that digital competence in communication education requires not only technical proficiency but also the ability to articulate pedagogical reasoning, a tacit dimension previously underemphasized in digital competence frameworks. Therefore, the investments in sound production facilities could allow students to produce content of professional quality, closing the divide between academic training and requirements in the radio journalism industry.

Practically, educators should prioritize professionally relevant tools mirroring industry practices and document successful ICT integration strategies to make tacit knowledge explicit and transferable. Institutions must invest in communication-specific infrastructure, particularly audio production facilities, provide dedicated faculty development time, and establish clear policies supporting ethical AI integration.

Future research should examine how explicit methodological frameworks can be developed from tacit practitioner knowledge, how AI integration can be systematically incorporated into communication curricula with ethical safeguards, and how perceptual gaps between faculty and students can be bridged through participatory design approaches. Longitudinal studies tracking ICT integration over time would illuminate how evolving technologies shape pedagogical practices, while comparative research across institutional and cultural contexts would enhance understanding of context-specific factors influencing successful integration. The integration of AI is needed to be systematically studied in future research by how it can be integrated into the communication curricula with ethical considerations that equip students to meet industry requirements.

Acknowledgements

The authors gratefully acknowledge the faculty and students from participating universities for their valuable contributions to this study, as well as the institutional reviewers and editorial team for their support.

Bibliographic references

- Abuhassna, H., & Alnawajha, S. (2023). Instructional Design Made Easy! Instructional Design Models, Categories, Frameworks, Educational Context, and Recommendations for Future Work. *European Journal of Investigation in Health, Psychology and Education*, 13(4), 715–735. <https://doi.org/10.3390/ejihpe13040054>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Adhami, N., & Taghizadeh, M. (2024). Integrating inquiry-based learning and computer supported collaborative learning into flipped classroom: Effects on academic writing performance and perceptions of students of railway engineering. *Computer Assisted Language Learning*, 37(3), 521–557. <https://doi.org/10.1080/09588221.2022.2046107>
- Aliyeva, G. B., Honcharuk, V., Pavliuk, N., Zinchenko, V., & Sivachenko, I. (2023). Review of modern pedagogical technologies and methods in the field of philology according to European standards. *Revista on line de Política e Gestão Educacional*, 27(esp.2), e023049. <https://doi.org/10.22633/rpge.v27iesp.2.18778>
- Bitar, N., & Davidovich, N. (2024). Transforming Pedagogy: The Digital Revolution in Higher Education. *Education Sciences*, 14(8), 811. <https://doi.org/10.3390/educsci14080811>
- Bondarchuk, A., Tonkikh, I., Lutsenko, S., Tsilyna, M., & Lukianchuk, I. (2026). Media in education: Production, content, and pedagogical approaches for journalists. *Revista Conrado*, 22(108), e5125–e5125. <https://conrado.ucf.edu.cu/index.php/conrado/article/view/5125>
- Boichenko, M., Churychkanych, I., Kulichenko, A., Shramko, R., & Rakhno, M. (2023). Mind maps to boost the learning of English as L2 at higher education institutions in Ukraine. *Amazonia Investiga*, 12(70), 229–240. <https://doi.org/10.34069/AI/2023.70.10.21>
- Cabero-Almenara, J., Barroso-Osuna, J., Gutiérrez-Castillo, J.-J., & Palacios-Rodríguez, A. (2021). The teaching Digital Competence of Health Sciences Teachers. A Study at Andalusian Universities (Spain). *International Journal of Environmental Research and Public Health*, 18(5), 2552. <https://doi.org/10.3390/ijerph18052552>
- Chapman, C., & Montecinos, C. (2025). Professional learning in Latin America and the Caribbean: Towards a Networked Learning System? *Professional Development in Education*, 51(1), 1–6. <https://doi.org/10.1080/19415257.2025.2446110>
- Churches, A. (2010). *Bloom's digital taxonomy*. Recuperado de <http://burtonslifelearning.pbworks.com/w/file/fetch/26327358/BloomDigitalTaxonomy2001.pdf>
- da Rosa, T. A. B., Andreica, A. B., & Aragón, R. (2025). Digital information and communication technologies and teacher training from an international perspective: A study between brazil and romania. *Studia Universitatis Babes-Bolyai. Studia Europaea*, 70(2), 145–177. <https://www.ceeol.com/search/article-detail?id=1387786>
- De Juana-Espinosa, S. A., Brotons, M., Sabater, V., & Stankevičiūtė, Ž. (2023). An analysis of best practices to enhance higher education teaching staff digital and multimedia skills. *Human Systems Management*, 42(2), 193–207. <https://doi.org/10.3233/HSM-220060>
- Degen, K., & Gleiss, A. (2025). Time to break up? The case for tailor-made digital platform regulation based on platform-governance standard types. *Electronic Markets*, 35(1), 5. <https://doi.org/10.1007/s12525-024-00747-7>
- D'Elia, P., Stalmach, A., Di Sano, S., & Casale, G. (2025). Strategies for inclusive digital education: Problem/project-based learning, cooperative learning, and service learning for students with special educational needs. *Frontiers in Education*, 9, 1447489. <https://doi.org/10.3389/educ.2024.1447489>
- Dowling, D. O. (2025). Theorizing Podcast Journalism: Toward a Medium-Specific Framework for Audio Reporting. *Journalism and Media*, 7(1), 2. <https://doi.org/10.3390/journalmedia7010002>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

- Eswaran, U. (2024). Project-Based Learning: Fostering Collaboration, Creativity, and Critical Thinking. In M. Bhatia & M. T. Mushtaq (Eds.), *Advances in Educational Technologies and Instructional Design* (pp. 23–43). IGI Global. <https://doi.org/10.4018/979-8-3693-2169-0.ch002>
- Fanguy, M., Costley, J., Almusharraf, N., & Almusharraf, A. (2023). Online collaborative note-taking and discussion forums in flipped learning environments. *Australasian Journal of Educational Technology*, 39(2), 142–158. <https://doi.org/10.14742/ajet.8580>
- Fernández-Barrero, M.-Á., López-Redondo, I., & Aramburú-Moncada, L.-G. (2024). Possibilities and challenges of Artificial Intelligence in the teaching and learning process of Journalism Writing. The experience in Spanish universities. *Communication & Society*, 37(4), 241–256. <https://doi.org/10.15581/003.37.4.241-256>
- Fowler-Watt, K. (Ed.). (2023). Challenges and new directions in journalism education. London: Routledge. <https://doi.org/10.4324/9781003301028>
- Garachkovska, O., Parfeniuk, I., Haludzina-Horobets, V., Dmytrenko, N., Osaula, V., & Grebnov, G. (2022). Social Media as a Tool for the Development of Future Journalists' Communicative Competence. *Journal of Curriculum and Teaching*, 11(6), 16. <https://doi.org/10.5430/jct.v11n6p16>
- Gopinathan, S., Kaur, A. H., Veeraya, S., & Raman, M. (2022). The Role of Digital Collaboration in Student Engagement towards Enhancing Student Participation during COVID-19. *Sustainability*, 14(11), 6844. <https://doi.org/10.3390/su14116844>
- Jaakkola, M. (2022). Journalists as Media Educators: Journalistic Media Education as Inclusive Boundary Work. *Journalism Practice*, 16(6), 1265–1285. <https://doi.org/10.1080/17512786.2020.1844040>
- Jiménez-Sierra, Á. A., Ortega-Iglesias, J. M., Cabero-Almenara, J., & Palacios-Rodríguez, A. (2023). Development of the teacher's technological pedagogical content knowledge (TPACK): A systematic review. *Frontiers in Education*, 8, 1078913. <https://doi.org/10.3389/educ.2023.1078913>
- Khokhar, Y. (2025). Bloom's taxonomy and its digital evolution: A framework for school education. *International Research Journal of Modernization in Engineering Technology and Science*, 7(1), 45–52. <https://d1wqtxts1xzle7.cloudfront.net/122478808/IRJMETs70200060914-libre.pdf?1745490398>
- Kurebay, B., Seitenova, S., Khassanova, I., Kazetova, A., Bayukanskaya, S., & Mailybaeva, G. (2023). Competence of primary school teachers in the use of internet resources. *International Journal of Education in Mathematics, Science, and Technology*, 11(4), 964–980. <https://doi.org/10.46328/ijemst.3466>
- Kushnir, I. (2025). Thematic analysis in the area of education: A practical guide. *Cogent Education*, 12(1), 2471645. <https://doi.org/10.1080/2331186X.2025.2471645>
- Mehendale, S. G. (2024). Calling for 'Podo-gogy': Why podcasting needs to be a part of journalism education in India. *Media Practice and Education*, 25(1), 77–94. <https://doi.org/10.1080/25741136.2023.2263825>
- Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record: The Voice of Scholarship in Education*, 108(6), 1017–1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
- Moise, R., & Chmiel, M. (2026). Theoretical orientations of higher education public relations educators in Europe and implications for pedagogy. *Journal of Communication Management*, 1–22. <https://doi.org/10.1108/JCOM-05-2025-0125>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Mwangi, A. I. (2025). Examining ethics in new media. (graduate thesis), The Aga Khan University. https://ecommons.aku.edu/theses_dissertations/2386/
- Noain-Sánchez, A. (2022). Addressing the Impact of Artificial Intelligence on Journalism: The perception of experts, journalists and academics. *Communication & Society*, 35(3), 105–121. <https://doi.org/10.15581/003.35.3.105-121>
- Plaza De La Hoz, J., Espinosa Zárate, Z., & Camilli Trujillo, C. (2024). Digitalisation and poverty in Latin America: A theoretical review with a focus on education. *Humanities and Social Sciences Communications*, 11(1), 1194. <https://doi.org/10.1057/s41599-024-03692-0>
- Ramírez, H. R., Franco, E., & Carcausto, W. (2025). Factors influencing the development of digital competencies in higher education teachers in Latin America: A systematic review. *Journal of Educational and Social Research*, 15(1), 104. <https://doi.org/10.36941/jesr-2025-0009>
- Reuter, A. (2022). Who let the DAWs Out? The Digital in a New Generation of the Digital Audio Workstation. *Popular Music and Society*, 45(2), 113–128. <https://doi.org/10.1080/03007766.2021.1972701>
- Riina, V., Stefano, K., & Yves, P. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens-With new examples of knowledge, skills and attitudes*. Joint Research Centre. <https://ideas.repec.org/p/ipt/iptwpa/jrc128415.html>
- Sánchez, S. P., Guerrero, A. J. M., Núñez, J. A. L., & Belmonte, J. L. (2023). Flipped learning as a pedagogical alternative for the work of musical expression in times of pandemic. *Retos*, (47), 384–393. <https://dialnet.unirioja.es/servlet/articulo?codigo=8638078>
- Sharma, A., Jayalakshmi, S., Tripathy, A., Katekhaye, D., & Sharma, A. (2024). Exploring innovative pedagogical approaches for enhanced student engagement. *Decision Making: Applications in Management and Engineering*, 7(1), 175–188. <https://dmame-journals.org/index.php/dmame/article/view/20>
- Shruthi, H. L., Radhakrishnan, A., Veigas, A. D., Railis, D. J., & Dinesh, R. S. (2025). Analyzing pedagogy and education in English language teaching using information and communication technology. *Education and Information Technologies*, 30(12), 16551–16573. <https://doi.org/10.1007/s10639-025-13439-2>
- Sitthiworachart, J., Joy, M., King, E., Sinclair, J., & Foss, J. (2022). Technology-Supported Active Learning in a Flexible Teaching Space. *Education Sciences*, 12(9), 634. <https://doi.org/10.3390/educsci12090634>
- Stevens, C. (2025). Teachers and teaching: Pedagogy, digital skills and professional development. *Open Learning: The Journal of Open, Distance and e-Learning*, 40(1), 1–3. <https://doi.org/10.1080/02680513.2024.2436665>
- Tokmakov, D., Tokmakova, A., Shotarova, S., Lyubomirov, S., Mileva, N., & Tokmakova, K. (2025). AI Educational Video Creation Methodology for University Courses. *2025 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, 1–8. <https://doi.org/10.1109/TALE66047.2025.11346699>
- Toledano, M., & Avidar, R. (2016). Public relations, ethics, and social media: A cross-national study of PR practitioners. *Public Relations Review*, 42(1), 161–169. <https://doi.org/10.1016/j.pubrev.2015.11.012>
- Torres Madronero, E., & Torres-Madronero, M. C. (2025). The use of information and communication technologies in teaching-learning processes of social science in higher education: A systematic review. *Innovations in Education and Teaching International*, 62(2), 731–744. <https://doi.org/10.1080/14703297.2024.2333387>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Turchyn, I., Zaitseva, S., Rudenko, N., Saienko, V., Kuzemko, N., & Deneffil, O. (2023). Using distance learning models as opportunities for blended learning for foreigners. *Revista Romaneasca Pentru Educatie Multidimensionala*, 15(4), 178–191. <https://doi.org/10.18662/rrem/15.4/787>
- Umar, N., Atan, N. A., & Majid, U. M. A. (2023). Learning activities based on social constructivism theory to promote social interaction and student's performance (EPSISM). In *AIP Conference Proceedings* (Vol. 2569, No. 1, p. 060004). AIP Publishing LLC. <https://doi.org/10.1063/5.0112879>
- Valverde-Berrocoso, J., Acevedo-Borrega, J., & Cerezo-Pizarro, M. (2022). Educational Technology and Student Performance: A Systematic Review. *Frontiers in Education*, 7, 916502. <https://doi.org/10.3389/feduc.2022.916502>
- Vandeyar, T., & Adegoke, O. O. (2024). Teachers' ICT in pedagogy: A case for mentoring and mirrored practice. *Education and Information Technologies*, 29(14), 18985–19004. <https://doi.org/10.1007/s10639-024-12603-4>
- Vuorikari, R., Pokropek, A., & Muñoz, J. C. (2025). Enhancing digital skills assessment: Introducing compact tools for measuring digital competence. *Technology, Knowledge and Learning*, 31, 519–546. <https://doi.org/10.1007/s10758-025-09825-x>
- Weisberg, L., & Dawson, K. (2023). The Intersection of Equity Pedagogy and Technology Integration in Preservice Teacher Education: A Scoping Review. *Journal of Teacher Education*, 74(4), 327–342. <https://doi.org/10.1177/00224871231182129>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

El papel de las tecnologías digitales en el avance de la calidad educativa para estudiantes con necesidades educativas especiales: un análisis de la educación superior

The role of digital technologies in advancing educational quality for students with special educational needs: A higher education analysis

Liudmyla Nikolenko¹ Svitlana Kulbida² Nataliia Pakhomova³ Olha Hubar⁴ Serhii Levsha⁵

Afiliación autor:

¹ Oles Honchar Dnipro National University, Associate Professor, Professor, Dnipro, Ukraine. nikolenko_l@uiis.in.ua

² Mykola Yarmachenko Institute of Special Pedagogy and Psychology, National Academy of Educational Sciences of Ukraine, Professor, Kyiv, Ukraine. svk5554@gmail.com

³ Educational and Research Institute of Special and Inclusive Education, Poltava V.G. Korolenko National Pedagogical University, Professor, Poltava, Ukraine. nataliypng24@gmail.com

⁴ Educational and Research Institute of Special and Inclusive Education, Poltava V.G. Korolenko National Pedagogical University, Associate Professor, Poltava, Ukraine. olgagubar82@gmail.com

⁵ Educational and Scientific Institute of Special and Inclusive Education, Poltava V.G. Korolenko National Pedagogical University, Poltava, Ukraine. serhiilevsha@gmail.com

Recibido: 06/04/26
Aceptado: 09/06/26

Cómo citar:

Nikolenko, L., Kulbida, S., Pakhomova, N., Hubar, O., & Levsha, S. (2026). The role of digital technologies in advancing educational quality for students with special educational needs: A higher education analysis. *Revista Eduweb*, 20(2), 378-396.
<https://doi.org/10.46502/issn.1856-7576/2026.20.02.22>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Resumen

La integración funcional de la tecnología digital en la educación superior es clave para mejorar el acceso a los materiales de aprendizaje y apoyar la inclusión de estudiantes con necesidades educativas especiales (NEE). El objetivo de este artículo es reconocer las tecnologías digitales relevantes e identificar las brechas y barreras en el proceso educativo en las instituciones de educación superior (IES) de la Unión Europea (UE). La síntesis, sistematización y generalización de la literatura científica, para delinear las principales soluciones digitales en educación inclusiva y las barreras estructurales relacionadas, se realizó mediante métodos cualitativos. La parte cuantitativa se basa en cálculos de chi-cuadrado (χ^2) y utiliza datos agregados de estadísticas oficiales para analizar patrones de distribución a lo largo de los ejes de tipo de discapacidad, nivel de logro educativo, edad y género. Encontramos evidencia de un efecto de estratificación en el logro educativo entre grupos con diferente gravedad de discapacidad, aunque con patrones específicos por edad y género. Sin embargo, debido a la naturaleza del análisis de datos agregados, los resultados deben considerarse descriptivos y no inferenciales, y no implican relaciones causales. Los hallazgos destacan el papel de las tecnologías digitales como elemento facilitador para brindar acceso y equidad a la educación superior a estudiantes con necesidades educativas especiales (NEE). No obstante, el impacto del acceso digital en los resultados sigue viéndose limitado por barreras y desafíos organizativos, infraestructurales y socioeconómicos, que deberán explorarse mediante enfoques empíricos más rigurosos.

Palabras clave: tecnologías digitales, educación superior inclusiva, tecnologías de la información y la comunicación (TIC), rendimiento educativo, estudiantes con necesidades educativas especiales (NEE), Unión Europea, análisis de chi-cuadrado, enfoque de métodos mixtos, accesibilidad, inclusión digital.

Abstract

The integration of enabling digital technology in a functional way in higher education is the key to enhance access to learning materials and to support the inclusion of students with special educational needs (SEN). The scope of this article is to recognise digital technologies which are relevant and to identify gaps and barriers to the educational process in higher education institutions (HEIs) in the European Union (EU). The synthesis, systematization and generalization of scientific literature, for outlining main digital solutions in inclusive education and related structural barriers, was realized through qualitative methods. The quantitative part is based on chi-square (χ^2) calculations, and uses data at an aggregated level from official statistics to analyze patterns of distribution along the axes of type of disability, level of educational attainment, age and gender. We find evidence of a stratification effect in educational attainment between groups with differing severity of disability, albeit with age and gender specific patterns. However, because of the nature of aggregate data analysis, the results are to be considered descriptive and not inferential, and no causal relationships are implied. The findings emphasize the role

of digital technologies as an enabling element in providing access to and equity in higher education for students with SEN. Nevertheless, the impact of digital access on outcomes continues to be limited by organizational, infrastructural and socio-economic barriers and challenges, and these will need to be explored using stronger empirical approaches.

Keywords: digital technologies, inclusive higher education, information and communication technologies (ICT), educational attainment, students with special educational needs (SEN), European Union, chi-square analysis, mixed-methods approach, accessibility, digital inclusion.

Introduction

Currently, inclusion is a widely accepted strategy for the development of education around the world. European countries demonstrate some of the highest levels of adaptation to learners with special educational needs. According to EASNIE (2024) data on average education levels, these countries include Denmark (ISCED 2 = 100), the Netherlands (ISCED 2 = 100), Switzerland (ISCED 2 = 100), Luxembourg (ISCED 1 = 99.73), Malta (ISCED 02 = 100), etc. However, more recent studies by Olsson & Volleberg (2025) have shown that the highest level of inclusion is in higher education institutions in Iceland (7.9), Norway (7.4), Scotland (7.4), and Sweden (7.2). Although the term “inclusion” is now used to refer to a much wider range of learners, not just those with special educational needs, we will focus on learners with special educational needs (hereafter, SEN) in higher education institutions, as it is for this group that specialized changes in approaches to theoretical and practical training are being implemented. In other words, the EU's education and training systems are currently geared towards ensuring that all students, regardless of their physical and/or mental health, complete their education. It is important to note that inclusive education in the EU appeals to the formation of intercultural competencies, democratic values, and respect for fundamental rights in students with special educational needs, preparing young people of different nationalities for positive interaction in society. Therefore, the issue of providing higher education institutions (hereafter, HEIs) with adaptive, adequate, and functional digital technologies capable of meeting the specific needs of students with SEN is becoming increasingly relevant.

Nonetheless, even with the increased attention to inclusive education and digital transformation, there is still a vague understanding of how digital tools affect the quality of the educational process in the case of students with special educational needs in higher education. This reveals an open issue in research regarding the identification of appropriate digital tools and their effect on the learning outcomes of this category of students. Within this framework, the research question of the study is: To what degree and in what ways can the use of digital technologies enhance the quality of education for students with special educational needs in Tertiary Education Institutions? Conversely, greater specificity is needed in the definition of the research purpose since a general statement thereof may be construed as lack of clarity and purpose for the work.

The purpose of the article is to identify digital technologies that ensure the proper quality of education for students with disabilities in higher education institutions of the European Union. The paper presents a theoretical analysis of the gaps and barriers that affect the quality of the educational process for this category of students. The study also includes an empirical analysis of the relationship between the type of disability and the level of education, taking into account gender differences. The descriptive analysis revealed notable structural differences in educational attainment across disability groups. The obtained results outline the

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

directions for the development of digital technologies in the higher education system and their use to improve accessibility and quality of education.

Literature Review

Digital accessibility and assistive technologies in inclusive higher education

The literature on digital technologies in inclusive higher education shows that digital tools should not be considered as a homogeneous group of technical solutions. Their educational value depends on the type of barrier they address and on the specific needs of students with special educational needs. In this regard, previous studies distinguish several functional groups of technologies: assistive tools that compensate for sensory, motor or communicative limitations; adaptive learning environments that personalize access to educational content; communication-support technologies; and institutional digital platforms that organize learning, assessment and interaction.

Assistive and adaptive technologies are most often discussed as instruments for expanding access to learning materials and supporting participation in the educational process. For example, AI-enhanced mind-mapping platforms and immersive tools such as ClassVR are considered useful for students with neurodevelopmental disorders because they support visual structuring, creative thinking and alternative ways of processing information (Fang et al., 2024). Virtual learning environments and online platforms also support course administration, assessment and interaction between students and teachers, which is especially important for students who need flexible learning formats (Long & Bouck, 2022). In science education, three-dimensional virtual laboratories may compensate for limited access to physical laboratory environments and provide alternative forms of practical learning (Elfakki et al., 2023). For students with hearing impairments, digital avatars and sign-language translation tools create additional channels of communication and improve access to educational information (Rocha et al., 2023). Another group of technologies is connected with independent learning and alternative access to educational content. Screen readers, speech-to-text tools, adaptive keyboards and specialized graphical interfaces help students overcome sensory, communicative and motor barriers in everyday learning activities (Matre & Cameron, 2024). Adaptive learning modules also make it possible to adjust the pace, sequence and format of educational content to students' individual cognitive responses. In the case of students with motor and neurological impairments, digital aids, speech therapy software and specialized keyboard interfaces may support communication and improve the accuracy of learning operations.

However, the existing literature also demonstrates that the technological availability of digital tools does not automatically guarantee educational quality. A number of studies emphasize the potential of assistive and adaptive technologies, but their long-term impact on educational attainment, academic retention and successful transition through higher education remains insufficiently measured. Therefore, digital technologies should be analyzed not only as tools that provide access, but also as elements of a broader inclusive educational environment.

Digital divide and structural barriers to SEN inclusion

A second important group of studies focuses on the digital divide and structural barriers that limit the inclusive potential of digital technologies. This literature is

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

significant because it challenges the assumption that digitalization is automatically inclusive. Although digital tools can expand access to educational materials, students from different socioeconomic contexts and rural communities often face unequal access to technological infrastructure and stable digital learning environments (Coker & Mercieca, 2023; Kormos & Julio, 2020). Therefore, the problem of digital inclusion is not limited to the physical availability of devices or Internet access.

International studies and policy reports also show that digital inequality includes differences in digital competencies, institutional readiness, technical support and the accessibility of digital platforms (European Agency for Special Needs and Inclusive Education, 2022; OECD, 2023). From this perspective, the digital divide is not only a technological issue, but also an organizational and social problem. If higher education institutions introduce digital tools without accessible design, adapted materials and systematic support, digitalization may reproduce the same inequalities that inclusive education is expected to reduce.

This point is especially important for students with SEN, because their educational barriers are often cumulative. They may include limited access to infrastructure, insufficient adaptation of educational content, lack of teacher preparedness and persistent social stereotypes about disability (Budnyk et al., 2022; Olynyk et al., 2023). Consequently, digital technologies can support inclusion only when they are integrated into a broader system of institutional accessibility and academic support.

Pedagogical and institutional conditions of digital inclusion

A third strand of literature examines how digital technologies are embedded in pedagogical practices and institutional strategies. Studies show that digital instruments can improve students' motivation, collaboration, communication and participation in inclusive educational settings (Kolbina et al., 2025; Ubachs, 2022). At the same time, these effects depend on the pedagogical conditions under which digital technologies are used. Digital tools do not improve educational quality by themselves; their effectiveness depends on teacher competence, inclusive instructional design, accessibility standards and the ability of higher education institutions to adapt learning environments to diverse student needs.

Teacher preparedness is one of the most frequently mentioned institutional conditions of inclusive digital education. Previous studies indicate that teachers often lack sufficient training for working with students with SEN in digitally mediated environments (Lopatina et al., 2024). This creates a gap between the formal availability of technologies and their real pedagogical use. In other words, assistive technologies may be present in the institution, but they may remain ineffective if teachers do not know how to integrate them into learning tasks, communication, assessment and feedback.

Policy-oriented literature adds another dimension to this discussion. International organizations emphasize that technological innovation should be aligned with inclusive policy frameworks, universal design principles and institutional quality assurance mechanisms (UNESCO, 2025). However, policy recommendations often remain general and do not always explain how digital inclusion affects concrete educational outcomes. This creates a gap between policy-level discourse and empirical analysis of educational attainment among students with disabilities.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Identifying critical gaps in literature

The reviewed literature allows several conclusions to be drawn. First, existing studies convincingly demonstrate that digital technologies can expand access to learning materials, support communication, personalize educational trajectories and increase the participation of students with SEN in higher education (Bešić et al., 2025; Fang et al., 2024; Navas-Bonilla et al., 2025; Samaniego López et al., 2025). Second, research on the digital divide shows that digitalization can also reproduce inequality when access to infrastructure, digital skills, accessible platforms and institutional support remains uneven (Coker & Mercieca, 2023; European Agency for Special Needs and Inclusive Education, 2022; Kormos & Julio, 2020; OECD, 2023). Third, studies on pedagogy and institutional readiness indicate that the inclusive effect of technology depends on teacher training, adapted materials, accessible design, academic support and organizational capacity (Lopatina et al., 2024; Ubachs, 2022).

At the same time, the literature remains fragmented. One group of studies concentrates mainly on the description of digital tools and their potential benefits (Elfakki et al., 2023; Long & Bouck, 2022; Matre & Cameron, 2024; Rocha et al., 2023). Another group focuses on structural barriers and institutional limitations (Budnyk et al., 2022; Olinyk et al., 2023). A third group discusses inclusive digital education at the level of policy and strategic recommendations (OECD, 2023; UNESCO, 2025). However, fewer studies connect these discussions with descriptive evidence on educational attainment and with the socio-demographic differentiation of persons with disabilities by age and gender.

This gap is important because the presence of digital technologies does not necessarily mean that educational inequality is reduced. The literature tends to emphasize the enabling potential of digital tools, but it less often examines whether students with different levels of disability are equally represented at higher levels of education. Therefore, the present study addresses this gap by combining a thematic synthesis of digital technologies and barriers in inclusive higher education with a descriptive analysis of aggregated Eurostat data on educational attainment among persons with different levels of disability. Such an approach does not aim to establish causal effects, but it allows digital inclusion to be discussed within the broader context of persistent structural disparities in access to higher education.

Methodology

Qualitative analysis

The following general scientific methods of cognition were used in the research process: (1) synthesis of scientific literature, which allowed characterizing digital technologies that support inclusive education for higher education seekers with SEN in the EU; (2) systematization method to identify gaps and barriers in ensuring the quality of the educational process for students with SEN in higher education institutions; (3) generalization method to compare the results of empirical research on the nature of educational inequality with the needs of students with disabilities in improving the quality of education through the introduction of digital technologies.

The goal of the qualitative part of the study is to recognize structural patterns, major barriers, and systemic voids in delivering inclusive higher education via digital technologies, which provides a more profound conceptual insight into the issue under investigation and enriches the empirical results.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Quantitative analysis

The empirical part of the study is based on the chi-square (χ^2) calculation as a structural indicator of distribution consistency (in %), which is acceptable for aggregated official data if the p-value is not interpreted as an inference. For this study, the chi-square (χ^2) test is only applied as a descriptive structure to compare the distributions, without considering the p-value for the interpretation as statistical inference, as the data are aggregated and have been taken from the official statistics.

The study involves a series of steps to identify structural differences in access to higher education among different groups of persons with disabilities:

- I. The formation of initial data for further calculations involves the analysis of secondary data from official reports (official percentage distributions) of the European Union (Eurostat, 2025), which allowed them to be systematized in Figure 1.

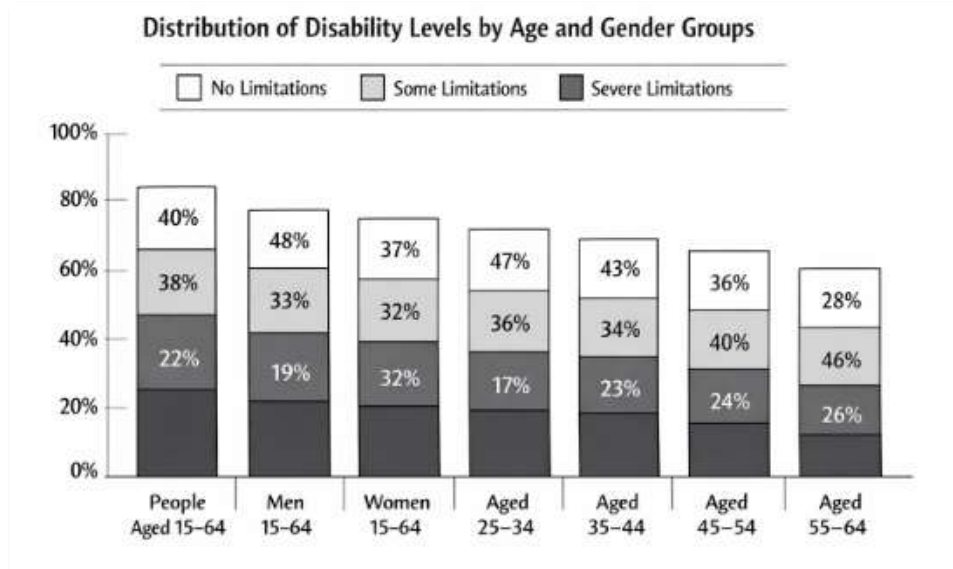


Figure 1. Observed values (O)

Source: Eurostat (2025)

Note: * – high educational attainment: low reliability.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Source of empirical data is the data collected by the European Labour Force Survey (EU Labour Force Survey), published by Eurostat (Eurostat, 2025). The EU Labour Force Survey is covering a wide range of issues regarding women employment, since it is collecting data on the involvement of adults in formal or non-formal education and training. Learner activity is counted during the four weeks prior to the date of survey. Participation rate in courses or training is presented as the ratio of participants to the total population of a selected age group. The respondents that did not respond the question referring to participation in an activity of employment, training or education are excluded from the sample.

In order to measure the disability, we have chosen the indicator limitation of the daily activities. It measures the severity of the handicap of an individual in carrying out his usual activities. It measures the extent of the limitation experienced by the individual in usual activities because of his health problem. In statistical terms the indicator is

known as the global activity limitation indicator (GALI). This GALI parameter is used in comparative analysis of the health and the functional capability of the population in the European social studies. The educational characteristics of the respondents in the figures are given in the form of grouped levels of educational achievement.

Based on the ISCED (International Standard Classification of Education), this classification is led by three good categories. First one, low educational level, it is for below primary education, primary education, and lower secondary education (ISCED 0–2); second one, secondary education, it is for upper secondary education and post-secondary non-tertiary education (ISCED 3–4); last one, tertiary education, it is for bachelor's, master's and doctoral programmes (ISCED 5–8).

However, within the scope of the calculations (in particular for the formation of initial data), only data on persons with disabilities and special educational needs in the context of higher education were used.

- I. The calculation of expected values to test the hypothesis of independence between disability type and education level was performed using the following formula:

$$E_{ij} = \frac{(\text{Rowtotal}_i * \text{Columntotal}_j)}{\text{Grandtotal}}, \quad (1)$$

where E_{ij} – expected values;

- II. Chi-square (χ^2) calculation to estimate the deviation of the observed distribution from the expected distribution, assuming statistical independence of variables. The calculation formula is as follows:

$$\chi^2_{cell} = \frac{(O * E)^2}{E}, \quad (2)$$

where χ^2_{cell} – chi-square; O – observed values (input data); E – expected values (E_{ij}).

- III. For testing the statistical significance of the association between the examined variables, the df was calculated as:

$$df = (r - 1)(c - 1), \quad (3)$$

df – degree of freedom; r – type of disability; c – level of education.

In this instance, since the data collected are not samples but aggregated percentages, the p-value cannot be interpreted as classical statistical significance. It is important to point out that because aggregated official data were used, the application of inferential statistics is limited; thus, in this study, the χ^2 test is used in a descriptive and comparative manner.

Using the qualitative and quantitative methodologies for data collection assures for methodological triangulation, enabling a holistic research problem investigation and contributes to research findings validity and reliability.

Thus, the purpose of applying the χ^2 calculation in this study is not to conduct inferential hypothesis testing, but to describe the extent to which the observed

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

distribution of educational attainment differs from the distribution expected under a condition of proportional independence between disability level, age group and gender. Since the study relies on aggregated official percentage data rather than individual-level microdata, the χ^2 values are interpreted as descriptive indicators of structural deviation, not as evidence for accepting or rejecting statistical hypotheses. H1: If educational attainment were distributed proportionally across disability groups, the observed values would be close to the expected values calculated under the independence benchmark.

H2: Larger deviations between observed and expected values indicate stronger structural disproportions in educational attainment across disability groups.

H3: Age and gender distributions are used to describe whether these disproportions are uniform across socio-demographic groups or concentrated in specific categories.

Results and Discussion

In recent years, education reforms in the European Union have been focused on the development of inclusive education. The EU's education policy shapes approaches that support the integration of people with different educational needs. Inclusion is based on the principle of equal value of every person in society. A person's social status is not linked to their abilities or academic achievements. Persons with disabilities and special educational needs are involved in a common educational space. The educational systems of EU countries are focused on eliminating discrimination in the educational process. At the same time, they are developing mechanisms for making education accessible to all groups of the population. The implementation of these approaches is coordinated by the European Pillar of Social Rights. The document was adopted by the European Council and the European Commission in December 2017. The provisions of the act enshrine the social, educational and cultural dimension of EU policy. These provisions define the strategic guidelines for shaping a common European future (European Commission, 2024).

Meanwhile, modern studies point out that the quality of inclusive education is more and more influenced by the degree of digitization of the educational environments, which allow for a flexible customization of the teaching and learning processes towards the specific needs of each student (OECD, 2023; UNESCO, 2025). Consequently, in the context of higher education, the digital transformation is emerging as a major facilitator of pan-European inclusive development.

The inclusive educational process involves the use of digital and information and communication technologies (ICT). Higher education institutions use these tools in teaching students with special educational needs. Digital educational technologies support the development of technical competencies of teachers and students. Navas-Bonilla et al. (2025) describe their use in the development of professional skills. A similar position is supported by González Villavicencio, & Estrella Flores (2023). The researchers link the use of digital tools to the expansion of the teacher's pedagogical capabilities. At the same time, digital educational technologies integrate students into a collaborative learning process. Therefore, **Figure 2** presents the conditions related to teachers and the institutional sphere for the effective digital inclusion of students with special educational needs.

Also, recent research shows that digital technologies have an outsize impact on improving access to and the personalization of learning for students with special educational needs, supporting the building of adaptive educational trajectories and

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

inclusive learning spaces (Bešić et al, 2025; Samaniego López et al., 2025). The convergence of assistive technologies, learning management systems, and AI-powered applications is also helping to break down structural barriers and increase participation rates among disabled students (Kolbina et al., 2025).

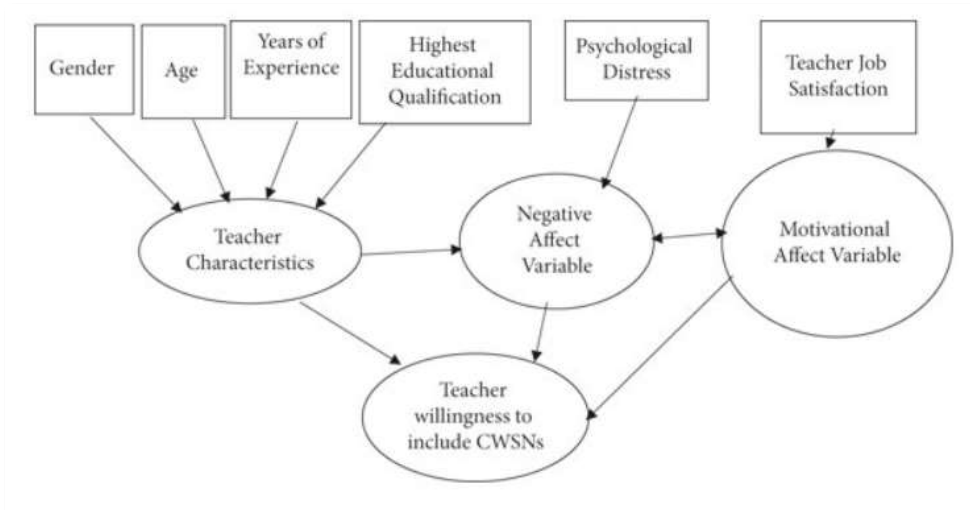


Figure 2. Teacher-related and institutional conditions for effective digital inclusion of students with special educational needs.

Source: compiled by the author based on Elfakki et al. (2023); Fang et al. (2024); Matre and Cameron (2024); Navas-Bonilla et al. (2025); Rocha et al. (2023); González Villavicencio, & Estrella Flores (2023)

This conditions clarifies that the inclusive potential of digital technologies depends on the interaction between technological access and the human, pedagogical and organizational conditions of higher education institutions. Digital technologies used by educational institutions in the European Union can expand student participation in the learning process and increase access to education. However, their effectiveness is limited when teachers lack training for inclusive digital instruction, when digital platforms are not accessible, or when institutional support for students with special educational needs remains fragmented. Therefore, digital inclusion should be understood not only as the introduction of technological tools, but also as the creation of conditions in which these tools can be pedagogically effective.

Digital technologies used by educational institutions in the European Union expand student participation in the learning process and increase access to education. The use of these tools improves the learning environment for people with special educational needs in higher education. Despite the proliferation of digital solutions, accessibility of education for people with disabilities remains uneven. Studies have identified a number of structural barriers to inclusive education. These include imperfect legislative regulation, limited accessibility of educational infrastructure, and differences between urban and rural educational institutions. Additional difficulties are created by insufficient adaptation of teaching materials and low levels of teacher training to work in an inclusive educational environment. Social stereotypes also limit the educational opportunities of people with disabilities. According to research, these factors explain the lower proportion of people with moderate and severe disabilities among higher education graduates (Kauffman et al., 2022).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

In addition, reports from international bodies show that digital divide is still a major problem, with gaps in access to technologies, digital skills, and the readiness of institutions continuing to have an impact on the quality of education received by students with SEN (OECD, 2023; European Agency for Special Needs and Inclusive Education, 2022). This underscores the importance of integrated policies in which technological innovation is accompanied with pedagogical and institutional reform. According to the Eurostat Labor Force Survey (2025), the educational attainment of the EU population varies significantly depending on health status. Among people aged 15-64 without disabilities, 33.6% have a university degree. For people with certain disabilities, this figure is lower and amounts to 23.9%. An even lower level is recorded among people with severe disabilities, where the share is 15.3%. The distribution of secondary education shows a different picture. The indicators hardly change depending on the presence of disability. Among people with severe disabilities, 43.7% have a secondary education. For people without disabilities, this figure is 43.9%. A slightly higher share is recorded among people with certain disabilities, 46.4%. The opposite pattern is observed in the group with low levels of education. The lowest share is recorded among people without disabilities, 22.5%. Among people with certain disabilities, the figure increases to 29.6%. The highest value is recorded in the severe disability group, where the share reaches 41.0%.

The analysis of the gender structure shows a similar gap between people without disabilities and people with certain disabilities for men and women. This gender distinction further confirms the complexity of educational inequality of the complexity of educational inequality, affected not just by the status of disability but layered by other socio-demographic factors, making multidimensional policy responses and inclusive digital tools necessary (Bešić et al., 2025; Ubachs, 2022). The same trend is observed in each education group. Women are more likely to have a high level of education. Men are more likely to fall into the category of low educational level. In 2024, the largest gender differences are recorded among people with higher education. Among people with certain disabilities, the share of young women with higher education is 26.3%. For young men, this figure is 21.1%, and the difference sometimes reaches 5%. A similar trend is found among people with severe disabilities. The share of young women with higher education is 18.1%. Among young men, this figure is 12.4%. The gender gap in this group reaches 5.7%. Meanwhile, digital technologies are progressively being understood as strategic instruments for the mitigation of such gaps through increased accessibility, flexibility and inclusiveness of the higher education systems (UNESCO, 2025; Kolbina et al., 2025).

The full distribution of educational attainment among people with special educational needs in the European Union is shown in Figure 3.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

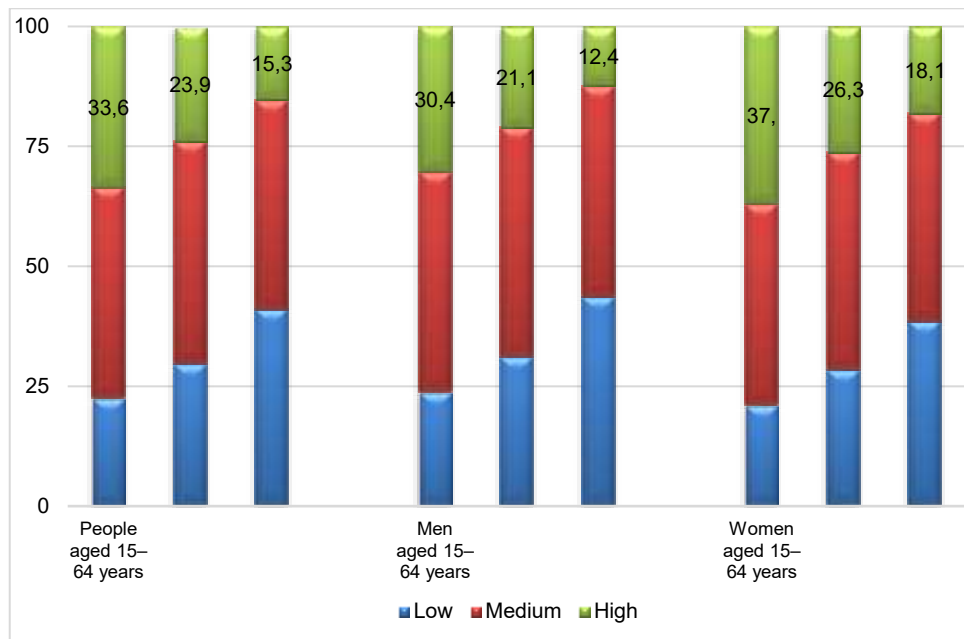


Figure 3. Distribution of educational attainment among persons with special educational needs in the EU in 2024 (%)
Source: Eurostat (2025)

A similar pattern was observed for each age group (divided into 10-year increments) shown in Figure 4.

Analysis by level of disability shows insignificant differences in the share of people with secondary education. The distribution of this category remains relatively stable across different groups. The situation is different for high and low educational levels. Among people without disabilities, high levels of education are more common. In this group, low levels of educational achievement are less common. Among people with severe disabilities, the share of low educational attainment is higher. At the same time, the share of people with higher education in this group is lower. Comparison of age groups shows a similar gap between people without disabilities and people with certain disabilities. This difference persists for all educational levels. It can be traced in groups from 25-34 years old to 55-64 years old. In the youngest age group of 15-24 years, the gap between disability groups is smaller. This is especially noticeable for the share of people with low or high levels of education.

Looking at the age groups of 25-34 years and older, researchers record a different trend. Regardless of disability, younger respondents are more likely to have a high level of education. Low educational level is less common among them compared to older generations. Some deviations from this trend are also recorded. For example, the proportion of people with severe disabilities who have higher education is higher among people aged 35-44. In this group, the figure is almost 18.6%. For people aged 25-34, it is lower and equals 16.3%.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

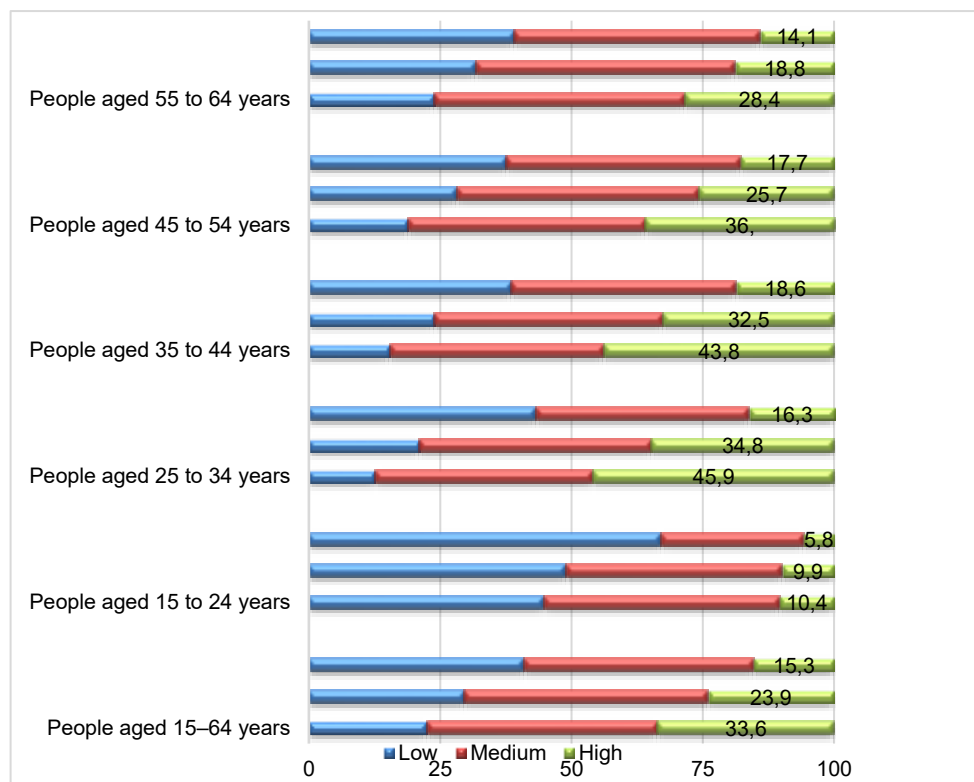


Figure 4. Distribution of educational attainment by disability level and age group among persons with special educational needs in the EU in 2024 (%)

Source: Eurostat (2025)

Note: * – high educational attainment: low reliability.

Among people with disabilities, the highest proportion of people aged 25-34 with higher education in 2024 was recorded in Luxembourg. The figure in this country is 46.6%. High values are also observed in Lithuania, 41.9%, and the Netherlands, 40.7%. All of these figures are above the European Union average. The EU average is 30.0%. The difference exceeds 10.0 percentage points. The lowest rate of educational attainment among people with disabilities was recorded in the Czech Republic. The share of people with higher education is 11.8%. The gap between people with and without disabilities in the EU remains significant. On average, it reaches 15.9%. The share of people with higher education among people with disabilities is 30.0%. For people without disabilities, this figure is 45.9%. There are significant differences in the size of the educational gap between the countries of the European Union. The smallest difference is recorded in Finland. In this country, it is 9.6%. In Poland, the gap is much larger and reaches 31.9%. The highest value is recorded in Ireland, where the difference between the groups is 34.6%.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

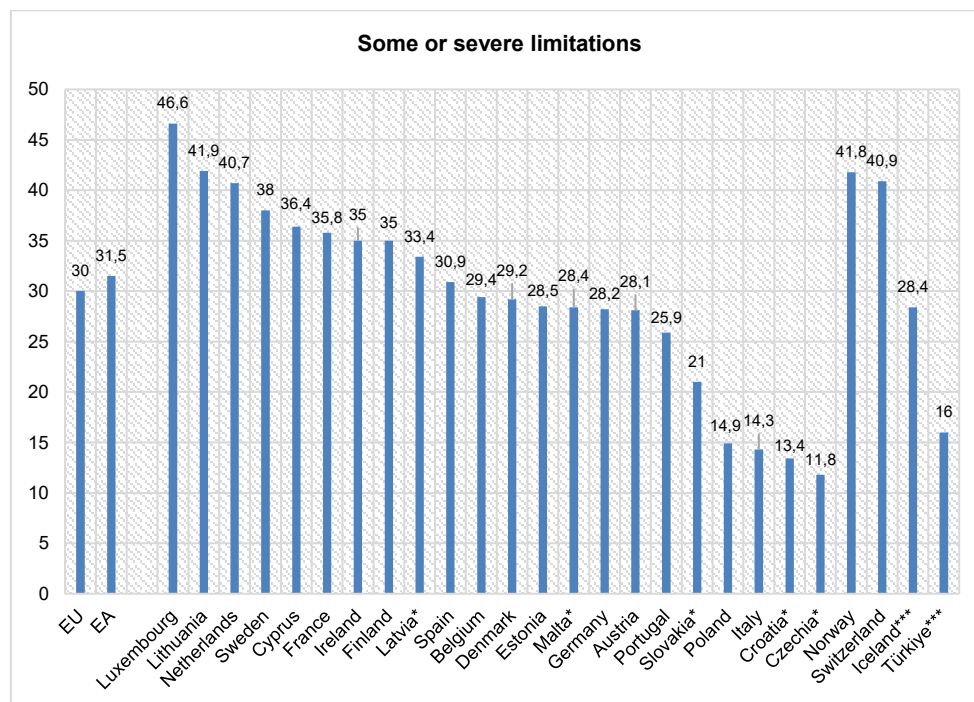


Figure 5. Level of higher education among people aged 25–34 by disability level in 2024 (%)

Source: Eurostat (2025)

Note: * – some or severe limitations: low reliability; ** – some or severe limitations: not published for reasons of low reliability; *** – data for 2022.

To empirically verify the existence of a statistically significant relationship between the level of disability and the educational level of persons with special educational needs, a quantitative analysis was conducted using the χ^2 (chi-square) criterion.

The χ^2 test is used in this study as a descriptive analytical instrument to detect structural patterns between variables, which is consistent with methodologies in recent literature on aggregated international data (OECD, 2023).

The analysis is based on aggregated statistical data from Eurostat (2025) and aims to identify structural differences in the distribution of educational achievements depending on the level of disability, age groups, and gender characteristics. The results obtained allow us to assess the inequality of educational opportunities within the EU's inclusive higher education system.

First, expected values were calculated for the observed distribution of educational attainment by disability level among persons aged 15–64. The calculation was performed under the independence benchmark, where the distribution of educational attainment is assumed to be proportional across disability groups. Since the study relies on aggregated Eurostat percentage data rather than individual-level microdata, these expected values are used only as descriptive reference values for comparison with the observed distribution (**Figure 6**).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

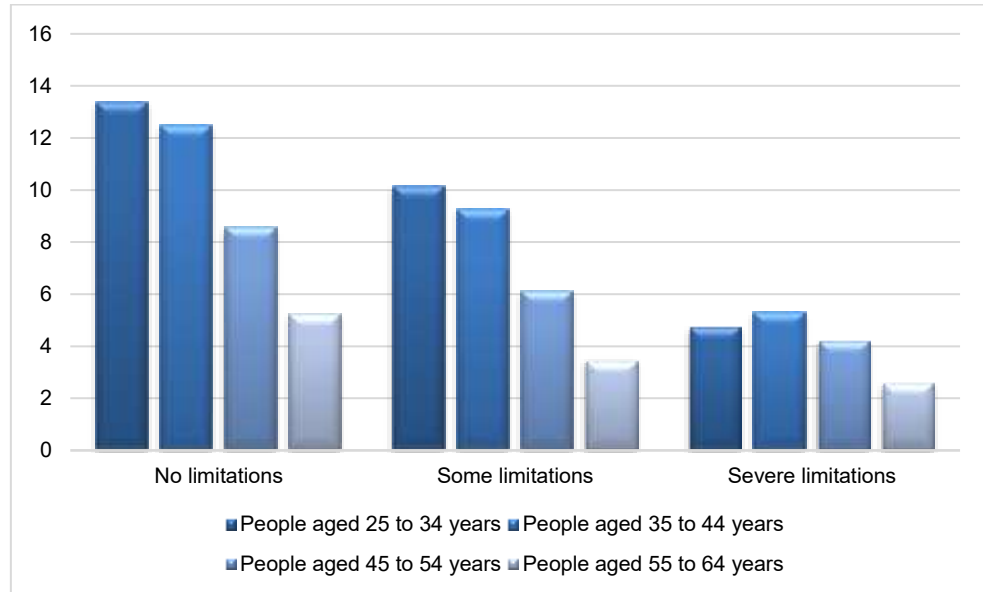


Figure 6. Expected distribution of educational attainment by disability level under the independence benchmark (%)

Source: calculated by the author based on aggregated percentage data from Eurostat.

The next step is to calculate the chi-square (χ^2) for different age groups and disability levels. The values obtained in Table 4 demonstrate the contribution of each cell to the total value of the χ^2 criterion.

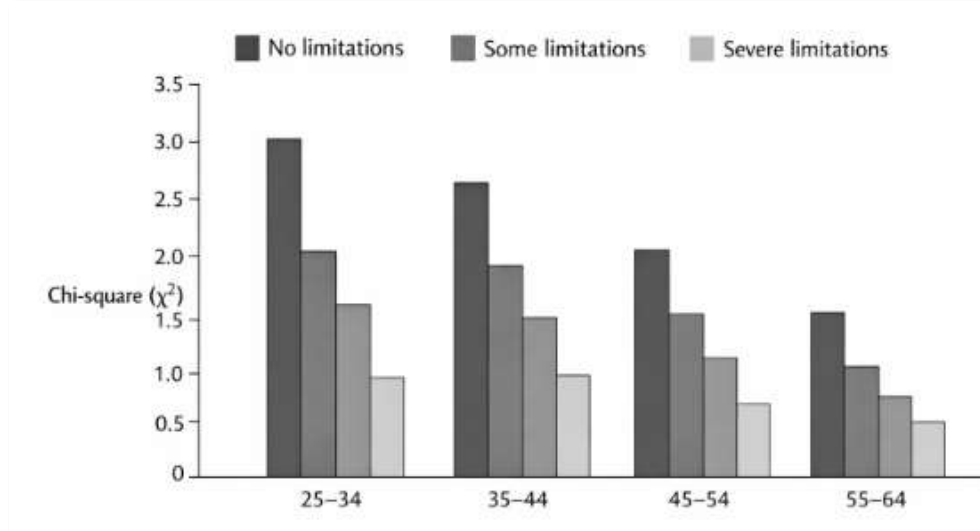


Figure 7. Results of calculating the χ^2 criterion.

Source: calculated by the author.

The largest contribution to the total χ^2 value is observed among persons without disabilities and persons with certain limitations in the 25-34 and 35-44 age groups, which indicates significant deviations from the expected distribution precisely during the period of higher education formation and completion.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

The calculation produced $\chi^2 = 17.17884356$ at $df = 4$. In this study, this value is not used for inferential hypothesis testing. Rather, it indicates a noticeable descriptive deviation between the observed distribution of educational attainment and the distribution expected under the independence benchmark. The largest deviations are concentrated in groups where disability severity is associated with lower representation at the tertiary education level and higher representation at the low educational attainment level.

Next, to reflect the theoretical distribution of indicators in the absence of the influence of the level of disability on the educational outcomes of men and women (for further calculation of the χ^2 criterion), the expected values were calculated for the analysis of the relationship between the level of disability and educational achievements, taking into account the gender distribution among persons aged 15–64 (**Figure 8**).

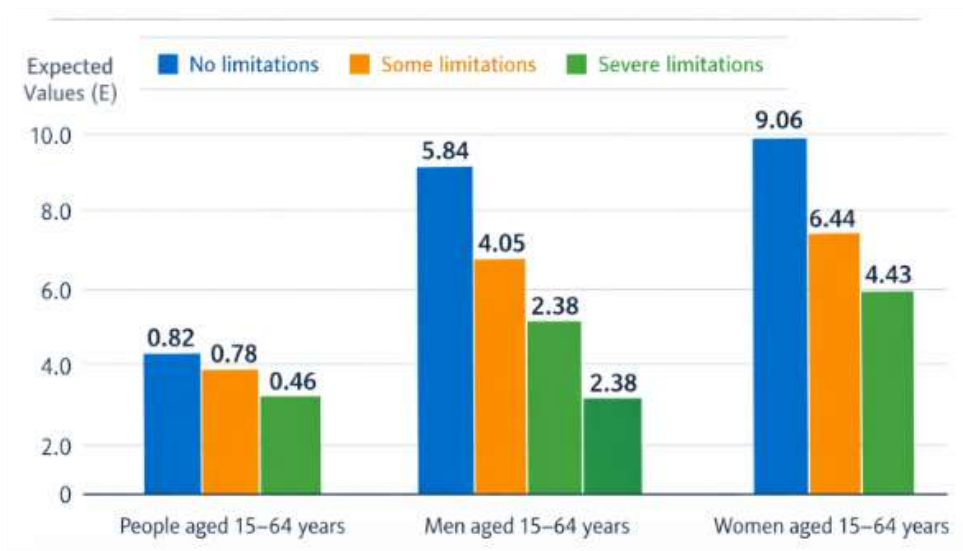


Figure 8. Results of calculating expected values.

Source: calculated by the author.

The results of the calculations shown in Table 6 illustrate the χ^2 values for each cell, taking into account gender differentiation.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Figure 9. Results of calculating the χ^2 criterion considering gender differentiation. Source: calculated by the author.

The total χ^2 value is 7.697169937 with $df = 4$. In accordance with the methodological limitations of the study, this value is not interpreted as evidence for rejecting or confirming statistical hypotheses. Rather, it is used as a descriptive indicator of deviation between the observed distribution of educational attainment and the distribution expected under the independence benchmark. The results show that gender differentiation does not remove the structural gap associated with disability severity. Instead, disability-related disproportions remain visible across educational levels, although their intensity differs between men and women.

These findings should therefore be interpreted not as proof of a causal relationship, but as evidence of persistent structural inequality in educational attainment among persons with different levels of disability. The results are consistent with previous studies emphasizing that digital technologies may improve accessibility, personalization and participation in inclusive education (Bešić et al., 2025; Navas-Bonilla et al., 2025; Samaniego López et al., 2025). However, the present analysis also shows that the availability of digital tools alone is not sufficient to eliminate educational stratification. The lower representation of persons with severe limitations at the tertiary education level suggests that digital inclusion depends on broader institutional conditions, including accessible infrastructure, teacher preparedness, adapted learning materials, regulatory coherence and continuous academic support.

In this sense, the contribution of the study lies in connecting the literature on digital technologies in inclusive education with descriptive evidence on disability-related differences in educational attainment. The results indicate that digital technologies should be understood as enabling conditions of educational quality rather than as independent solutions. Their inclusive potential becomes meaningful only when technological access is combined with pedagogical, organizational and policy-level changes in higher education institutions. This interpretation is also important for future research, since aggregated data allow only descriptive comparison and should be complemented by individual-level data, institutional case studies and mixed-methods designs capable of explaining how digital tools affect the actual educational trajectories of students with SEN.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Conclusions

The research confirms that digital tools are important instruments for ensuring personalization, access, and flexibility for students with special educational needs in higher education institutions of the European Union. Unlike predominantly descriptive patterns in literature, this study contributes to the discussion by combining a qualitative systematization of digital technologies with a quantitative descriptive analysis of disability-related disparities in educational attainment. The empirical results indicate a consistent structural association between disability severity and educational level, suggesting the persistence of stratification in higher education among persons with different levels of disability.

The results have significant theoretical implications, as they strengthen the idea that digitalization needs to be viewed not only as a matter of technology-related processes but also as a systemic element of inclusive education policy. The findings enrich current theoretical understandings of inclusive education by incorporating the factor of digital accessibility and by demonstrating how disability status, socio-demographic variables and educational outcomes interrelate.

At the same time, there are some methodological limitations of the research. The analysis of secondary data in its aggregated form constraint the use of inferential statistical methods and the establishment of causal links. Moreover, the qualitative part is founded on the synthesis of already conducted research, which might be to some extent generalising with respect to the diversity of institutional solutions in the individual EU member states. These constraints point to the potential for additional inquiry employing primary data and mixed methods designs with enhanced inferential capability.

From an applicative viewpoint, the findings highlight that merely adopting digital technologies does not guarantee equal education. The success of digital inclusion is influenced by existence of institutional infrastructure and digital competencies in educators and by coherence in regulations. Stubborn obstacles, including disparities in infrastructure, a lack of legislation, gaps between urban and rural schools, inadequate teacher training, and social stereotypes, still hinder the full realization of inclusive education.

In general the results of the study indicate that digital technologies can significantly contribute to equalizing opportunities and the quality of higher education for students with special educational needs. Nevertheless, the realisation of this potential will need a whole policy approach that encompasses technological innovation through to institutional, pedagogical and societal change.

Bibliographic references

- Bešić, E., Frizzarin, A., & Todorova, K. (2025). Digital technology use in inclusive schools in four European countries: Within- and between-school differences. *Journal of Research on Technology in Education*, 57(5), 1190–1203. <https://doi.org/10.1080/15391523.2024.2378084>
- Budnyk, O., Sydoriv, S., Serman, L., Lushchynska, O., Tsehelnik, T., & Matsuk, L. (2022). Inclusive education in rural schools of Ukraine or how to ensure quality inclusive education in rural schools in Ukraine? *Revista Brasileira De Educação Do Campo*, 7, e13940–e13940. <https://doi.org/10.20873/uft.rbec.e13940>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Coker, H., & Mercieca, D. (2023). Digital technology for inclusive education: reflecting on the role of teachers. In *Inclusion, equity, diversity, and social justice in education: A critical exploration of the sustainable development goals* (pp. 233–243). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-19-5008-7_16
- EASNIE (2024). Cross-country reports. *European Agency for Special Needs and Inclusive Education (EASNIE)*. <https://www.european-agency.org/activities/data/cross-country-reports>
- Elfakki, A. O., Sghaier, S., & Alotaibi, A. A. (2023). An efficient system based on experimental laboratory in 3D virtual environment for students with learning disabilities. *Electronics*, 12(4), 989. <https://doi.org/10.3390/electronics12040989>
- European Agency for Special Needs and Inclusive Education. (2022). *Inclusive digital education methodology paper*. https://www.european-agency.org/sites/default/files/Inclusive_Digital_Education_Methodology_Paper.pdf
- European Commission (2024). *Inclusive education*. European Education Area. <https://education.ec.europa.eu/focus-topics/improving-quality/inclusive-education>
- Eurostat (2025). Disability statistics - access to education and training. <https://acortar.link/XZ9P6G>
- Fang, M., Abdallah, A. K., & Vorfolomeyeva, O. (2024). Collaborative AI-enhanced digital mind-mapping as a tool for stimulating creative thinking in inclusive education for students with neurodevelopmental disorders. *BMC Psychology*, 12(1), 488. <https://doi.org/10.1186/s40359-024-01975-4>
- González Villavicencio, J. L., & Estrella Flores, J. P. (2023). Educación del Siglo XXI, competencias, metodologías y estrategias. *Esprint Investigación*, 2(1), 5–15. <https://doi.org/10.61347/ei.v2i1.50>
- Kauffman, J. M., Anastasiou, D., Felder, M., Lopes, J., Hallenbeck, B. A., Hornby, G., & Ahrbeck, B. (2022). Trends and issues involving disabilities in higher education. *Trends in Higher Education*, 2(1), 1–15. <https://doi.org/10.3390/higheredu2010001>
- Kolbina, L., Sopivnyk, I., Hubar, O., Teslenko, S., & Tsybal-Slatvinska, S. (2025). Implementation of inclusive higher education through the use of digital technologies. *Revista Eduweb*, 19(1), 68-84. <https://doi.org/10.46502/issn.1856-7576/2025.19.01.5>
- Kormos, E., & Julio, L. (2020). Contrasting instructional technology adoption in K-12 education to promote digital equity. *International Journal of Web-Based Learning and Teaching Technologies (IJWLTT)*, 15(3), 19–30. <https://doi.org/10.4018/IJWLTT.2020070102>
- Long, H. M., & Bouck, E. C. (2022). Calculators and online games: Supporting students with learning disabilities in mathematics. *Intervention in School and Clinic*, 58(4), 280–286. <https://doi.org/10.1177/10534512221093787>
- Lopatina, H., Tsybuliak, N., Popova, A., Hurenko, O., & Suchikova, Y. (2024). Inclusive education in higher education institution: Are Ukrainian faculty members' ready for it? *Research in Education*, 118(1), 49-72. <https://doi.org/10.1177/00345237231207721>
- Matre, M. E., & Cameron, D. L. (2024). A scoping review on the use of speech-to-text technology for adolescents with learning difficulties in secondary education. *Disability and Rehabilitation: Assistive Technology*, 19(3), 1103-1116. <https://doi.org/10.1080/17483107.2022.2149865>
- Navas-Bonilla, C. D. R., Guerra-Arango, J. A., Oviedo-Guado, D. A., & Murillo-Noriega, D. E. (2025). Inclusive education through technology: a systematic review of types, tools and characteristics. *Frontiers in Education*, 10, 1527851. <https://doi.org/10.3389/educ.2025.1527851>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- OECD. (2023). *Digital equity and inclusion in education: An overview of practice and policy in OECD countries*. https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/08/digital-equity-and-inclusion-in-education_c56b91ad/7cb15030-en.pdf
- Olinyk, T., Mishchenko, O., Ilevliev, O., Saveliev, D., & Hubina, S. (2023). Inclusive education in Ukraine: conditions of implementation and challenges. *Cadernos de Educação Tecnologia e Sociedade*, 16(se2), 50–62. <https://doi.org/10.14571/brajets.v16.nse2.50-62>
- Olsson, E., & Volleberg, I. (2025). *Inclusion Indicators 2025: Rights and inclusion of people with intellectual disabilities in 33 European countries*. Inclusion Europe. <https://str.inclusion.eu/abd4926d4300153c68fc98502.pdf>
- Rocha, D. F., Bittencourt, I. I., de Amorim Silva, R., & Ospina, P. L. (2023). An assistive technology based on Peirce's semiotics for the inclusive education of deaf and hearing children. *Universal Access in the Information Society*, 22(4), 1097–1116. <https://doi.org/10.1007/s10209-022-00919-2>
- Samaniego López, M. V., Orrego Riofrío, M. C., Barriga-Fray, S. F., & Paz Viteri, B. S. (2025). Technologies in Inclusive Education: Solution or Challenge? A Systematic Review. *Education Sciences*, 15(6), 715. <https://doi.org/10.3390/educsci15060715>
- Ubachs, G. (2022). *Diversity and inclusion in digital higher education*. Eadtu. https://eadtu.eu/images/Task_Force_Diversity_and_Inclusion_report_2022.pdf
- UNESCO Institute for Information Technologies in Education. (2025). *Digital technologies for inclusive education: Recommendations*. https://iite.unesco.org/wp-content/uploads/2025/01/IITE_Publication-2_Recommendations.pdf

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Fomento de la inclusión vía EdTech: Desarrollo de competencias en futuros docentes mediante laboratorios virtuales, hackatones y tecnologías inmersivas

Fostering inclusion via EdTech: Fostering preservice teachers' competence through virtual labs, hackathons, and immersive technologies

Tetyana Koycheva¹ Nataliia Hrytsai² Svitlana Yakymenko³ Valeriia Sukhetska⁴ Lesya Matsenko⁵

Afiliación autor:

¹ Doctor of Pedagogical Sciences, Full Professor, Professor of the Department of Pedagogy, State Institution "South Ukrainian National Pedagogical University named after K. D. Ushynsky", Ukraine.
tikoycheva@gmail.com

² Doctor of Pedagogical Sciences, Professor, Head of the Department of Natural Sciences, Rivne State University of Humanities, Ukraine. grynati1104@ukr.net

³ Doctor of Pedagogical Sciences, Professor of Elementary Education Department, Admiral Makarov National University of Shipbuilding, Ukraine. yakymenkosi@ukr.net

⁴ PhD student, Department of Social Work and Rehabilitation, National University of Life and Environmental Sciences of Ukraine, Ukraine. valeriia_s@nubip.edu.ua

⁵ Candidate of Pedagogical Sciences, Associate Professor, Associate Professor of the Pedagogy Department, National University of Life and Environmental Sciences of Ukraine, Ukraine.
l.matsenko@nubip.edu.ua

Recibido: 30/04/26
Aceptado: 19/06/26

Cómo citar:

Koycheva, T., Hrytsai, N., Yakymenko, S., Sukhetska, V., & Matsenko, L. (2026). Fostering inclusion via EdTech: Fostering preservice teachers' competence through virtual labs, hackathons, and immersive technologies. *Revista Eduweb*, 20(2), 397-413. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.23>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

El artículo examina el contenido del aprendizaje digital inclusivo e identifica los principios clave para organizar actividades educativas en entornos digitales inclusivos. Se presta especial atención al desarrollo de la competencia digital de los estudiantes para crear condiciones de aprendizaje accesibles para niños con discapacidades. El estudio analiza las plataformas digitales, los servicios en línea, los entornos virtuales, los laboratorios en línea, los hackatones virtuales y las tecnologías de RV/RA utilizadas en la preparación de futuros especialistas para trabajar en educación digital inclusiva. Para evaluar la preparación de los futuros especialistas para trabajar en entornos digitales inclusivos, se realizó un experimento de evaluación. Los resultados demostraron niveles de preparación comparables en los grupos de control y experimental, predominando los niveles bajos y medios. Posteriormente, se implementó un experimento formativo para evaluar la efectividad de las condiciones pedagógicas y el sistema de capacitación propuestos. La fiabilidad de los resultados obtenidos se verificó mediante la prueba χ^2 de Pearson. Los hallazgos revelaron mejoras sustanciales entre los participantes del grupo experimental. Tras la intervención, el 49,9 % de los estudiantes alcanzó un alto nivel de preparación según el criterio motivacional, el 47,7 % según el criterio de contenido y el 54,2 % según el criterio de actividad. Al mismo tiempo, la proporción de estudiantes con bajo nivel de preparación disminuyó al 9,1%, 8,2% y 7,6%, respectivamente. Estos cambios indican un marcado aumento en la motivación, el conocimiento profesional, las habilidades prácticas y la capacidad de los estudiantes para aplicar tecnologías digitales en entornos educativos inclusivos. En contraste, el grupo de control mostró cambios mínimos y no demostró un progreso comparable. Los resultados confirman la eficacia del sistema pedagógico desarrollado y las condiciones pedagógicas para preparar a futuros especialistas para trabajar en entornos educativos digitalmente inclusivos.

Palabras clave: competencia digital de los estudiantes, entorno digital inclusivo, plataformas digitales, servicios y entornos virtuales, laboratorios en línea, hackatones virtuales, tecnologías de RV/RA.

Abstract

The article examines the content of inclusive digital learning and identifies the key principles for organizing educational activities in digitally inclusive environments. Particular attention is paid to developing students' digital competence to create accessible learning conditions for children with disabilities. The study analyzes digital platforms, online services, virtual environments, online laboratories, virtual hackathons, and VR/AR technologies used in preparing future specialists for work in inclusive digital education. To assess future specialists' readiness to work in digitally inclusive environments, an ascertainment experiment was conducted. The results demonstrated comparable readiness levels in the control and experimental groups, with low and average levels predominating. A formative experiment was subsequently implemented to evaluate the effectiveness of the proposed pedagogical conditions and training system. The reliability of the obtained results

was verified using Pearson's χ^2 test. The findings revealed substantial improvements among participants in the experimental group. Following the intervention, 49.9% of students achieved a high level of readiness according to the motivational criterion, 47.7% according to the content criterion, and 54.2% according to the activity criterion. At the same time, the proportion of students demonstrating low readiness decreased to 9.1%, 8.2%, and 7.6%, respectively. These changes indicate a marked increase in students' motivation, professional knowledge, practical skills, and ability to apply digital technologies in inclusive educational settings. In contrast, the control group showed only minor changes and did not demonstrate comparable progress. The results confirm the effectiveness of the developed pedagogical system and the pedagogical conditions for preparing future specialists to work in digitally inclusive educational environments.

Keywords: digital competence of students, digital inclusive environment, digital platforms, services and virtual environments, online laboratories, virtual hackathons, VR/AR technologies.

Introduction

The modern education system in the information age of knowledge is crucial for supporting and developing the most valuable asset of society – human capital. The change in educational guidelines in the modern information society must undoubtedly be reflected in the system of professional training of future specialists for work under the conditions of inclusive digital education for students, with a focus on the capabilities of digital technologies. The implementation of the competency approach ensures the formation of knowledge of digital technologies. It is relevant to the formation of readiness in the conditions of inclusive digital education of future specialists. Training is aimed at the formation of a personality in the conditions of inclusive education and the development of future specialists focused on information and communication technologies. The challenges of creating a pedagogically favorable digital environment for the development of each child's cognitive sphere are addressed by special modern pedagogy, which ensures that each individual with special educational needs can follow their optimal developmental trajectory (Chiu et al., 2022).

Digital technologies in inclusive and special education help "construct" learning, expand the possibilities of specialists' means of influence, solve correctional and developmental tasks, and cannot be applied traditionally. Therefore, the problem of training future specialists to work in conditions of inclusive digital education of students in conditions of digitalization of society is becoming more urgent, because innovations in society and higher education, as drivers of technological progress around the world, are given a leading role in ensuring a high-quality educational space and global competitiveness of national economies. At all stages of the cognitive process, digital transformation occurs (Falloon, 2020).

Today, the solution acquires theoretical and practical significance: from the publication of the results obtained and the search for relevant directions. Accordingly, future specialists working in the conditions of inclusive digital education of students are required to have a high level of digital competence, since in their future professional activities, they will have to not only widely use digital tools in the educational process and in scientific research work, but also constantly master new technologies and choose the most effective among them.

The remainder of this article is organized as follows. The next section presents the theoretical foundations of inclusive digital education and reviews contemporary approaches to the development of digital competence among future specialists. The

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

methodology section describes the research design, participants, instruments, and procedures employed in the study. The subsequent section reports the results of the experimental investigation and evaluates the effectiveness of the proposed pedagogical system and pedagogical conditions. These findings are then discussed in relation to existing research on inclusive digital learning and professional training. Finally, the article concludes by summarizing the main findings, outlining the practical implications of the study, and identifying directions for future research.

Literature Review

Recent studies increasingly emphasize the role of digital technologies in promoting inclusive and equitable educational environments. Researchers have demonstrated that digital transformation contributes to the resilience, flexibility, and accessibility of educational systems, particularly in response to contemporary social and educational challenges (Motz et al., 2023). Similarly, the integration of physical and digital learning environments has been shown to enhance student engagement, collaboration, and social participation, creating more inclusive learning experiences in higher education (Akahome, 2026).

A growing body of research highlights digital competence as a key prerequisite for successful inclusive education. Rofiah et al. (2024) found that higher levels of digital literacy among preservice teachers are associated with more positive attitudes toward inclusive educational practices. Likewise, Oyelerere et al. (2020) demonstrated that smart learning ecosystems based on digital storytelling, blockchain technologies, and learning analytics can improve accessibility and personalization for learners with diverse educational needs.

Particular attention has been paid to the inclusion of learners with disabilities in digitally mediated educational environments. Mialichi & Costa Castilho Moreira (2025) reported that digital technologies can enhance participation and autonomy among students with autism spectrum disorder; however, institutional and communicative barriers continue to hinder full inclusion. Similar conclusions were reached by Alvarez-Sánchez et al. (2026), who identified infrastructure limitations and insufficient digital skills as significant obstacles to the successful implementation of inclusive digital learning initiatives.

Despite substantial progress in understanding the contribution of digital technologies to inclusive education, existing studies mainly focus on accessibility, digital literacy, learning environments, and technological solutions. Considerably less attention has been devoted to the pedagogical conditions and mechanisms for preparing future professionals to work effectively in inclusive digital learning environments. In particular, insufficient research has examined how professional training can foster the cognitive, motivational, and practical readiness of future specialists to implement inclusive digital education through modern digital technologies.

Therefore, the problem of developing effective pedagogical conditions for preparing future specialists to work in inclusive digital learning environments remains insufficiently investigated and requires further empirical verification.

Research objective: preparation of future specialists for work in conditions of inclusive digital education of students.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Methodology

Research Design and Participants

This study employed a mixed-methods research design integrating theoretical analysis, empirical investigation, and statistical procedures to evaluate the effectiveness of pedagogical conditions for preparing future specialists to work in inclusive digital learning environments.

The research was conducted between 2023 and 2025 and involved 114 undergraduate students enrolled in teacher education and related educational programs. The participants were assigned to an experimental group (EG, $n = 56$) and a control group (CG, $n = 58$).

Research Procedure

The study began with an analysis of contemporary research on inclusive digital education, digital competence, and professional preparation for work in digitally enriched educational settings. The findings of this review informed the conceptual framework of the study and the identification of the motivational, content-related, and activity-related dimensions of professional readiness.

To establish baseline equivalence between the groups, an ascertainment assessment was conducted prior to the intervention. The results indicated comparable levels of readiness among participants, with low and average levels predominating.

The experimental intervention was subsequently implemented in the experimental group. The training system incorporated digital platforms, virtual learning environments, online laboratories, virtual hackathons, and virtual and augmented reality (VR/AR) technologies. The intervention was guided by pedagogical conditions aimed at strengthening students' motivation, expanding their knowledge of digital tools for inclusive education, and developing practical competencies required for professional activity in digitally inclusive learning environments. Participants in the control group continued their studies according to standard instructional practices.

Instruments and Data Analysis

Data were collected through questionnaires, diagnostic assessments, and systematic observations of students' educational activities. Participants' readiness was evaluated according to motivational, content-related, and activity-related criteria and classified as high, average, or low.

Descriptive statistics were used to summarize the results, while Pearson's chi-square (χ^2) test was employed to examine differences between the experimental and control groups at the significance level of $p < .05$. The statistical analysis made it possible to determine whether the observed changes were associated with the implemented pedagogical intervention.

Ethical Considerations

The study adhered to established ethical standards for educational research. Participation was voluntary, and all participants provided informed consent before

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

data collection began. Students were informed about the purpose of the study, the research procedures, and their right to withdraw at any stage without adverse consequences. Confidentiality and anonymity were maintained throughout the research process, and all data were used exclusively for scientific purposes in accordance with applicable data protection requirements.

Results and Discussion

The content of inclusive digital education. The main principles of work in inclusive digital education of students.

Inclusive education differs significantly from traditional education. The peculiarity of inclusive education lies in the search for approaches that take into account all possibilities for working under the conditions of inclusive digital education for students when training future specialists. Given this approach, it is important to train specialists who have modern competencies for working with children with special educational needs, not just a range of skills and knowledge. These modern specialists must be ready to apply individualized digital teaching methods, using technologies and adapting curricula that support the active learning of such children under the conditions of inclusive digital education. Future specialists must have strong motivation, ability, and empathy to create an inclusive digital learning environment that reveals each student's capabilities. The training of such specialists includes practical experience in inclusive classes, and not only their theoretical knowledge (Brudermann et al., 2019).

Education for children with special educational needs in the context of inclusive digital learning can be organized by applying the following basic principles:

- The principle of interactivity holds that all children, including those with SEN, should learn together in an inclusive digital environment. This means that a child with SEN continues to interact with classmates, friends, a teacher's assistant, and a teacher on an equal footing.
- The principle of an individual approach to ensure the most effective continuation of the educational process underscores the need to take into account the nature of the child's impairments and the child's ability to communicate.
- The principle of differentiation means that digital learning in a digitally inclusive environment for students should adapt to each student's capabilities and needs, using multi-level learning technologies.
- The principle of plasticity makes it possible to study at a pace appropriate for the child, taking into account the capabilities of each student with SEN to adapt quickly or slowly to online classes, and addressing difficulties with adaptation and understanding of the material being studied. Therefore, it is important to select educational programs skillfully and to take into account each student's pace in accordance with their educational needs (McDonagh et al., 2021).

The content of students' digital competence for creating a digitally inclusive environment for children with disabilities.

Information in the 21st century has become the most important production resource. In the modern labor market, there is a need for specialists with advanced digital competence and new foundational digital skills that must be developed throughout life.

Digital competence is an integral characteristic of a person that dynamically combines skills, abilities, knowledge, promotes an attitude towards the use of digital

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

technologies for participation in public life, personal development, communication, work, learning in accordance with the sphere of competences (responsibly, creatively, critically, safely, ethically) enables a future specialist to perform complex tasks in a digital environment (Bozkurt & Sharma, 2022). For the development of digital competence in a future specialist, it is important to realize its role in overcoming the challenges of the fourth industrial revolution Industry 4.0, the transformation of societies, and professional growth, which significantly contributes to the student's motivation to gain interactive experience in the classroom, self-improvement, and the formation of transdisciplinary thinking, as this has a positive impact on competitiveness in the labor market. Therefore, the quality of professional training of specialists to work in the conditions of inclusive digital learning of each child depends on their level of professionalism, so the requirements for professional, professional, and digital training of students are constantly increasing due to the high pace of the digital society and the digitalization of the economy (Narvaez Rojas et al., 2021).

Digital platforms, services, virtual environments, online laboratories, virtual hackathons, and virtual and augmented reality (VR/AR) technologies for training future specialists to work in the context of digital, inclusive education and student education.

Traditional forms of scientific training for students often complicate access to research activities and have several limitations. Among the main problems, it is worth highlighting the complexity of individual mentoring, uneven levels of student training, geographical barriers, and limited resources for educational institutions.

Online formats, including digital platforms, remote hackathons, and virtual laboratories, allow, regardless of their place of residence, to involve a wide audience in the educational process, offer modern effective solutions to these problems, provide access to modern hardware and software, and open up opportunities for interactive learning and personalized mentoring (Brevik et al., 2019).

In combination with collective discussion of the results, modern virtual environments create conditions for participants' independent work in the educational process, which contributes to the development of scientific communication and teamwork. The integration of virtual hackathons and online laboratories into the training of young scientists meets the modern requirements of educational digitalization. It opens new opportunities for an early start in scientific activity. Various digital platforms are used to organize virtual hackathons and online laboratories, enabling interactive communication between participants and mentors (Caena & Redecker, 2019).

Such digital platforms include virtual laboratories with integrated simulators, environments for remote modeling and programming, and specialized hackathon platforms that allow for real-time team projects and competitions.

Innovative features of these tools for preparing future professionals to work in an inclusive environment include remote access to software and hardware, project and task management systems, interactive whiteboards for collaboration, and communication tools such as video conferencing, chat, and voice channels. Thanks to these features, researchers (students and pupils) can maintain joint project documents, receive instant feedback from mentors, perform complex tasks and experiments, and coordinate work in teams. Such digital environments, where

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

learning is integrated with practical activities, create an interactive space that fosters analytical skills, critical thinking, and teamwork.

Virtual labs and online hackathons are organized around structured scenarios that combine independent work with mentor coordination. Students receive project topics or tasks, are united in teams, and then work in specialized digital environments where tools for modeling, communication, and data analysis are available. Virtual labs allow students to perform experiments in a safe, digitally inclusive learning environment with the possibility of multiple repetitions of testing different scenarios and procedures, which is impossible in traditional laboratories.

Online hackathons provide a team-intensive format for working on a project in a short time, stimulating collective decision-making, creativity, and problem-solving skills. Compared to traditional scientific educational practices, these formats differ in their scalability, flexibility, ability to involve participants from different countries and regions, and the wide use of digital tools for evaluation and interaction. They combine practical, educational, and research components, creating a digitally inclusive learning environment for students in which participants simultaneously develop teamwork skills, acquire knowledge, and gain first-hand experience performing scientific tasks in the digital space (Yates et al., 2021).

Online platforms, including those for data analysis, modeling, programming, experimental solutions, and prototyping, facilitate the effective development of technical skills. At the same time, they also form soft skills: critical thinking, teamwork, presentation and communication skills, and time management, which are necessary in the modern professional and educational context for successful activity (Oyetade et al., 2022). Therefore, virtual hackathons, online laboratories, digital platforms, services, and virtual environments are effective tools for the early involvement of students in practical and research activities.

VR/AR allows for simulating scientific processes and conducting complex experiments in a virtual safe environment, which allows students and pupils to test different scenarios and conduct multiple attempts, the limitations of which exist in physical laboratories. AI tools provide automatic task selection, personalized learning, and real-time analysis of participants' effectiveness and progress (Van den Beemt et al., 2023).

Experimental verification of the effectiveness of pedagogical conditions for training future specialists to work in conditions of inclusive digital education of students.

The development, research, verification, and adjustment of the effectiveness of the proposed pedagogical conditions for training future specialists to work in inclusive digital educational settings were carried out during 2023-2025. It included the following stages: search, modeling, and experimental.

Digital technologies are developing rapidly nowadays. Therefore, the range of online services available to all specialists is expanding, and their capabilities are evolving. However, the main components of pedagogical conditions remain, aimed at the result and at ensuring the holistic formation of readiness in future specialists to work under the conditions of inclusive digital education for students.

The experimental base included 114 applicants for the degree of "bachelor's". EG – 56 respondents and CG – 58 respondents.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The content of the ascertaining stage of the pedagogical experiment.

In the context of the research conducted, the structural components of future specialists' readiness to work under the conditions of inclusive digital learning for students were identified: motivational, content, and activity, as they are interconnected.

As a result of the experimental work conducted, we determined a position on the criteria (motivational, content, activity) and indicators of readiness for the phenomenon outlined.

Motivational criterion.

Indicators: motivation to organize the higher education process using digital technologies; the need to use online services in the learning process; students' orientation toward seeking new digital tools; variation in the digital resources used in the learning process.

Content criterion.

Indicators: knowledge of pedagogical digital tools, theoretical awareness of the existence and use in professional activities of digital platforms, services, virtual environments, online laboratories, virtual hackathons, virtual and augmented reality technologies (VR/AR)

Activity criterion.

Indicators: ability to create an inclusive digital learning environment for students; virtual classroom; professional use of digital platforms, services, virtual environments, online laboratories, virtual hackathons, virtual and augmented reality technologies (VR/AR) in the context of digital inclusive learning for students and working with an electronic journal.

The above made it possible to characterize the levels of readiness (high, average, low) of future specialists to work in a digitally inclusive environment.

To determine the level of readiness for the phenomenon described among future specialists, an ascertaining experiment was conducted before the experimental training and involved surveying students on their awareness of how to implement digital technologies in the context of inclusive digital learning for students. Respondents were conditionally combined into experimental EG and control groups (CG). The results of the ascertaining experiment are presented in Table 1.

Table 1.

Results of diagnostics of the levels of readiness of future specialists to work in an inclusive digital environment (ascertaining experiment)

Levels	Control Group	Experimental Group
Low	35,9%	39,9%
Average	58,7%	54,2%
High	5,4%	5,9%

Source: created by the authors

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Based on the data in Table 1, the ability to implement students' knowledge of ways to use digital technologies in the context of inclusive digital learning for students in the CG and EG is at approximately the same level. We observe the predominance of low and average levels.

The probability of the results of the experimental work carried out at the ascertaining stage, and the reliability of the experimental data were determined and confirmed using the Pearson χ^2 – non-parametric criterion, with the help of which we assessed the reliability and found differences between the two distributions, and also obtained 95% reliability of the probability results. In particular, we tested the null hypothesis H_0 that the two (experimental) empirical distributions are identical.

The basic calculation formula of the chi-square criterion looks like this:

$$\chi_{emp}^2 = N \times M \times \sum_{i=1}^L \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)^2}{\frac{n_i}{N} + \frac{m_i}{M}}$$

N – total number of EG respondents.

M – total number of respondents CG.

n_i – number of EG respondents who have average scores on criteria of all levels: high, average, and low.

m_i – number of CG respondents who have average scores on criteria of all levels: high, average, and low.

L – rating scale, $L = 4$.

The number of degrees of freedom estimates the significance levels for the chi-square test ν , which we calculated using the formula:

$$\nu = (k - 1) \cdot (c - 1)$$

k – number of columns (groups), sample.

c – number of characteristics by which the samples differ, assessment levels (rows).

We determine the number of degrees of freedom using the formula:

$$\nu = (k - 1) \cdot (c - 1) = (2 - 1)(4 - 1) = 3$$

For significance levels $P=0.05$ and $P=0.01$, we find the values χ_{cr}^2 :

$$\chi_{cr(0,05)}^2 = 7,815$$

$$\chi_{cr(0,01)}^2 = 11,345$$

Therefore:

$$\chi_{emp}^2 < \chi_{cr(0,05)}^2$$

We accept the null hypothesis in the ascertaining section of the experiment that the initial levels of readiness of respondents in the experimental and control groups to work in a digitally inclusive environment do not differ significantly. The results of the experiment showed that at significance levels of 0.01 and 0.05, there were no statistically significant differences in readiness between the groups that participated in the experiment. Therefore, the number of students in the experimental and control groups is equivalent, making it impossible to assess the reliability and validity of the formative experiment's results on the success factor.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

We conclude that the following tasks were completed in the ascertaining experiment: the distribution of students into EG and CG was carried out; the components, criteria, indicators, and levels of readiness of future specialists for the outlined phenomenon were substantiated. Diagnostic tools were developed, a cross-sectional (diagnostic) study was conducted, and the data obtained were analyzed and interpreted.

Analysis and results of the formative stage of the pedagogical experiment.

The results of the ascertaining experiment determined the course of the formative experiment. The quantitative composition of the students participating in the experiment remained unchanged.

The formative experiment involved testing the pedagogical conditions for training future specialists to work in a digitally inclusive environment. It was at this stage that the effectiveness of the proposed author's system of training specialists and the pedagogical conditions identified and substantiated by us were clarified.

While the CG students studied according to the standard methodology, the EG students, within the framework of the author's developed system for organizing the educational process, were offered methods with proven effectiveness worldwide and that are most widely used with children with OOP during virtual communication. The most effective and progressive among them were the following: Picture Communication Symbols (PCS), Picture Exchange Communication Symbols (PECS), Multimodal Communication, ARASAAC, Augmentative and Alternative Communication (AAC), and Visual Supports. These programs are organized to present information in an accessible, visually organized way for students, from simple to complex, in the context of inclusive digital learning. They contain sets of symbols that are not simplified.

In the EG, we used the most common virtual platforms for teaching a child with disabilities in an inclusive digital environment:

- Dragon Naturally Speaking – a program that converts words into fast and accurate transcription of speech to text in the context of inclusive digital learning of students.
- Google Docs Voice Typing – an online program that helps users in a digitally inclusive environment use their computer's microphone to convert speech to text in Google Docs.
- Windows Speech Recognition – a program that allows you to convert spoken words to text and is built into Windows.
- Otter Voice Meeting Notes – a program for converting speech to text and recording conversations, which is successfully used for children with disabilities and helps create text notes based on voice recordings.
- Dictation.io is a program that converts spoken language into written text in seconds.
- AppleDictation is a program built into macOS that allows users to control a computer with voice commands and convert speech into text.

The outlined programs, when used by EG students, significantly helped children with disabilities in an inclusive digital environment during their educational activities by simplifying the educational process.

Outlining the main ways to prepare future specialists to work in a digitally inclusive learning environment, we reflected on the digital profile of each EG student:

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Mastery of digital technologies in a digitally inclusive environment (skills, abilities, knowledge for safe and productive use in educational and further professional activities of digital technologies).
- Professional development in a digital environment (skills, abilities, knowledge in the use of digital technologies and appropriate selection for self-development).
- Ability to work with data (skills, abilities, knowledge for searching for data and information, their use and analysis in accordance with the goals of education and the goals of further professional activity).
- Ensuring digital well-being (skills, abilities, knowledge for the reasonable use of digitalization tools).
- Communication (skills, abilities, knowledge for communicating in a digitally inclusive environment using digital tools).

The leading features of the integrity of the professional training of future EG specialists to work in an inclusive environment in the conditions of digitalization of society were as follows:

- Systematic formation of digital professional competencies as a complete adequacy to the specific professional functions of specialists, the primary implementation of target guidelines for appropriate training.
- The orientation of the work process in an inclusive environment to achieve in it the internal unity of the components of consistent mastery by specialists of digital and pedagogical means, professional digital competence, pedagogical and digital culture, and pedagogical professionalism in the digital dimension.
- The presence of internal connections between blocks of professional disciplines of the curriculum, which give priority to the subordination of their value-content characteristics to the general strategy, the renewal of the entire content of the educational field under the influence of systemic challenges of society.
- The organization of the educational process in an inclusive environment based on the typical structure of the professional and pedagogical activity of a specialist, a kind of model that is invariant to special systems in professional activity and professional training.
- High-quality completeness of professional training in higher education for work in an inclusive environment of future specialists in the conditions of digitalization of the educational environment (creation of conditions for professional self-education, self-organization and self-education; continuous promotion of self-regulation, professional creativity of students in order to ensure a high resource level of this process; reliance of the student body on the psychological mechanism of professional training).

Outlining modern ways of training future EG specialists to work in conditions of inclusive digital education of students, we proposed the use of advanced technologies for the educational process of students, such as artificial intelligence (AI), virtual and augmented reality (VR/AR), which significantly expanded the educational potential of students in the online format.

Digital platforms for online laboratories and virtual hackathon services, virtual environments, and augmented reality provide a high level of personalization of the educational and research process.

Adaptive learning interfaces and algorithms enabled EG students to tailor tasks to each participant's experience and level of knowledge in the educational process. It was they who allowed education seekers to adapt to individual needs, including gradual or modular task complexity, the provision of additional materials for

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

preparation, and the ability to choose modern digital tools that corresponded to the competencies of an individual participant or the entire team.

In the digital environment, mentoring methods and traditional approaches were combined with innovative digital tools. These included interactive chats, webinars, regular video consultations to resolve issues promptly, forums for discussing problem situations and results, evaluation of intermediate results, and feedback systems. Such support for EG students enabled mentors to track students' progress, provide personalized recommendations, and adjust task complexity, which significantly increased motivation and learning effectiveness.

Participation of EG students in virtual hackathons and online laboratories contributed to the formation of a wide range of competencies. Technical skills (modeling, working with digital tools, data analysis, developing experimental solutions) and soft skills (time management, critical thinking, teamwork, effective communication with colleagues and mentors, presentation skills) are acquired. The effectiveness of online platforms compared to traditional teaching methods is evident in faster mastery of practical skills, greater flexibility, and greater availability of resources.

The introduction of these innovations contributed to the development of students' competencies, stimulated creativity and independence, and opened up new opportunities for self-expression.

We identified the main advantages of using digital technologies in preparing EG students for work in an inclusive digital environment:

- Independent access of EG students to educational services, promoting student autonomy.
- The ability to complete educational tasks at an accessible and convenient pace.
- The opportunity for students to reveal their potential and demonstrate their own achievements in various ways.
- Access for students with SEN to information via the Internet.
- Expanding the range of educational tasks in accordance with the skills, characteristics, and individual capabilities of each individual.
- Motivating students to meet their own cognitive needs, deepening and expanding their cognitive interests, etc.
- Facilitating the process of interaction with peers and communication with teachers and other social groups.

During their studies within the experimental professional training system, EG students were introduced to pedagogical conditions that ensure high-quality professional activity among future specialists in an inclusive digital environment.

The first pedagogical condition is the formation of positive motivation among students to organize the process of higher education using digital technologies, with varied digital resources in the learning process.

The second pedagogical condition is updating the content of students' professional training, taking into account the needs of inclusive education of students and mastering knowledge of pedagogical digital tools, theoretical awareness of the existence and use in professional activities of digital platforms, services, virtual environments, online laboratories, virtual hackathons, technologies of virtual and augmented reality (VR/AR).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The third pedagogical condition is the development of digital competence of future specialists in order to be able to create an inclusive digital learning environment for students; a virtual classroom; professional use of digital platforms, services, virtual environments, online laboratories, virtual hackathons, virtual and augmented reality (VR/AR) technologies in the context of digitally inclusive learning for students and working with an electronic journal.

Let us describe the analysis of the results of the formative stage of the experiment – diagnostics of the levels of readiness of future specialists to work in conditions of inclusive digital learning of students according to the selected criteria. The diagnostic tools remained unchanged at the formative stage.

The results of the formative experiment by the motivational criterion are presented in Table 2.

Table 2.

Results of diagnostics of the levels of readiness of future specialists by the motivational criterion to work in conditions of inclusive digital learning of students (formative experiment)

Levels	Control Group	Experimental Group
Low	33,1%	9,1%
Average	54,8%	41,0%
High	12,1%	49,9%

Source: created by the authors

The results of the formative experiment by the content criterion are presented in Table 3.

Table 3.

Results of diagnostics of the levels of readiness of future specialists by the content criterion for work in the conditions of inclusive digital learning of students (formative experiment)

Levels	Control Group	Experimental Group
Low	30,0%	8,2%
Average	58,1%	44,1%
High	11,9%	47,7%

Source: created by the authors

The results of the formative experiment by the activity criterion are presented in Table 4.

Table 4.

Results of diagnostics of the levels of readiness of future specialists by the activity criterion for work in the conditions of inclusive digital learning of students (formative experiment)

Levels	Control Group	Experimental Group
Low	31,7%	7,6%
Average	54,0%	38,2%
High	14,3%	54,2%

Source: created by the authors

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

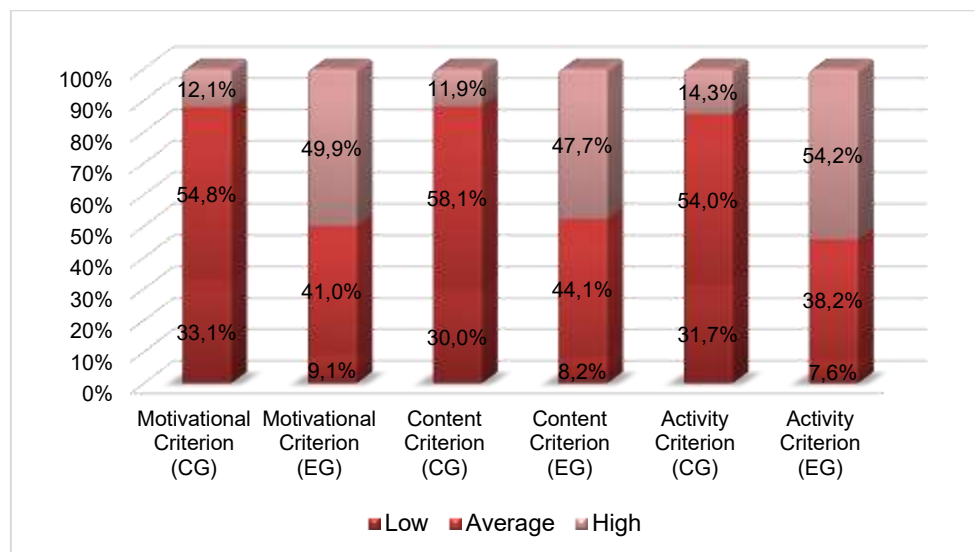


Figure 1. Levels of future specialists' readiness for work in inclusive digital learning environments by motivational, content, and activity criteria.

Source: created by the authors

To verify the reliability of the obtained research results during the formative stage of the experiment, a statistical analysis of the experimental data (Pearson's non-parametric χ^2 criterion) was conducted using statistical processing methods to clarify the statement that the difference in the indicators of the two groups, in the CG and EG, is significant, that is, a consequence of the implementation of pedagogical conditions for preparing future specialists for work in a digital inclusive environment, and not the influence of random factors.

Null hypothesis H_0 : the control and experimental samples in terms of the level of readiness of future specialists for work in inclusive education are homogeneous according to the studied criterion χ^2 .

Alternative hypothesis H_1 : the control and experimental samples in terms of the level of readiness of future specialists for work in inclusive education are different according to the studied criterion χ^2 .

Thus, the obtained results ($\chi^2_{\text{emp}} > \chi^2_{\text{crit}}$) are significant at the 5% level, therefore the Null Hypothesis H_0 is rejected and the alternative hypothesis H_1 is accepted at a high level of significance: that the level of readiness of future specialists to work in inclusive education among respondents of the experimental and control groups differs significantly, which indicates the effectiveness of the application of the developed system and pedagogical conditions for training future specialists to work in a digitally inclusive environment.

We concluded that the system and pedagogical conditions for training future specialists to work in a digitally inclusive environment that we have substantiated are effective, because in the process of the formative experiment in the EG, we observe positive changes in the value and motivational orientations of future specialists, their personal characteristics, abilities, and professional training. The results of the CG did not increase significantly.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Limitations of the Study

Despite the positive results obtained during the formative experiment, several limitations of the study should be acknowledged. First, the research involved 114 undergraduate students enrolled in teacher education and related programs, which may limit the generalizability of the findings to other academic disciplines, institutional contexts, or international educational settings. Although the sample size was sufficient for the statistical procedures employed, broader and more diverse samples would strengthen the external validity of future investigations.

Second, the effectiveness of the proposed pedagogical system was examined under conditions where participants had access to a range of digital resources, including online platforms, virtual environments, online laboratories, and VR/AR technologies. The availability of such technological infrastructure may vary considerably across educational institutions. As noted by Alvarez-Sánchez et al. (2026), differences in technological capacity, access to digital resources, and institutional support can influence the implementation and outcomes of digitally inclusive educational initiatives. Consequently, the effectiveness of similar interventions may depend on the technological readiness of particular educational settings.

In addition, the study focused on short-term changes in students' readiness to work in digitally inclusive environments.

Conclusions

The study examined the pedagogical foundations of preparing future specialists for professional activity in digitally inclusive educational environments. The findings demonstrate that effective preparation for inclusive digital education requires not only the development of digital competence but also the integration of motivational, cognitive, and practical components of professional readiness.

The research identified and substantiated three pedagogical conditions that support the formation of readiness for work in digitally inclusive settings: the development of positive motivation toward the use of digital technologies in inclusive education, the modernization of professional training content through the integration of contemporary digital tools and resources, and the systematic development of students' digital competence for designing and managing inclusive learning environments.

The results of the formative experiment confirmed the effectiveness of the proposed pedagogical system. Compared with the control group, students in the experimental group demonstrated substantially higher levels of readiness across all assessed dimensions. The proportion of participants achieving a high level of readiness increased to 49.9% according to the motivational criterion, 47.7% according to the content criterion, and 54.2% according to the activity criterion, while the share of students with low levels decreased considerably. Statistical analysis using Pearson's χ^2 test confirmed that the observed differences were not attributable to random variation and reflected the impact of the implemented pedagogical intervention.

The findings contribute to the growing body of research on inclusive digital education by providing empirical evidence that the integration of digital platforms, virtual learning environments, online laboratories, virtual hackathons, and VR/AR technologies can significantly enhance the professional preparation of future specialists. The study also demonstrates the importance of combining technological

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

innovation with carefully designed pedagogical conditions to achieve sustainable educational outcomes.

Future research should investigate the long-term effects of such interventions, examine their applicability across different educational contexts and disciplines, and explore the potential of emerging technologies, particularly artificial intelligence-driven educational tools, to further strengthen inclusive digital learning and professional training.

Bibliographic references

- Akahome, J. E. (2026). Designing inclusive learning spaces in higher education: Examining how physical and digital space design (learning commons, makerspaces) fosters community and engagement. *Information and Learning Sciences*, 1-18. <https://doi.org/10.1108/ILS-09-2025-0176>
- Alvarez-Sánchez, A., Garzón-Espinoza, S. P., Suárez del Villar-Labastida, A., & Casanovas-Cosío, E. (2026). Technology and e-learning as catalysts for inclusive community development in social innovation and entrepreneurship. In M. V. García, J. P. Reyes, C. Núñez, & C. Gordón-Gallegos (Eds.), *Proceedings of the International Conference on Computer Science, Electronics and Industrial Engineering (CSEI 2024)* (Lecture Notes in Networks and Systems, Vol. 1532). Springer. https://doi.org/10.1007/978-3-031-98890-5_12
- Bozkurt, A., & Sharma, R. C. (2022). Digital transformation and the way we (mis)interpret technology. *Asian Journal of Distance Education*, 17(1). <https://asianjde.com/ojs/index.php/AsianJDE/article/view/630>
- Brevik, L. M., Gudmundsdottir, G. B., Lund, A., & Strømme, T. A. (2019). Transformative agency in teacher education: Fostering professional digital competence. *Teaching and Teacher Education*, 86, 102875. <https://doi.org/10.1016/j.tate.2019.07.005>
- Brudermann, T., Aschemann, R., Füllsack, M., & Posch, A. (2019). Education for sustainable development 4.0: Lessons learned from the University of Graz, Austria. *Sustainability*, 11(8), 2347. <https://doi.org/10.3390/su11082347>
- Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (DigCompEdu). *European Journal of Education*, 54(3), 356–369. <https://doi.org/10.1111/ejed.12345>
- Chiu, T. K. F., Sun, J. C.-Y., & Ismailov, M. (2022). Investigating the relationship of technology learning support to digital literacy from the perspective of self-determination theory. *Educational Psychology*, 42(10), 1263–1282. <https://doi.org/10.1080/01443410.2022.2074966>
- Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency (TDC) framework. *Educational Technology Research and Development*, 68(5), 2449–2472. <https://doi.org/10.1007/s11423-020-09767-4>
- McDonagh, A., Camilleri, P., Engen, B. K., & McGarr, O. (2021). Introducing the PEAT model to frame professional digital competence in teacher education. *Nordic Journal of Comparative and International Education (NJCIE)*, 5(4), 5–17. <https://doi.org/10.7577/njcie.4226>
- Mialichi, C., & Costa Castilho Moreira, J. C. (2025). Mídia e inclusão: O impacto do entorno midiático na experiência acadêmica de estudantes autistas no ensino superior. *Revista Comunicação Midiática*, 20(1), 183–198. <https://doi.org/10.5016/wtc2zg08>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Motz, R., Porta, M., & Reategui, E. (2023). Building resilient educational systems: The power of digital technologies. In S. Berrezueta (Ed.), *Proceedings of the 18th Latin American Conference on Learning Technologies (LACLO 2023)* (Lecture Notes in Educational Technology, pp. 379–392). Springer. https://doi.org/10.1007/978-981-99-7353-8_28
- Narvaez Rojas, C., Alomia Peñafiel, G. A., Loaiza Buitrago, D. F., & Tavera Romero, C. A. (2021). Society 5.0: A Japanese concept for a superintelligent society. *Sustainability*, 13(12), 6567. <https://doi.org/10.3390/su13126567>
- Oyelere, S. S., Silveira, I. F., Martins, V. F., Eliseo, M. A., Akyar, Ö. Y., Costas-Jauregui, V., Caussin, B., Motz, R., Suhonen, J., & Tomczyk, Ł. (2020). Digital storytelling and blockchain as pedagogy and technology to support the development of an inclusive smart learning ecosystem. In Á. Rocha, H. Adeli, L. P. Reis, S. Costanzo, I. Orovic, & F. Moreira (Eds.), *Trends and innovations in information systems and technologies: WorldCIST 2020* (Advances in Intelligent Systems and Computing, Vol. 1161, pp. 397–408). Springer. https://doi.org/10.1007/978-3-030-45697-9_39
- Oyetade, K., Zuva, T., & Harmse, A. (2022). Educational benefits of hackathon: A systematic literature review. *World Journal on Educational Technology: Current Issues*, 14(6), 1668–1684. <https://doi.org/10.18844/wjet.v14i6.7131>
- Rofiah, K., Ngeenge, R. T., Kholidya, C. F., & Ainin, I. K. (2024). Digital literacy and perception of inclusive education of preservice teachers at Indonesian universities. In Ł. Tomczyk (Ed.), *New Media Pedagogy: Research Trends, Methodological Challenges, and Successful Implementations* (Communications in Computer and Information Science, pp. 24–43). Springer. https://doi.org/10.1007/978-3-031-63235-8_2
- Van den Beemt, A., Groothuisen, S., Özkan, L., & Hendrix, W. (2023). Remote labs in higher engineering education: engaging students with active learning pedagogy. *Journal of Computing in Higher Education*, 35(2), 320–340. <https://doi.org/10.1007/s12528-022-09331-4>
- Yates, A., Starkey, L., Egerton, B., & Flueggen, F. (2021). High school students' experience of online learning during Covid-19: The influence of technology and pedagogy. *Technology, Pedagogy and Education*, 30(1), 59–73. <https://doi.org/10.1080/1475939X.2020.1854337>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

Integración de la tecnología digital para el desarrollo de la alfabetización profesional entre los estudiantes de educación superior

Digital technology integration for developing professional literacy among higher education students

Olga Chashechnikova¹  Svitlana Kondratiuk²  Iryna Hordiienko³  Nataliia Kulchytska⁴  Olena Balalaieva⁵ 

Afiliación autor:

¹ Doctor of Pedagogical Sciences, Professor, Head of the Department of Mathematics, Physics and Teaching Methods, Faculty of Physics and Mathematics, Sumy State Pedagogical University named after A. S. Makarenko, Ukraine. chash-olga-s@ukr.net

² Candidate of Pedagogical Sciences, Professor of the Department of Preschool and Primary Education, Director of the Educational and Scientific Institute of Pedagogy and Psychology, Sumy State Pedagogical University named after A. S. Makarenko, Ukraine. kondratiuks.m@gmail.com

³ Candidate of Pedagogical Sciences, Associate Professor of the Department of Mathematics and Economics (Faculty of Physics, Mathematics, Economics and Innovative Technologies), Drohobych Ivan Franko State Pedagogical University, Ukraine. i.hordiienko@dspu.edu.ua

⁴ Candidate of Pedagogical Sciences, Associate Professor, Chairperson of the Department of Mathematics and Informatics and Methods of Teaching, Faculty of Mathematics and Informatics, Vasyl Stefanyk Carpathian National University, Ukraine. nataliia.kulchytska@pnu.edu.ua

⁵ Candidate of Pedagogical Sciences, Associate Professor, Department of Philosophy and International Communication, National University of Life and Environmental Sciences of Ukraine, Ukraine. olena.balalaieva@gmail.com

Recibido: 31/04/26

Aceptado: 01/06/26

Cómo citar:

Chashechnikova, O., Kondratiuk, S., Hordiienko, I., Kulchytska, N., & Balalaieva, O. (2026). Digital technology integration for developing professional literacy among higher education students. *Revista Eduweb*, 20(2), 414-433. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.24>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Resumen

El artículo investiga la integración de las tecnologías digitales como medio para desarrollar la alfabetización profesional entre estudiantes de educación superior en el contexto de la digitalización educativa. La alfabetización profesional se define como un constructo multidimensional que comprende componentes motivacionales, de contenido e información, y de actividad, que permiten a los estudiantes utilizar eficazmente el conocimiento profesional, los recursos digitales, el pensamiento crítico y las habilidades de resolución de problemas basadas en la tecnología en entornos académicos y profesionales. El propósito de este estudio es determinar la efectividad de la integración de las tecnologías digitales en el desarrollo de la alfabetización profesional entre estudiantes de educación superior y verificar experimentalmente las condiciones pedagógicas que facilitan este proceso. La investigación empleó un diseño de métodos mixtos que combina enfoques teóricos, empíricos, cualitativos y cuantitativos. El estudio se llevó a cabo entre 2023 y 2025 e involucró a 380 estudiantes, incluyendo un grupo experimental ($n = 190$) y un grupo de control ($n = 190$). Los datos se recopilaron mediante cuestionarios, pruebas, entrevistas, observaciones y tareas de evaluación diagnóstica. El análisis estadístico se realizó utilizando la prueba χ^2 de Pearson con un nivel de significancia de $\alpha = 0,05$. Los resultados demostraron mejoras sustanciales en el grupo experimental tras la implementación de plataformas digitales, herramientas de inteligencia artificial, laboratorios virtuales y tecnologías interactivas. La proporción de estudiantes con un alto nivel de alfabetización profesional aumentó del 12,1 % al 47,9 % según el criterio motivacional, del 13,8 % al 46,5 % según el criterio de contenido e información, y del 11,8 % al 47,3 % según el criterio de actividad. En consecuencia, los indicadores de bajo nivel disminuyeron del 39,9 % al 11,1 %, del 45,9 % al 11,1 % y del 51,3 % al 12,2 %, respectivamente. Por el contrario, en el grupo de control solo se observaron cambios menores. Los hallazgos confirman la eficacia de la integración de la tecnología digital para potenciar la alfabetización profesional y la competencia digital de los estudiantes.

Palabras clave: tecnologías digitales, desarrollo de la alfabetización profesional de los estudiantes, instituciones de educación superior, aplicaciones de Internet, tecnologías de inteligencia artificial.

Abstract

The article investigates the integration of digital technologies as a means of developing professional literacy among higher education students in the context of educational digitalization. Professional literacy is defined as a multidimensional construct comprising motivational, content-information, and activity components that enable students to effectively use professional knowledge, digital resources, critical thinking, and technology-based problem-solving skills in academic and professional environments. The purpose of this study is to determine the effectiveness of integrating digital technologies into the development of professional literacy among higher education students and to experimentally verify the pedagogical conditions

that facilitate this process. The research employed a mixed-methods design combining theoretical, empirical, qualitative, and quantitative approaches. The study was conducted during 2023–2025 and involved 380 students, including an experimental group ($n = 190$) and a control group ($n = 190$). Data were collected through questionnaires, testing, interviews, observations, and diagnostic assessment tasks. Statistical analysis was performed using Pearson's χ^2 test at a significance level of $\alpha = .05$. The results demonstrated substantial improvements in the experimental group following the implementation of digital platforms, artificial intelligence tools, virtual laboratories, and interactive technologies. The proportion of students with a high level of professional literacy increased from 12.1% to 47.9% according to the motivational criterion, from 13.8% to 46.5% according to the content-information criterion, and from 11.8% to 47.3% according to the activity criterion. Correspondingly, low-level indicators decreased from 39.9% to 11.1%, from 45.9% to 11.1%, and from 51.3% to 12.2%, respectively. In contrast, only minor changes were observed in the control group. The findings confirm the effectiveness of digital technology integration in enhancing students' professional literacy and digital competence.

Keywords: digital technologies, development of professional literacy of students, higher education institutions, Internet applications, artificial intelligence technologies.

Introduction

Despite the recognized benefits of digital technologies for enhancing learning flexibility, accessibility, and personalization, their integration into higher education remains associated with several challenges (Gudonienė et al., 2025). Previous studies indicate that the effectiveness of digital technologies depends not only on their availability but also on the quality of pedagogical implementation, students' digital readiness, and institutional support. Researchers report that the introduction of artificial intelligence, virtual learning environments, and digital platforms may lead to unequal learning outcomes due to differences in students' digital competence, motivation, and self-regulation skills (Liu & Zhong, 2025). Furthermore, concerns have been raised regarding excessive reliance on technology, reduced interpersonal interaction, ethical issues related to AI use, and difficulties in assessing the actual impact of digital tools on professional competence development (Dringó-Horváth et al., 2025).

Modern transformation processes in higher education institutions necessitate developing students' professional literacy and rethinking approaches to organizing the educational process. The introduction of digital technologies has become a powerful tool for expanding access to knowledge, improving the quality of higher education, and modernizing traditional didactic practices. However, it is also a challenge (Saúde et al., 2024).

Given the growing role of digital technologies in professional and everyday life, higher education faces the need to develop students' professional literacy, critical thinking, independence, and digital competence appropriate to the profession (Bhuiyan et al., 2021).

The existing body of research also presents inconsistent findings regarding the relationship between technology use and professional competence formation. While many studies report positive effects of digital learning environments on students' engagement and skill development, others emphasize that technological innovation alone does not guarantee meaningful educational outcomes without appropriate pedagogical conditions and instructional design. In addition, most previous studies have focused on digital competence, AI literacy, or technology acceptance, whereas considerably less attention has been devoted to the systematic development of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

professional literacy as an integrated construct encompassing motivational, cognitive, and practical dimensions (Tan, 2025).

Therefore, a significant research gap remains concerning the pedagogical conditions under which digital technologies contribute to the comprehensive development of students' professional literacy. Addressing this gap provides the rationale for the present study and determines its scientific and practical significance.

Literature Review

The integration of digital technologies into higher education has become a significant avenue for enhancing students' professional literacy and creating adaptive learning environments that respond to contemporary labor market demands. Current research increasingly highlights the role of digital technologies, artificial intelligence (AI), and innovative educational ecosystems in transforming educational processes and strengthening students' professional competencies required for future careers. Recent studies emphasize the growing impact of AI and digital technologies on educational transformation. Research demonstrates that AI-based tools can optimize educational processes, improve learning efficiency, and support digital educational environments, while also presenting challenges related to implementation and ethical use. Similarly, studies examining Fourth Industrial Revolution technologies indicate that AI, robotics, and blockchain create opportunities for personalized, scalable, and accessible learning experiences that can significantly influence students' professional preparation (Chaka, 2023). Furthermore, researchers emphasize the transformative potential of AI for adapting educational processes to individual student needs and enhancing practical training experiences (Prasetya et al., 2025).

Existing evidence also suggests that digital technologies significantly influence the development of cognitive, communicative, and professional competencies associated with professional literacy. Comparative analyses reveal that hybrid learning models positively affect students' communicative and cognitive development, demonstrating the importance of integrating digital and practical learning experiences (Yoshida et al., 2022). Similarly, distance simulations and digital learning environments have been shown to strengthen cognitive flexibility, psychomotor abilities, self-regulation, and adaptability – competencies considered essential components of professional literacy in contemporary educational contexts (Sancho-Cantus et al., 2023).

Researchers further argue that effective digital integration requires developing comprehensive educational ecosystems that combine synchronous and asynchronous communication tools, gamified learning environments, and flexible assessment systems to enhance motivation, communication, and digital competence (Moundy et al., 2025; Araújo et al., 2025). At the same time, the expansion of generative artificial intelligence creates new competency requirements for both students and educators. Although AI literacy and ethical awareness are increasingly recognized as important educational outcomes, existing studies indicate a lack of unified frameworks that integrate the pedagogical, technical, and ethical dimensions of AI implementation in higher education (Burneo-Arteaga et al., 2025).

Although the concepts of digital competence, digital literacy, professional competence, and professional literacy are frequently used interchangeably in

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

contemporary educational research, they represent distinct theoretical constructs. Digital literacy primarily refers to the ability to access, evaluate, create, and communicate information using digital technologies. Digital competence encompasses a broader set of knowledge, skills, attitudes, and ethical dispositions required for effective and responsible use of digital tools. Professional competence is generally understood as the integrated capacity to perform professional tasks successfully through the application of specialized knowledge, skills, and experience.

In contrast, professional literacy extends beyond technological proficiency and includes the ability to critically interpret professional information, solve professional problems, make informed decisions, engage in continuous learning, and effectively apply knowledge within authentic professional contexts. Therefore, digital competence can be considered one of the components contributing to professional literacy rather than an equivalent concept.

A review of recent studies reveals that most research has concentrated on digital competence development, artificial intelligence literacy, technology acceptance, and the implementation of digital learning environments. These studies consistently demonstrate positive effects on student engagement and technological skills; however, their findings remain fragmented regarding the broader development of professional literacy. Moreover, the literature presents ongoing debates concerning whether digital technologies directly contribute to professional development or whether their effectiveness depends on specific pedagogical conditions, instructional design, and students' motivational readiness.

Consequently, a theoretical gap remains in understanding professional literacy as a multidimensional construct that integrates motivational, cognitive, informational, and practical dimensions within digitally enriched educational environments. Existing studies rarely examine how digital technologies influence these dimensions simultaneously or identify the pedagogical conditions that facilitate their integrated development. This gap provides the conceptual foundation for the present study.

The purpose of this study is to determine the effectiveness of integrating digital technologies into the development of professional literacy among higher education students and to experimentally verify the pedagogical conditions that facilitate this process.

Methodology

Research Design

This study employed a mixed-methods research design, combining quantitative and qualitative approaches, to investigate the effectiveness of integrating digital technology in developing professional literacy among higher education students. The research was conducted during the 2023–2025 academic years and included two consecutive stages: ascertaining and formative. The ascertaining stage aimed to identify the initial level of students' professional literacy, whereas the formative stage focused on implementing and evaluating the effectiveness of the developed pedagogical system.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Participants

The study involved 380 undergraduate students enrolled in pedagogical, technical, economic, and social science programmes at Ukrainian higher education institutions during the 2023–2025 academic years. Participants were selected using purposive sampling. The inclusion criteria were: (1) enrolment in a bachelor's degree programme; (2) regular participation in educational activities during the study period; and (3) informed consent to participate in the research. The exclusion criteria included incomplete participation in the educational intervention, absence from more than 20% of learning activities, and incomplete diagnostic data.

The sample consisted of 380 students divided into a Control Group (CG, $n = 190$) and an Experimental Group (EG, $n = 190$). Due to organizational constraints within the participating institutions, random assignment was not feasible; therefore, a quasi-experimental design with equivalent groups was employed. Prior to the intervention, both groups demonstrated comparable distributions across all professional literacy criteria, indicating baseline equivalence.

Research Procedure

The study was implemented through two sequential phases.

Stage 1 – Ascertaining pase

- Determining initial professional literacy levels.
- Diagnosing students' motivational, content-information, and activity components.
- Establishing baseline indicators for control and experimental groups.

Stage 2 – Formative pase

- Implementation of pedagogical conditions and digital educational interventions.
- Integration of digital platforms, AI tools, virtual laboratories, and interactive technologies.
- Evaluation of changes in professional literacy formation levels.

Instruments and Data Collection

Professional literacy was assessed through a comprehensive diagnostic framework that included three components: motivational, content-information, and activity.

The motivational component was assessed using a Professional Literacy Motivation Questionnaire consisting of 20 items rated on a five-point Likert scale. The content-information component was evaluated through a Professional Knowledge and Information Processing Test containing 30 multiple-choice items focused on digital technologies, professional information management, and critical analysis of professional resources. The activity component was assessed through performance-based practical tasks that required students to apply digital technologies to solve professionally oriented problems.

Additional data were collected through questionnaires, interviews, pedagogical observation, and diagnostic assessment tasks. Based on the obtained scores,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

students were classified into high, average, and low levels according to predefined evaluation criteria and scoring rubrics.

Research Methods

The study employed several groups of methods:

- **Theoretical methods:** comparative analysis, content analysis, SWOT analysis, conceptual analysis, synthesis, classification, systematization, and generalization.
- **Empirical methods:** pedagogical experiment, observation, interviews, testing procedures, and diagnostic assessments.
- **Statistical methods:** quantitative and qualitative analysis, descriptive statistics, and inferential statistical procedures.

Data Analysis

Quantitative and qualitative analyses were conducted to evaluate differences between groups and determine the effectiveness of the proposed educational intervention. Statistical significance was assessed using Pearson's chi-square (χ^2) test at a significance level of $\alpha = .05$.

To determine the effectiveness of the intervention, post-experimental distributions of professional literacy levels in the experimental and control groups were compared.

For the motivational criterion, statistically significant differences were identified, $\chi^2(2) = 39.05$, $p < .001$, Cramer's $V = 0.32$. For the content-information criterion, the analysis revealed significant differences, $\chi^2(2) = 42.83$, $p < .001$, Cramer's $V = 0.34$. The largest differences were observed for the activity criterion, $\chi^2(2) = 61.07$, $p < .001$, Cramer's $V = 0.40$. These effect sizes indicate moderate to moderate-to-large practical significance of the intervention.

Reliability and Validity

Content validity of the diagnostic instruments was established through expert evaluation involving seven specialists in higher education pedagogy, educational technology, and digital learning. The experts reviewed the relevance, clarity, and representativeness of all assessment items and confirmed their alignment with the conceptual structure of professional literacy.

The reliability of the instruments was assessed using Cronbach's alpha coefficient. The obtained values ranged from 0.81 to 0.88 across the three assessment scales, indicating satisfactory internal consistency. Additional reliability was ensured through triangulation of questionnaire data, testing procedures, interviews, observations, and diagnostic tasks. The use of both control and experimental groups strengthened the internal validity of the study and enabled objective evaluation of the intervention outcomes.

Results and Discussion

Content and advantages of using digital technologies and platforms to develop students' professional literacy. Main criteria of professional literacy. Digital technologies have become an integral part of the modern world, as they influence the development of professional literacy among students at higher

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

education institutions and have a decisive impact on social processes and the economy.

Given the rapid development of social media and the availability of devices, communicative and interpersonal interactions are changing in modern society. Digital technologies are an environment that opens up new perspectives for learning at any time, providing a continuous educational process, defining individual paths for the education of specialists, and transforming users of electronic resources into creators. Digital technologies are now being actively introduced into the field of higher education, which places new demands on the professional training of specialists for teachers and students, which is a necessary condition for effective teaching and mastery of the material (Knyshe et al., 2024).

Among the main advantages of using digital technologies and platforms to develop students' professional literacy, several key aspects can be identified: objectivity, interactivity, accessibility, time-saving, personalization, and flexibility (Hizam et al., 2023).

Digital tools, thanks to interactive materials with gamification elements, enable all students to engage in learning, even those with the least interest. It is also possible to adapt content to the individual needs of young students.

The use of digital platforms provides teachers and students with 24-hour access to educational materials, which helps increase teaching efficiency and the adaptability of the educational process to modern requirements (Yulin & Danso, 2025).

Professional literacy today encompasses the ability to work in groups or independently, using modern digital tools, resources, systems, and processes to collect professional information from various media, create new systems and products, and acquire new knowledge (Basilotta-Gómez-Pablos et al., 2022).

Professional literacy, in the context of the digital transformation of the economy, is considered an indicator of human capital assessment and reflects the ability of each individual to effectively and safely use advanced achievements in digital technologies, and also serves as an indicator of readiness for the development of students' professional competence and for integration into the global digital space. The main criteria for professional literacy are: critical thinking – the ability to distinguish between real facts and disinformation, analyze information, determine the truthfulness and validity of sources of knowledge; the ability to fact-check – the digitalization of the educational process provides students with the opportunity to check the facts before trusting information or distributing it actively; the use of criteria for evaluating information – the evidence base, source, authority, context and objectivity to evaluate information sources (Mejías-Acosta et al., 2024).

Innovative approaches to the development of students' professional literacy: the use of Internet applications, mobile applications, and artificial intelligence technologies.

Mobile applications are popular among Internet resources that help students organize effective independent learning and select the most effective means and methods for self-improvement.

Among the criteria for the convenience of digital platforms, the following factors stand out: the availability of multimedia materials; a clear and simple interface that

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

ensures ease of navigation; interaction between participants in the educational process; the choice of methodically sound electronic content; the possibility of using the free version of the platform; the formation of motivation to achieve high results through elements of competition; a variety of tasks, etc.

The integration of artificial intelligence technologies is an inevitable and strategically necessary step, driven by technological and global economic trends. The use of AI allows you to free up time for more creative automation of test creation, the process of checking tasks, analyzing student performance, and personalized work in higher education.

The use of AI and digital technologies opens up new prospects for improving education in higher education institutions.

The introduction of AI in education is a strategic necessity for continually increasing the competitiveness of future specialists and for generating ideas or processing prior materials.

Based on the above, we formulate recommendations for the integration of digital technologies into the development of professional literacy of students of higher education institutions:

1. Focus training on the diagnosis and automation of professional tasks, on innovative approaches to the development of professional literacy of students: the use of Internet applications, mobile applications, and artificial intelligence technologies.
2. Supplement educational programs with disciplines that cover practical and ethical aspects of the use of AI (compiling queries to generative models).
3. Replace reproductive tasks with project work and oral tasks, updating assessment methods that require verification, critical analysis in complex professional contexts, and integration of AI results.

Analysis of the formation of professional literacy of students of higher education institutions.

The purpose of the research and experimental work was to test the development and verify the effectiveness of the system and pedagogical conditions for the formation of students' professional literacy through the integration of digital technologies in higher education institutions.

During the 2023-2025 academic year, research and experimental work were carried out and included the following stages: ascertaining and formative.

The ascertaining stage of the experiment consisted of determining the initial level of students' professional literacy in higher education institutions.

All students had the same educational environment.

The structure of the formation of students' professional literacy through the integration of digital technologies was determined, which includes motivational, content-informational, and activity components.

The motivational component of the formation of students' professional literacy reflects the level of respondents' personal involvement in the process of self-education, their ability to reflect, and the motives behind it.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The content-information component includes the level of mastery of professional knowledge. It determines students' ability to effectively use professional information for professional development and students' professional literacy by integrating digital technologies into higher education institutions.

The activity component provides practical application of knowledge of digital technologies to develop students' professional literacy, contributes to the development of professional flexibility, independence, and the ability to manage one's own educational trajectory.

Let us present the results of the study's ascertaining stage.

Table 1.

The level of formation of professional literacy of students according to the motivational criterion (ascertaining stage)

Levels	Control Group	Experimental Group
Low	39,5%	39,9%
Average	48,3%	48,0%
High	12,2%	12,1%

Analysis of the level of students' professional literacy formation by the motivational criterion (ascertainment stage) revealed a similar structure in the experimental and control groups, with a predominance of average and low levels. A high level was recorded in only 12.2% of students in the control group and 12.1% in the experimental group.

The results indicate the need to develop an innovative system and pedagogical conditions to increase students' professional literacy by the motivational criterion, which will be taken into account during the formative stage of the experiment.

The study of the level of formation of students' professional literacy by the content-informational criterion involved determining the systematicity of knowledge, the volume and depth of knowledge in professional disciplines, and the level of awareness of resources for the digitalization of the educational process.

Let us present the results of the study's confirmatory stage in accordance with the second criterion.

Table 2.

Level of formation of students' professional literacy according to the content-information criterion (ascertaining stage)

Levels	Control Group	Experimental Group
Low	45,4%	45,9%
Average	40,7%	40,3%
High	13,9%	13,8%

Qualitative and quantitative analyses of the obtained data show that, according to the content-information criterion, the low level of formation of the outlined phenomenon prevails. A low level was observed in 45.4% of students in the control group and 45.9% in the experimental group. This indicates the need for further work to deepen students' understanding of how their professional literacy develops according to the content-information criterion, using modern digital technologies.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

To determine the activity criterion, a set of methods for organizing educational activities, practical actions, and students' potential ability to work throughout their lives was assessed.

Having summarized the data obtained, we correlated them with the signs of formation of students' professional literacy according to the activity criterion.

Table 3.

Level of formation of students' professional literacy according to the activity criterion (ascertaining stage)

Levels	Control Group	Experimental Group
Low	51,1%	51,3%
Average	37,0%	36,9%
High	11,9%	11,8%

Qualitative analysis and quantitative analysis of the data obtained show that the low level of formation of the outlined phenomenon prevails according to the activity criterion. A low level was observed in the control group among 51.1% of students and in the experimental group among 51.3%. This indicates the need for further work to deepen students' knowledge of the formation of their professional literacy according to the activity criterion, using modern digital technologies.

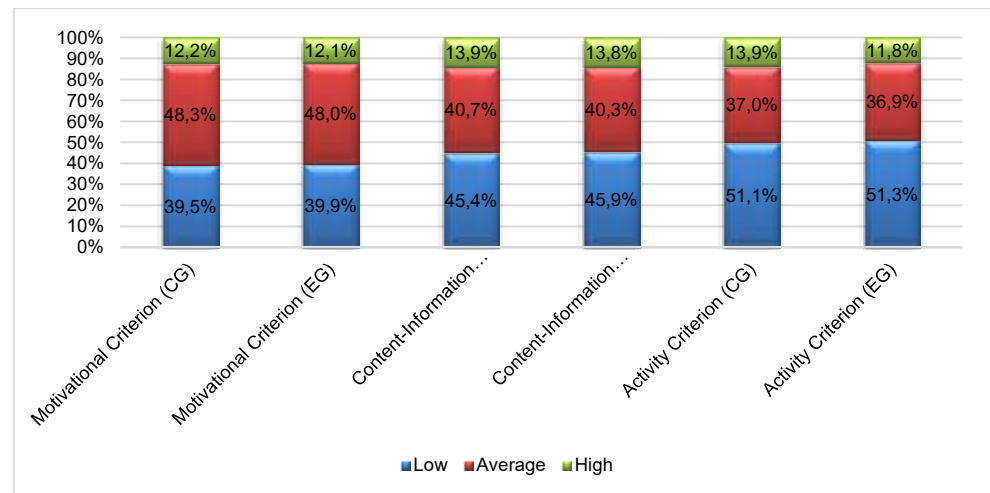


Figure 1. Comparative distribution of students' professional literacy levels according to motivational, content-information, and activity criteria (ascertaining stage)

Qualitative and quantitative analyses of the data obtained at the ascertaining stage of the study show that a low level of formation of the outlined phenomenon prevails across most criteria. This indicates the need for further work to deepen students' knowledge of how their professional literacy develops across all criteria, using modern digital technologies.

So, at the formative stage of the study, we offered EG students a developed system and pedagogical conditions to develop students' professional literacy by integrating digital technologies into higher education institutions.

The use of digital platforms in EG has significantly changed students' professional education, reshaping skill development and learning conditions. Digital platforms for accessing education have become indispensable tools that help improve

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

professional skills. For EG students, an educational environment was created that used digital platforms, including a wide range of online environments, from LMS (learning management systems) to specialized educational websites, modern social networks, and interactive applications. The EG educational system included virtual centers that provided access to an array of educational resources, enabling interaction with peers and teachers from around the world. Using digital platforms, EG students overcame the limitations of the traditional educational environment, making learning accessible anywhere, at any time. An infrastructure was created that is accessible to students regardless of their socio-economic status or location. Digital platforms, by creating individual learning trajectories, enabled EG students to pursue personalized learning tailored to each student's preferences and specific needs; they facilitated the assessment of students' strengths and weaknesses, as well as their learning styles, and contributed to the development of lifelong learning initiatives.

The use of digital platforms in EG encompassed a wide range of tools, including virtual classrooms, online courses, interactive simulations, and AI-based educational systems.

EG students used immersive technologies such as augmented reality (AR) and virtual reality (VR). Simulations and virtual environments allowed EG students to practice scenarios and skills in a controlled, safe setting.

Gamification was proposed to improve motivation among EG students. Kahoot! and Quizizz used game mechanics to make learning more enjoyable, interactive, and interesting for EG students and to motivate them to compete with their peers actively. Digital platforms that integrate digital technologies into the development of students' professional literacy have radically transformed learning through virtual laboratories and interactive simulations, making education more cost-effective and accessible. Virtual laboratories for EG students' learning have been given special importance in STEM fields, where practical experience is essential for developing competencies and practical skills.

One of the most promising areas for integrating digital technologies into the development of students' professional literacy is the combination of machine learning algorithms and artificial intelligence. Virtual environments and simulations for developing students' professional literacy have provided an exciting and realistic learning experience.

Online education platforms, open educational resources (OER), and mobile learning applications have enabled EG students to access high-quality educational content and resources, regardless of their socioeconomic status or location.

The implementation of the proposed system, using artificial intelligence tools, interactive digital services, virtual laboratories, and VR/AR environments, has provided EG students with increased cognitive activity, the development of critical, spatial, and analytical thinking, and the formation of skills in analyzing technological processes and in design.

The use of VR/AR technologies in project activities contributed to the development of students' professional literacy and the formation of pedagogical design skills among applicants to higher education institutions. Future specialists developed their own VR/AR scenarios for professional activities and created interactive training modules for laboratory work, virtual instruction, and demonstration purposes. The

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

InMind 2, PhET Interactive Simulations, Autodesk Tinkercad, ROQED, Labster, and Science platforms were used to organize practical classes and virtual laboratory work aimed at modeling complex, professionally oriented, and scientific and technical processes, developing research competencies, and practicing experimental skills.

In the EG, generative models such as Sora, GPT, and DALL·E were used to create process simulations, interactive visualizations, and automated test tasks.

The use of virtual laboratories, 3D printing technologies, and simulation programs provided EG students with opportunities to develop spatial thinking, deepen their understanding of professional processes, and independently design practical solutions. In combination with mobile technologies (learning management systems, interactive applications, professional simulators, AR/VR environments), this created a comprehensive digital educational environment that contributed to the comprehensive development of students' professional literacy and technological culture among EG students.

We substantiated the feasibility of identifying pedagogical conditions that are decisive for the formation of students' professional literacy through the integration of digital technologies into higher education institutions:

- Information open adaptive environment of a higher education institution, integrated with digital resources and platforms for personalized learning.
- Pedagogical competent management of students' activities in order to form students' professional literacy through the integration of digital technologies into higher education institutions.
- Organization of collective self-educational activities of students and their independent activities through the integration of digital technologies.

Research and experimental verification of the system for developing students' professional literacy through the integration of digital technologies in higher education institutions.

The formative stage of the experimental study aimed to test the effectiveness of the developed system in developing students' professional literacy through the integration of digital technologies in higher education institutions. At this stage, the practical implementation of the developed system and the defined pedagogical conditions, which were laid down as the basis for the pedagogical experimental influence, were carried out. The purpose of the formative experiment was to test the developed system and the defined pedagogical conditions, and to identify the dynamics of changes in the levels of formation of the outlined phenomenon in the experimental groups compared to the control groups.

The preparatory stage included the clarification of methodological approaches, the development of the experimental program and diagnostic tools, the selection of the experimental base, and the provision of instructions on the conditions for respondents' participation in the formative stage of the study.

The main stage included the implementation of the developed system and the defined pedagogical conditions into the educational process of the experimental groups. The control groups were trained according to the standard methodology.

The final stage is devoted to conducting a control section, generalizing the results of the experiment in the control and experimental groups, analyzing the

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

effectiveness of the developed system, the specified pedagogical conditions, comparing the obtained data, and formulating conclusions.

To assess the significance of the results obtained for each criterion and the overall level of students' professional literacy development through the integration of digital technologies in higher education institutions, quantitative and qualitative analyses were conducted, along with statistical analysis using the Pearson χ^2 test. To assess the significance of the obtained results, Pearson's chi-square (χ^2) test of independence was applied. The statistic was calculated according to the formula:

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

where O_i represents the observed frequencies and E_i represents the expected frequencies under the null hypothesis.

The degrees of freedom were calculated using the formula:

$$df = (r - 1)(c - 1)$$

where r is the number of rows and c is the number of columns in the contingency table.

The significance level was set at $\alpha = .05$. The null hypothesis (H_0) assumed that no statistically significant differences existed between the distributions of professional literacy levels in the experimental and control groups. The alternative hypothesis (H_1) assumed that statistically significant differences existed between the groups following the intervention.

Two statistical hypotheses were formulated, assuming the lowest level of statistical significance ($\alpha = 0.05$).

H_0 : The dynamics of the levels of formation of professional literacy of students through the integration of digital technologies in higher education institutions in the experimental groups are not more significant than in the control groups.

H_1 : The dynamics of the levels of formation of professional literacy of students through the integration of digital technologies in higher education institutions in the experimental groups are more significant than in the control groups.

Empirical values obtained χ_{emp}^2 were compared with the values χ_{cr}^2 – critical tabular. To assess the dynamics of the levels of formation of professional literacy of students through the integration of digital technologies in higher education institutions, with a probability of error p of 0.05, 0.01, and 0.001 units at all levels, χ_{cr}^2 allows us to state that hypothesis H_1 was accepted if $\chi_{emp}^2 \geq \chi_{cr}^2$ and the hypothesis $H_0 - \chi_{emp}^2 < \chi_{cr}^2$. Let us move on to the analysis of the experimental results.

At the formative stage of the study, we offered EG students a developed system and pedagogical conditions to develop students' professional literacy through the integration of digital technologies into higher education institutions. The CG studied according to the standard education system.

The results obtained are presented in the following tables.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Table 4.

Dynamics of the levels of formation of students' professional literacy through the integration of digital technologies into higher education institutions according to the motivational criterion (formative stage)

Levels	Control Group		Experimental Group	
	Before the experiment	After the experiment	Before the experiment	After the experiment
Low	39,5%	28,9%	39,9%	11,1%
Average	48,3%	51,1%	48,0%	41,0%
High	12,2%	20,0%	12,1%	47,9%

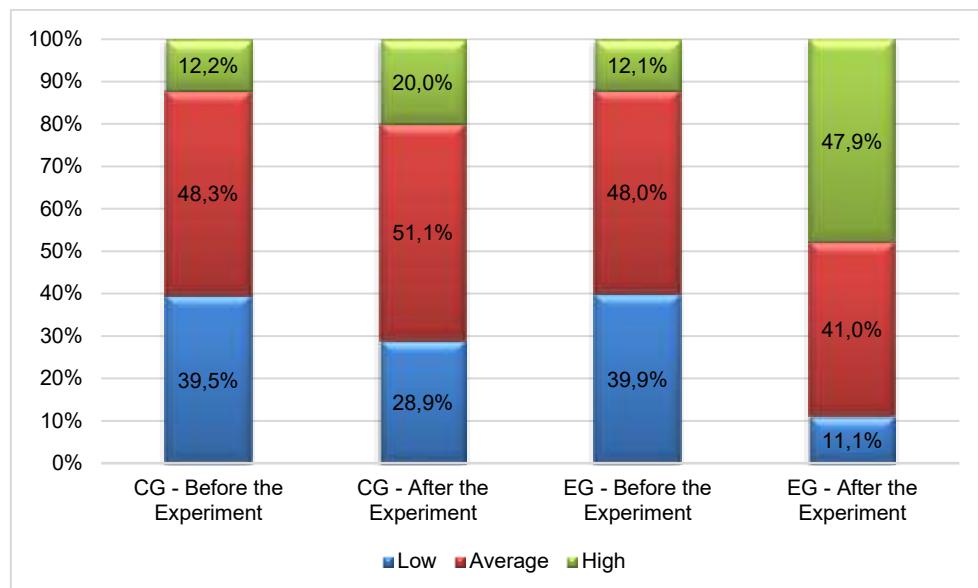


Figure 2. Dynamics of the levels of formation of students' professional literacy through the integration of digital technologies into higher education institutions according to the motivational criterion (formative stage)

Analysis of the dynamics of students' professional literacy formation levels through the integration of digital technologies, using a motivational criterion, showed positive changes in the experimental group compared to the control group.

Next, we studied the characteristics of indicators of the formation of students' professional literacy through the integration of digital technologies, using the content-information criterion.

The results obtained are shown in Table 5.

Table 5.

Dynamics of the levels of formation of students' professional literacy through the integration of digital technologies in higher education institutions according to the content-information criterion (formative stage)

Levels	Control Group		Experimental Group	
	Before the experiment	After the experiment	Before the experiment	After the experiment
Low	45,4%	35,8%	45,9%	11,1%
Average	40,7%	43,1%	40,3%	42,4%
High	13,9%	21,1%	13,8%	46,5%

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

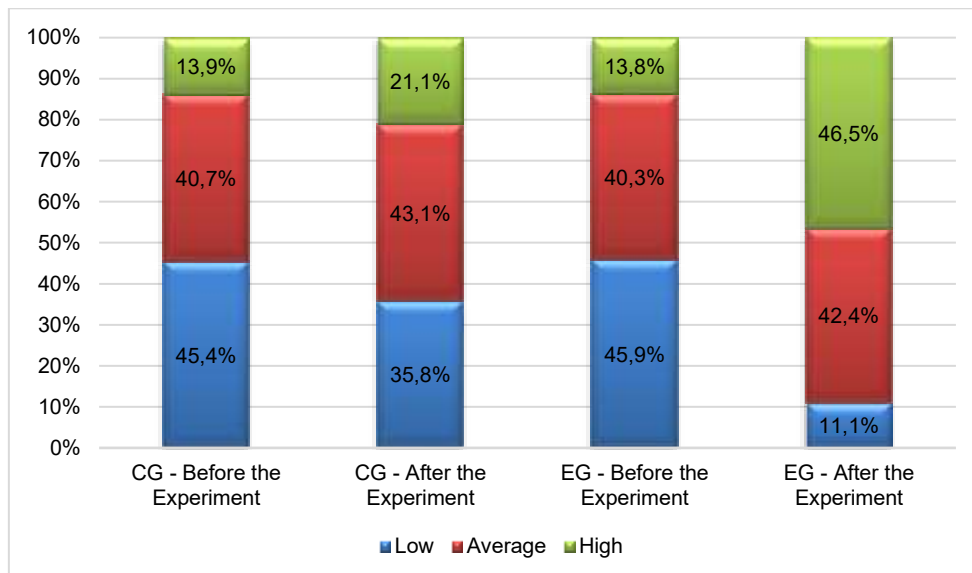


Figure 3. Dynamics of the levels of formation of students' professional literacy through the integration of digital technologies into higher education institutions according to the content-information criterion (formative stage)

Analysis of the dynamics of students' professional literacy formation levels through the integration of digital technologies into higher education institutions, according to the content-information criterion, showed noticeable positive changes compared to the control group, specifically in the experimental group.

The study's results evidence the effectiveness of the pedagogical conditions and the system.

The next stage of our study was to determine the features of the formation of students' professional literacy through the integration of digital technologies into higher education institutions according to the activity criterion.

Table 6.

Dynamics of the levels of formation of students' professional literacy through the integration of digital technologies into higher education institutions according to the activity criterion (formative stage)

Levels	Control Group		Experimental Group	
	Before the experiment	After the experiment	Before the experiment	After the experiment
Low	51,1%	45,8%	51,3%	12,2%
Average	37,0%	35,4%	36,9%	40,5%
High	11,9%	18,8%	11,8%	47,3%

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

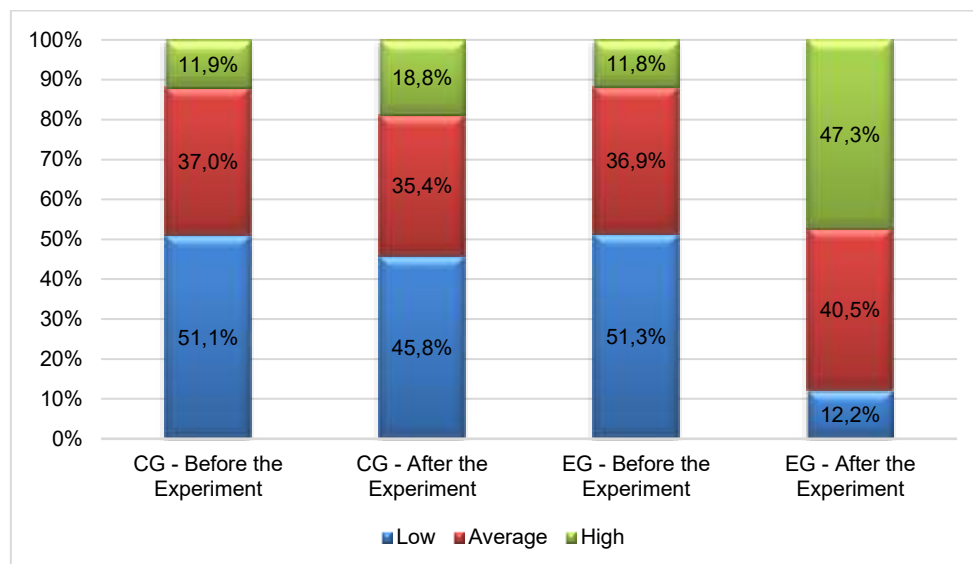


Figure 4. Dynamics of the levels of formation of students' professional literacy through the integration of digital technologies into higher education institutions by the activity criterion (formative stage)

To evaluate the effectiveness of the intervention, Pearson's χ^2 test was applied to compare the distributions of professional literacy levels between the experimental and control groups after the formative stage.

For the motivational criterion, statistically significant differences were identified between the groups, $\chi^2(2) = 39.05$, $p < .001$, Cramer's $V = 0.32$, indicating a moderate effect size.

For the content-information criterion, the analysis also revealed statistically significant differences, $\chi^2(2) = 42.83$, $p < .001$, Cramer's $V = 0.34$, demonstrating a moderate effect of the intervention.

The largest differences were observed for the activity criterion, where Pearson's test showed $\chi^2(2) = 61.07$, $p < .001$, Cramer's $V = 0.40$, indicating a moderate-to-large effect size.

Overall, the findings demonstrate that students in the experimental group achieved significantly higher levels of professional literacy than students in the control group across all assessed criteria. The obtained effect sizes confirm that the integration of digital technologies had not only statistical significance but also practical educational value.

Table 7.

The distributions of professional literacy levels between the experimental and control groups after the formative stage.

Criterion	χ^2	df	p	Cramer's V	Effect Size
Motivational	39.05	2	< .001	0.32	Moderate
Content-information	42.83	2	< .001	0.34	Moderate
Activity	61.07	2	< .001	0.40	Moderate-Large

The statistical findings presented in Table 7 provide empirical confirmation of the effectiveness of the intervention. While descriptive percentages indicate substantial

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

improvements in the experimental group, the chi-square analysis demonstrates that these differences are unlikely to have occurred by chance. The moderate effect sizes obtained for the motivational ($V = 0.32$) and content-information ($V = 0.34$) criteria, together with the moderate-to-large effect size for the activity criterion ($V = 0.40$), suggest that the intervention had not only statistical significance but also meaningful practical value for the development of students' professional literacy.

The obtained χ^2 values exceeded the critical value for $df = 2$ ($\chi^2_{crit} = 5.99$, $\alpha = .05$), indicating statistically significant differences between the experimental and control groups for all assessed criteria. Since all p-values were below .001, the null hypothesis was rejected and the alternative hypothesis was accepted.

The findings of this study demonstrate that the integration of digital technologies into the educational process contributes significantly to the development of professional literacy among higher education students. Statistically significant differences between the experimental and control groups across all assessed criteria confirm the effectiveness of the proposed pedagogical conditions and digital learning environment.

The obtained results are consistent with previous studies highlighting the positive influence of digital technologies on students' professional development. In particular, the findings support the conclusions of Yoshida et al. (2022), who reported that blended and technology-enhanced learning environments promote cognitive development, self-regulation, and professional skill acquisition. Similarly, the present results align with the conclusions of Sancho-Cantus et al. (2023), who demonstrated that digitally supported learning activities facilitate the development of adaptability, problem-solving abilities, and professional competencies required in contemporary educational and professional contexts.

The substantial improvements observed in the experimental group also support the arguments of Chaka (2023) and Prasetya et al. (2025), who emphasized that artificial intelligence, virtual environments, and digital educational ecosystems create opportunities for personalized learning and enhanced professional preparation. The increase in high-level indicators across motivational, content-information, and activity criteria suggests that digital technologies influence not only students' knowledge acquisition but also their engagement, self-directed learning, and practical application of professional skills.

At the same time, the present findings extend existing research by examining professional literacy as a multidimensional construct integrating motivational, cognitive, informational, and practical dimensions. While many previous studies have focused primarily on digital competence or AI literacy, the current study demonstrates that digital technologies may contribute to broader educational outcomes when implemented within a structured pedagogical framework. Therefore, the findings partially address the research gap identified in the literature regarding the integrated development of professional literacy in digitally enriched educational environments.

Several factors may explain the positive outcomes observed in the experimental group. First, the combination of digital platforms, virtual laboratories, AI-based tools, and interactive technologies provided students with greater opportunities for active learning and practical engagement. Second, personalized learning trajectories and continuous access to educational resources may have enhanced students' motivation and autonomy. Third, the integration of collaborative and project-based

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

activities likely contributed to the development of higher-order thinking skills and professional problem-solving abilities.

However, alternative explanations should also be considered. Improvements may have been partially influenced by increased student motivation associated with participation in an innovative educational intervention (Hawthorne effect) or by differences in instructor engagement during the implementation process. Furthermore, because the study employed a quasi-experimental design without random assignment, causal interpretations should be made cautiously.

Conclusions

The study investigated the effectiveness of integrating digital technologies into the development of professional literacy among higher education students and experimentally verified the pedagogical conditions supporting this process. Professional literacy was conceptualized as a multidimensional construct comprising motivational, content-information, and activity components.

The findings demonstrated that the implementation of digital platforms, artificial intelligence tools, virtual laboratories, VR/AR technologies, and interactive learning environments contributed to statistically significant improvements in students' professional literacy. Following the intervention, the proportion of students with a high level of professional literacy in the experimental group increased from 12.1% to 47.9% according to the motivational criterion, from 13.8% to 46.5% according to the content-information criterion, and from 11.8% to 47.3% according to the activity criterion. Pearson's chi-square analysis confirmed significant differences between the experimental and control groups for all assessed criteria: motivational criterion, $\chi^2(2) = 39.05$, $p < .001$, Cramer's $V = 0.32$; content-information criterion, $\chi^2(2) = 42.83$, $p < .001$, Cramer's $V = 0.34$; activity criterion, $\chi^2(2) = 61.07$, $p < .001$, Cramer's $V = 0.40$. These results indicate moderate to moderate-to-large practical effects of the intervention.

The theoretical contribution of the study lies in expanding the understanding of professional literacy as an integrated construct that combines motivational, cognitive, informational, and practical dimensions within digitally enriched educational environments. The study also contributes to the growing body of research examining the pedagogical potential of digital technologies beyond the development of digital competence alone.

The practical significance of the findings is associated with the development of pedagogical conditions that can be implemented in higher education institutions to support students' professional preparation. The proposed approach may be used to enhance educational programmes through the integration of artificial intelligence, virtual laboratories, digital learning platforms, and personalized learning trajectories. Several limitations should be acknowledged. The study employed a quasi-experimental design without random assignment, which limits causal interpretation of the findings. The sample was restricted to students from a limited number of higher education institutions, potentially affecting the generalizability of the results. In addition, the absence of longitudinal follow-up measurements does not allow conclusions regarding the long-term sustainability of the observed effects.

Future research should investigate the long-term impact of digital technology integration on professional literacy development, compare the effectiveness of specific categories of digital tools, and examine the applicability of the proposed

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

pedagogical framework across different academic disciplines, educational systems, and cultural contexts.

Bibliographic references

- Araújo, A. A., Kalinowski, M., & Baldassarre, M. T. (2025). Embracing experiential learning: Hackathons as an educational strategy for shaping soft skills in software engineering. In *2025 IEEE/ACM 37th International Conference on Software Engineering Education and Training (CSEE&T)* (pp. 319–324). IEEE. <https://doi.org/10.1109/CSEET66350.2025.00040>
- Basilotta-Gómez-Pablos, V., Matarranz, M., Casado-Aranda, L.-A., & Otto, A. (2022). Teachers' digital competencies in higher education: A systematic literature review. *International Journal of Educational Technology in Higher Education*, 19, 1–16. <https://doi.org/10.1186/s41239-021-00312-8>
- Bhuiyan, B. A., Molla, M. S., & Alam, M. (2021). Managing innovation in technical education: Revisiting the developmental strategies of Politeknik Brunei. *Annals of Contemporary Developments in Management & HR*, 3(4), 44–57. <https://doi.org/10.48550/arXiv.2111.02850>
- Burneo-Arteaga, P., Lira, Y., Murzi, H., Balula, A., & Costa, A. (2025). Capability-based training framework for generative AI in higher education. *Frontiers in Education*, 10, 1594199. <https://doi.org/10.3389/feduc.2025.1594199>
- Chaka, C. (2023). Fourth industrial revolution – A review of applications, prospects, and challenges for artificial intelligence, robotics and blockchain in higher education. *Research and Practice in Technology Enhanced Learning*, 18, 2. <https://doi.org/10.58459/rptel.2023.18002>
- Dringó-Horváth, I., Rajki, Z., & T. Nagy, J. (2025). University teachers' digital competence and AI literacy: Moderating role of gender, age, experience, and discipline. *Education Sciences*, 15(7), 868. <https://doi.org/10.3390/educsci15070868>
- Gudonienė, D., Stanevičienė, E., Huet, I., Dickel, J., Dieng, D., Degroote, J., Rocio, V., Butkienė, R., & Casanova, D. (2025). Hybrid teaching and learning in higher education: A systematic literature review. *Sustainability*, 17(2), 756. <https://doi.org/10.3390/su17020756>
- Hizam, S. M., Akter, H., Sentosa, I., & Ahmed, W. (2023). Digital competency of educators in the virtual learning environment: A structural equation modeling analysis. *IOP Conference Series: Earth and Environmental Science*, 704(1), 012023. <https://doi.org/10.1088/1755-1315/704/1/012023>
- Knysh, I., Drobin, A., Filimonova, T., Koycheva, T., Kushnir, A., & Kuchai, O. (2024). The use of information technologies in the educational space of Ukraine (on the example of STEAM technologies). *Revista Conrado*, 20(100), 437–448. <https://conrado.ucf.edu.cu/index.php/conrado/article/view/3979>
- Liu, X., & Zhong, B. (2025). Integrating generative artificial intelligence into student learning: A systematic review from a TPACK perspective. *Educational Research Review*, 49, 100741. <https://doi.org/10.1016/j.edurev.2025.100741>
- Mejías-Acosta, A., D'Armas Regnault, M., Vargas-Cano, E., Cárdenas-Cobo, J., & Vidal-Silva, C. (2024). Assessment of digital competencies in higher education students: Development and validation of a measurement scale. *Frontiers in Education*, 9, 1497376. <https://doi.org/10.3389/feduc.2024.1497376>
- Moundy, K., Chafiq, N., & Talbi, M. (2025). Hybrid skills: Analysis of digital soft skills development in students during digital literacy learning through a digital textbook and flipped classroom. *Journal of Educators Online*, 22(1). <https://doi.org/10.9743/JEO.2025.22.1.13>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Prasetya, F., Fortuna, A., Samala, A. D., Latifa, D. K., Andriani, W., Gusti, U. A., Raihan, M., Criollo-C, S., Kaya, D., & Cabanillas García, J. L. (2025). Harnessing artificial intelligence to revolutionize vocational education: Emerging trends, challenges, and contributions to SDGs 2030. *Social Sciences & Humanities Open*, 11, 101401. <https://doi.org/10.1016/j.ssaho.2025.101401>
- Sancho-Cantus, D., Cubero-Plazas, L., Botella Navas, M., Castellano-Rioja, E., & Cañabate Ros, M. (2023). Importance of soft skills in health sciences students and their repercussion after the COVID-19 epidemic: A scoping review. *International Journal of Environmental Research and Public Health*, 20(6), 4901. <https://doi.org/10.3390/ijerph20064901>
- Saúde, S., Barros, J., & Almeida, I. (2024). Impacts of generative artificial intelligence in higher education: Research trends and students' perceptions. *Social Sciences*, 13(8), 410. <https://doi.org/10.3390/socsci13080410>
- Tan, Q. (2025). Reimagining teacher development in the era of generative AI: A scoping review. *Teaching and Teacher Education*, 168, 105236. <https://doi.org/10.1016/j.tate.2025.105236>
- Yoshida, Y., Uno, T., Tanaka, H., Hakosaki, I., Shigeta, K., & Yano, R. (2022). Cognitive changes with psychomotor skill acquisition through blended learning among nursing students: A qualitative study. *Nurse Education in Practice*, 65, 103486. <https://doi.org/10.1016/j.nepr.2022.103486>
- Yulin, N., & Danso, S. D. (2025). Assessing pedagogical readiness for digital innovation: A mixed-methods study. *arXiv*. <https://doi.org/10.48550/arXiv.2502.15781>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Formación digital para futuros profesionales del derecho en comercio exterior de productos agrícolas: UE y Ucrania

Digital educational training of future legal professionals in foreign trade of agricultural products: EU and Ukraine

Serhii Kravchenko¹  Oleksandr Pachchenko²  Olha Tsybulska³  Olena Khrapenko⁴  Hanna Samilo⁵ 

Afiliación autor:

¹ Ph.D., Associate Professor, Director of the Center for Extramural and Distance Learning of National University "Odessa Law Academy", Odessa, Ukraine.

serhii.kravchenko@onua.edu.ua

² Ph.D., Associate Professor of the Department of Civil Law Disciplines, Institute of Law and Security, Odessa State University of Internal Affairs, Odessa, Ukraine. velespan@gmail.com

³ Ph.D., Associate Professor of the Department of International and European Law of National University «Odessa Law Academy», Odessa, Ukraine. olha.tsybulska@gmail.com

⁴ Candidate of Juridical Sciences, Associate Professor, Assistant Professor of the Department of Judiciary, Law Enforcement Authorities and Advocacy National University «Odessa Law Academy», Odessa, Ukraine. lenahrapenko@gmail.com

⁵ Ph.D., Head of the Department of "Constitutional, Administrative and Labor Law", National University "Zaporizhzhia Polytechnic", Zaporizhzhia, Ukraine. samilo.hanne@gmail.com

Recibido: 10/04/26

Aceptado: 15/06/26

Cómo citar:

Kravchenko, S., Pachchenko, O., Tsybulska, O., Khrapenko, O., & Samilo, H. (2026). Digital educational training of future legal professionals in foreign trade of agricultural products: EU and Ukraine. *Revista Eduweb*, 20(2), 434-447. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.25>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

Existe una creciente demanda de profesionales jurídicos altamente cualificados con conocimientos de derecho internacional y europeo, herramientas digitales para el comercio exterior y las particularidades de la regulación de la exportación e importación de productos agrícolas. La digitalización de los procesos comerciales, la expansión del comercio electrónico y la introducción de sistemas de certificación digital plantean nuevos retos para el sistema de formación jurídica. En particular, el análisis y la aplicación de las mejores prácticas educativas de la UE contribuirán a fortalecer la capacidad institucional de Ucrania y a garantizar su participación efectiva en el mercado internacional de productos agrícolas. El objetivo del estudio es un análisis comparativo de la formación digital de futuros abogados en el ámbito del comercio exterior. La metodología de la investigación consta de los siguientes métodos: método estructural-funcional, método empírico, método de análisis y síntesis, y método sistémico. Como resultado del estudio, se realizó un análisis exhaustivo de la formación digital de futuros abogados especializados en la regulación jurídica del comercio exterior de productos agrícolas en el contexto del programa de integración europea de Ucrania. A partir de un análisis jurídico comparativo, se identificaron las tendencias en la formación de competencias digitales de los abogados en la UE y se evaluó la preparación del sistema de formación jurídica ucraniano para implementar las herramientas digitales modernas necesarias para la actividad profesional en el mercado agrícola internacional. Se prestó especial atención al impacto de la guerra en la transformación de la educación superior en Ucrania. Se propusieron líneas estratégicas para adaptar las mejores prácticas europeas en la digitalización de la educación.

Palabras clave: educación moderna, educación jurídica digital, competencias digitales, integración europea, prácticas educativas, preparación de estudiantes.

Abstract

There is a growing demand for highly qualified legal professionals who have knowledge of international and European law, digital tools of foreign trade activity and the specifics of regulating the export and import of agricultural products. The digitalization of trade processes, the expansion of e-commerce, the introduction of digital certification systems create new challenges for the legal education system. In particular, the analysis and implementation of the best educational practices of the EU will contribute to strengthening the institutional capacity of Ukraine and ensuring effective participation in the international market of agricultural products. The purpose of the study is a comparative analysis of the digital educational training of future lawyers in the field of foreign trade. The research methodology consists of the following methods: structural-functional method, empirical method, method of analysis and synthesis, system method. As a result of the study, a comprehensive analysis of the digital educational training of future lawyers specializing in the legal regulation of foreign trade in agricultural products was conducted in the context of Ukraine's European integration course. Based on comparative legal analysis, trends in the formation of digital competencies of lawyers in the EU were identified and the

readiness of the Ukrainian legal education system to implement modern digital tools necessary for professional activity in the international agricultural market was assessed. Particular attention was paid to the impact of the war on the transformation of higher education in Ukraine. Strategic directions for adapting best European practices in the digitalization of education were proposed.

Keywords: modern education, digital legal education, digital competencies, European integration, educational practices, student preparation.

Introduction

The development of digital technologies significantly transforms the educational environment and requires the integration of digital competencies into the professional training of students. In the context of European integration and Ukraine's approximation to EU standards, there is a need to combine international experience in digital education with national educational practices.

The European Declaration on Digital Rights and Principles (European Union, 2023) defines basic standards of digital literacy, access to technology and data security, which are important guidelines for the formation of competencies of future specialists in the field of foreign trade. The conclusion of the Association Agreement between Ukraine and the EU (European Commission, 2017) is aimed at harmonizing the legal field and economic relations, including trade in agricultural products, which requires appropriate training of specialists. EU Regulation No. 1308/2013 establishes a single organization of agri-food markets, and the WTO provisions on agricultural trade regulate international standards that affect the activities of specialists in the field of foreign economic activity (World Trade Organization, n.d.).

The digitalization of the educational process plays an important role in the transformation of education. The European Commission, in its reports "Digital Education Action Plan (2021–2027)" identifies priorities for integrating digital tools, improving the digital competence of teachers and students, and creating conditions for innovative learning. The digital competence frameworks (DigComp, DigCompEdu) serve as a reference point for assessing the level of digital training and planning educational programs. An analysis of the current state of digital education in Europe shows the active implementation of e-learning and interactive methods, which contributes to the formation of professional competencies (European Association for Viewers Interests [EAVI], 2018).

At the same time, the development of Ukraine's foreign trade demonstrates dynamic growth despite the difficult conditions of the economic and security crisis. This creates a need for training specialists who possess both practical knowledge in the field of foreign economic activity and digital competencies for effective operation in the conditions of the modern market. European experience combined with national specifics opens up opportunities for the development of digital training of future specialists and the formation of highly qualified personnel for the agricultural sector and foreign trade activities.

The lack of comprehensive research on the features of digital training for lawyers in the specific field of foreign trade in agricultural products, as well as the lack of a systematic comparative analysis of the experience of the EU and Ukraine, create obstacles to the effective harmonization of educational standards and the implementation of best European practices in the domestic legal education system.

Thus, the relevance of the study is due to the need to integrate digital educational technologies and European standards into the training of specialists in foreign trade

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

in agricultural products in Ukraine, which will contribute to increasing the competitiveness of the national agricultural sector and adaptation to international market requirements.

The purpose of the study is to conduct a comparative analysis of digital training systems for future lawyers in the field of foreign trade in agricultural products in the EU and Ukraine, identify key differences, identify best practices, and formulate recommendations for improving the Ukrainian system of specialist training, taking into account European integration processes.

The object of the study is the system of professional training of future lawyers specializing in the legal regulation of foreign trade in agricultural products in the European Union and Ukraine.

The subject of the study is digital technologies, methods, tools and learning platforms used in the process of training future international lawyers in the field of foreign trade in agricultural products, as well as a comparative characteristic of educational standards, programs and practices of digitalization of legal education in the EU and Ukraine.

To achieve the goal, it is necessary to solve the following tasks:

- 1) Analyze the regulatory framework for digital education of lawyers in the EU and Ukraine;
- 2) Analyze digital tools and platforms used to train future professionals in the EU and Ukraine;
- 3) Identify challenges and barriers to the digital transformation of legal education in Ukraine in the context of European integration; formulate practical recommendations for implementing best European practices of digital learning into the domestic legal training system.

To ensure terminological clarity of the study, it is necessary to identify key concepts used in the context of digital training of future specialists in the field of foreign trade in agricultural products:

- Digital learning is understood as an educational process based on the use of digital technologies, tools and platforms to organize, conduct and support educational activities, including distance, blended and online learning using multimedia resources, interactive simulations and electronic educational environments.
- Digital competence is defined according to the European Digital Competence Framework as the ability to use digital technologies confidently, critically and responsibly for learning, work and participation in social life, which includes information literacy, communication, digital content creation, security and problem solving.
- Legal Tech in the context of legal education means a set of technological solutions, software products, and digital tools used to automate legal processes, analyze legal information, manage document flow, predict court decisions, and optimize the provision of legal services, as well as to train future lawyers to work with such systems.
- Digital transformation of education is defined as a systemic process of profound changes in the education system, which involves not only the introduction of digital technologies, but also changes in pedagogical approaches, teaching methods, organizational structures and culture of educational institutions in

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- order to improve the quality, accessibility and efficiency of education in accordance with the requirements of the digital economy and society.
- The European Qualifications Framework is a tool for comparing qualifications across Europe, defining eight levels of qualifications based on learning outcomes expressed in terms of knowledge, skills and competences, regardless of the system in which they were acquired.
 - Interactive learning methods refer to a set of pedagogical approaches and techniques based on the active interaction of students with the teacher, with each other, and with the learning material, including the case method, role-playing games, simulations, discussions, project work, and problem-based learning.
 - Academic mobility is defined as the ability of students, teachers and researchers to move between higher education institutions in different countries to study, teach, conduct research or undertake internships with the aim of exchanging knowledge, experience and cultural values, which contributes to the internationalization of education and improving its quality.
 - Harmonization of educational standards means the process of harmonizing and aligning national education systems, educational programs, qualification requirements and quality assurance procedures with common European standards within the framework of the Bologna Process and other initiatives in order to ensure comparability, recognition and transparency of qualifications in the European Higher Education Area.

Theoretical Framework and Literature Review

The analysis of scientific sources indicates the growing attention of researchers to the digital transformation of education, especially in the context of professional training of those applicants who will work in the field of international trade in agricultural products.

Radkevych et al. (2018) provide a thorough comparison of vocational education models in the EU, where one of the central features is the close integration of digital solutions into the interaction between universities and employers. The researchers emphasize that digital technologies provide rapid updating of knowledge, flexibility of educational trajectories and data-based decision-making. The authors actually indicate: the development of qualifications in the EU is impossible without modern digital tools, and the relevant experience should become a reference point for Ukraine. We share the opinion that digital competencies are mandatory for lawyers who will work with the regulatory mechanisms of agricultural trade, since most trade and legal procedures are electronic.

Methodological recommendations by Turchyn et al. (2022) emphasize the dominance of practice-oriented digital forms of learning in European universities. Researchers emphasize that the use of simulations, interactive platforms and digital simulators not only increases the efficiency of learning, but also “models professional scenarios that are as close as possible to real practice”. We fully agree with this position, since the training of specialists in the field of international agricultural trade should involve working with real digital platforms used in the European market.

European scholars Gisbert-Cervera & Caena (2022) draw attention to the fact that the digital competence of the teacher is a catalyst for the digital development of the student. The authors actually note: a teacher who does not own modern digital tools is not able to effectively form these skills in others. They justify the need for

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

systematic support and advanced training of teachers within the framework of DigCompEdu.

Starkey (2020) conducts a systematic review of international practices in teacher training for the digital era, where the author emphasizes the need to integrate digital competencies into teaching activities, which directly affects the effectiveness of student learning. It is highlighted that the level of digital literacy of the teacher determines the quality of the formation of relevant skills in students, and insufficient training of teachers creates significant barriers to the implementation of innovative teaching methods. These findings are directly consistent with the need to train Ukrainian lawyers to work with electronic platforms and digital systems for regulating foreign trade in agricultural products.

Mannila et al. (2018) examined the relationship between teachers' digital competences, their self-esteem and learning needs. The authors emphasize that a high level of digital mastery of teachers increases their confidence in applying innovative methods and, as a result, contributes to the effective formation of digital skills in students. This confirms the need for a systematic approach to improving the skills of teachers, in particular in the training of future specialists in foreign trade of agricultural products, where modern digital skills are mandatory for working with electronic certificates, customs systems and trading platforms.

Bakhmat's (2022) study focuses on the formation of students' professional competencies in a digital educational environment. The author demonstrates that the use of electronic platforms and interactive tools increases the level of practical training of education seekers and provides the opportunity to apply theoretical knowledge in real situations. Similar conclusions are confirmed in the work of Bakhmat et al. (2022), which emphasizes that the digital transformation of education in conditions of war and informatization of society ensures the stability of the education system, promotes the accessibility of training and forms competencies relevant to the modern labor market. These observations confirm the importance of a practice-oriented approach in the training of lawyers to work with international trade processes in the agricultural sector.

In summary, the sources cited indicate a close relationship between the development of foreign trade and the need for highly qualified personnel with digital competencies. In Ukraine, despite the crisis conditions and martial law, there is an increase in trade, which emphasizes the need to modernize vocational education. Thus, the research data confirm that digital tools and competencies are becoming a key element in the training of specialists capable of operating effectively in the field of international agricultural trade, ensuring the competitiveness of Ukraine in world markets.

Methodology

This study employs a qualitative documentary research design with a structured comparative approach. The empirical basis of the study consists of EU legal acts, Ukrainian regulatory documents, methodological recommendations, institutional reports, and peer-reviewed scientific publications published between 2018 and 2025. The selection of sources was based on relevance to digital legal education, foreign trade regulation, and European integration processes.

The structural-functional method is used to analyze the organizational and functional aspects of vocational education systems, including teacher training and curriculum

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

structure. It is based on the study of educational models of the EU and Ukraine, in particular their organization, use of digital technologies and integration of practical components. The method helped to identify elements of the system that contribute to the formation of digital competencies of students.

Documentary analysis of statistical and analytical sources was employed to examine trends in foreign trade development and the evolving demand for professional and digital competencies in the agricultural sector. Statistical reports, institutional analyses, and analytical publications issued by the National Institute for Strategic Studies, UNIAN, and the World Bank were included in the documentary corpus. The examination of these sources enabled the identification of key trends, challenges, and competency requirements relevant to the training of future legal professionals involved in foreign trade activities.

The method of analysis and synthesis involves the systematization and integration of data from various sources: scientific publications, regulatory acts, and statistical materials. The use of this method allowed us to identify patterns and trends in digital education and training of specialists in foreign agricultural production.

The systems method provides a comprehensive approach to studying the process of training future specialists as a single system, including legal, educational, technological and economic components. The application of this method allows to assess the relationships between regulatory requirements, digital competencies of students and teachers, program structure and labor market needs.

The comparative analysis was conducted using the following analytical categories:

- 1) Digital competencies formation;
- 2) Integration of Legal Tech tools;
- 3) Digital infrastructure and educational platforms;
- 4) Teacher digital preparedness;
- 5) Interactive teaching methods;
- 6) Alignment with EU digital education frameworks;
- 7) Adaptation of legal education to the agricultural trade sector.

Inclusion criteria covered official EU and Ukrainian policy documents, peer-reviewed publications, and institutional analytical reports addressing digital legal education, vocational training, digital competencies, and foreign trade regulation in the agricultural sector. Sources not directly related to legal education or lacking analytical relevance to the research objectives were excluded.

The combination of these research methods ensures scientific validity, systematicity, and practical relevance of the results. Each method contributed to the achievement of the research objectives: the structural-functional method facilitated the identification of organizational elements of educational systems; the documentary analysis of statistical and analytical sources enabled the identification of trends, challenges, and competency requirements; the method of analysis and synthesis supported the integration and interpretation of information from diverse sources; and the systems method provided a comprehensive understanding of the relationships among educational, legal, technological, and economic components involved in the training of future legal professionals.

The documentary analysis was conducted through structured comparative interpretation of EU and Ukrainian regulatory, scientific, and institutional sources according to predefined analytical categories.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Results and Discussion

Comparative Analysis of the Regulatory Framework for Digital Legal Education in the EU and Ukraine

The comparative documentary analysis demonstrated that the European Union has developed a systematic and institutionally coordinated approach to the digital transformation of education through strategic policy documents, digital competence frameworks, and unified educational standards. In particular, the European Declaration on Digital Rights and Principles (European Union, 2023), the Digital Education Action Plan 2021–2027, DigComp, and DigCompEdu establish a comprehensive framework for the formation of digital competencies, integration of innovative technologies into the educational process, and continuous professional development of teachers (European Union, 2023; European Union, 2021; European Commission, 2023; Digital Skills and Jobs Platform, 2024).

The analysis of EU regulatory and methodological documents revealed that digital competencies are considered a mandatory component of professional education, including legal education related to foreign trade and agricultural market regulation. EU educational policy emphasizes practical digital training, interdisciplinary learning, and the integration of Legal Tech tools into educational programs (European Commission, 2025; European Commission, 2018).

In contrast, the Ukrainian system of legal education is currently undergoing accelerated digital transformation in response to European integration processes and wartime challenges. The documentary analysis indicates that Ukraine has adopted strategic directions toward educational digitalization and harmonization with European standards; however, the implementation of these initiatives remains uneven due to infrastructural disparities, insufficient institutional support, and limited digital preparedness of some educational institutions (Ivanenko et al., 2023; European Training Foundation, 2024).

At the same time, methodological recommendations developed within Ukrainian higher education institutions, particularly the course “Ukraine–EU: Digital Transformation” implemented at the National University “Lviv Polytechnic,” demonstrate a gradual approximation of domestic legal education to European educational practices (Turchyn et al., 2022). The findings suggest that Ukraine is transitioning from emergency digital adaptation toward a more systematic integration of digital educational models.

Comparative Analysis of Digital Tools and Educational Platforms

The structured comparative analysis revealed significant differences between the EU and Ukraine regarding the integration of digital technologies into the training of future legal professionals specializing in foreign trade in agricultural products.

The analysis of European educational practices demonstrates that vocational and legal education institutions in the EU actively integrate digital learning platforms, electronic certification systems, online simulations, and blended learning technologies directly into curricula. In Finland, digital educational ecosystems combine electronic textbooks, online learning environments, and progress monitoring systems. In the Netherlands, educational institutions actively use electronic portfolios and digital simulations of export procedures and customs processes. Germany applies blended learning models focused on business process

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

modeling and digital trade management, while Scandinavian countries prioritize lifelong digital learning and continuous competence development (Radkevych et al., 2018).

The documentary analysis further indicates that the integration of digital tools into European educational programs is closely connected with labor market needs and practical professional training. Educational institutions cooperate with governmental bodies, business representatives, and international organizations to ensure that students acquire practical digital skills required for work with customs platforms, electronic certification systems, trade databases, and Legal Tech solutions (EAVI, 2018; European Commission, 2025).

In Ukraine, digital educational practices expanded significantly due to the challenges caused by the military conflict and the need to ensure continuity of the educational process. The findings demonstrate that Ukrainian higher education institutions actively introduced distance learning technologies, electronic educational platforms, and blended learning formats. However, unlike the EU model, Ukrainian digitalization often remains reactive rather than strategically institutionalized (Bakhmat et al., 2022; Yatsukh, 2025).

The comparative analysis revealed that the Ukrainian legal education system still faces limitations related to uneven access to digital infrastructure, insufficient financing of technological modernization, and the incomplete integration of practical digital tools related to international agricultural trade regulation (Leu-Severynenko, 2022; European Training Foundation, 2024).

Teacher Digital Competence and Professional Preparedness

The documentary analysis identified teacher digital competence as one of the key analytical categories influencing the effectiveness of digital legal education.

European educational policy documents and scientific studies consistently emphasize that teachers' digital preparedness directly affects students' professional competence formation. The DigCompEdu framework provides a structured model for the development of teachers' digital competencies, including digital communication, online assessment, content creation, and integration of digital technologies into professional training (European Commission, 2023).

The analysis of scientific literature demonstrates that EU educational systems implement systematic teacher training programs focused on digital skills development and practical application of innovative teaching methods. European universities provide continuous professional development opportunities for academic staff, including specialized training in online teaching methodologies, Legal Tech applications, and interactive educational technologies (Gisbert-Cervera & Caena, 2022; Starkey, 2020).

The comparative analysis further revealed that teacher self-efficacy significantly influences the successful implementation of digital learning models. As shown by Mannila et al. (2018), teachers with a higher level of digital confidence are more likely to apply innovative teaching approaches and facilitate students' acquisition of practical professional skills.

In Ukraine, the process of developing teachers' digital competencies intensified considerably during wartime conditions. The documentary analysis demonstrates that the transition to distance and blended learning accelerated the acquisition of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

digital skills among academic staff. Nevertheless, the findings indicate substantial disparities in the level of digital preparedness between educational institutions and regions (Bakhmat et al., 2022).

The results also demonstrate that many Ukrainian educators still require additional professional training in the application of digital educational technologies, interactive teaching methods, and Legal Tech tools relevant to foreign trade and agricultural law (Ivanenko et al., 2023; Yatsukh, 2025).

Challenges and Barriers to the Digital Transformation of Legal Education in Ukraine

The comparative documentary analysis identified several major barriers affecting the digital transformation of legal education in Ukraine.

First, infrastructural inequality remains a significant challenge. The analysis revealed uneven access to stable internet connection, digital platforms, and technological equipment across educational institutions, particularly under wartime conditions (Bakhmat et al., 2022).

Second, the findings indicate insufficient institutionalization of digital educational policies compared to the EU model. While the European Union has established unified competence frameworks and coordinated implementation mechanisms, Ukraine is still developing a comprehensive and fully integrated digital education strategy for legal training (European Union, 2021; Ivanenko et al., 2023).

Third, the study identified limited integration of Legal Tech technologies and practical trade-oriented simulations into legal education programs. Unlike European educational institutions, Ukrainian universities only partially incorporate digital tools related to customs procedures, electronic certification, online dispute resolution, and international trade documentation (Radkevych et al., 2018; Turchyn et al., 2022).

Fourth, the analysis revealed the need for systematic professional development of teachers in the field of digital pedagogy and technological innovation. The lack of consistent institutional support mechanisms complicates the sustainable implementation of digital learning approaches (Starkey, 2020).

At the same time, the findings demonstrate that wartime challenges have accelerated educational innovation and stimulated the active implementation of online learning technologies, electronic educational resources, and international academic cooperation (Bakhmat et al., 2022; Yatsukh, 2025).

Comparative Findings and Implications for Legal Education Modernization

The comparative analysis demonstrated that the EU model of digital legal education is characterized by systematic institutional coordination, practical integration of digital technologies, and strong alignment between education and labor market demands (Radkevych et al., 2018; European Commission, 2025).

Ukraine, in contrast, remains in the stage of accelerated digital adaptation driven by European integration processes and wartime conditions. Nevertheless, the documentary analysis indicates a gradual convergence of Ukrainian educational practices with European standards (Ivanenko et al., 2023; European Training Foundation, 2024).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The structured comparative documentary analysis allowed the identification of key analytical categories reflecting the differences and similarities between the EU and Ukrainian approaches to the digital training of future legal professionals in the field of foreign trade in agricultural products. The comparison demonstrates the level of institutionalization of digital education practices, the integration of digital competencies into professional training, and the major challenges affecting the modernization of legal education in Ukraine. The analytical categories presented below summarize the principal findings derived from the reviewed regulatory documents, scientific literature, and institutional reports.

Table 1.

Comparative analytical framework of digital legal education development in the EU and Ukraine

Analytical category	European Union	Ukraine	Key implication for legal education modernization
Digital competencies framework	Institutionalized implementation of DigComp and DigCompEdu frameworks integrated into educational policy and curricula (European Commission, 2023; Digital Skills and Jobs Platform, 2024)	Ongoing adaptation of European digital competence standards with uneven implementation across institutions (Ivanenko et al., 2023)	Need for harmonization of national legal education standards with EU digital competence frameworks
Integration of Legal Tech tools	Active implementation of Legal Tech platforms, electronic databases, simulations, and digital trade management systems (Radkevych et al., 2018; European Commission, 2025)	Limited integration of Legal Tech technologies into legal education curricula (Turchyn et al., 2022)	Modernization of curricula through practical digital legal training
Teacher digital preparedness	Systematic professional development programs and institutional digital training policies (Gisbert-Cervera & Caena, 2022; Starkey, 2020)	Uneven digital preparedness of teachers, intensified by wartime educational transformation (Bakhmat et al., 2022; Yatsukh, 2025)	Need for continuous professional capacity building of academic staff
Digital infrastructure and educational platforms	Developed digital ecosystems with integrated e-learning environments and electronic assessment systems (EAVI, 2018)	Rapid expansion of distance learning platforms, but infrastructural disparities remain significant (Leu-Severynenko, 2022; European Training Foundation, 2024)	Strengthening institutional digital infrastructure and technological accessibility
Practical orientation of legal education	Strong integration of simulations, case studies, and market-oriented digital learning tools (Radkevych et al., 2018)	Predominantly theoretical approach with limited practical digital simulations (Turchyn et al., 2022)	Increased implementation of practice-oriented digital educational methods
Institutional coordination of digital education policy	Coordinated EU-level digital education strategy supported by common frameworks and funding mechanisms (European Union, 2021)	Developing national digital education policies under conditions of crisis adaptation and European integration (Ivanenko et al., 2023)	Need for comprehensive institutional coordination and long-term digital education strategy

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The comparative findings presented in Table 1 demonstrate that the EU model of digital legal education is characterized by systematic institutional coordination, advanced integration of digital technologies, and strong alignment between educational programs and labor market demands. In contrast, the Ukrainian system of legal education is currently characterized by accelerated digital adaptation under wartime conditions and European integration processes. At the same time, the analysis revealed substantial potential for the modernization of Ukrainian legal education through the implementation of European digital competence frameworks, expansion of Legal Tech integration, strengthening of teacher digital preparedness, and development of practice-oriented educational models.

The findings suggest that further modernization of legal education in Ukraine should focus on:

- Institutional implementation of European digital competence frameworks;
- Systematic teacher training in digital pedagogy and Legal Tech applications;
- Development of specialized digital platforms for legal education in agricultural trade and foreign economic activity;
- Integration of practical simulations, electronic certification systems, and trade documentation tools into curricula;
- Strengthening international academic cooperation and joint educational initiatives with EU institutions.

Therefore, the structured documentary comparison revealed that the successful digital transformation of legal education in Ukraine requires not only technological modernization, but also institutional, methodological, and pedagogical adaptation to European educational standards.

Conclusions

The comparative documentary analysis demonstrated that the European Union has developed a systematic and institutionally coordinated model of digital legal education based on unified competence frameworks, strategic policy documents, and the practical integration of digital technologies into professional training. The findings indicate that EU educational systems actively combine digital learning tools, Legal Tech solutions, interactive educational methods, and continuous teacher professional development to ensure the effective preparation of specialists capable of working in the field of international trade and agricultural market regulation.

The structured comparison revealed that Ukraine is currently undergoing accelerated digital transformation of legal education under the influence of European integration processes and wartime challenges. The analysis demonstrated that Ukrainian higher education institutions have significantly expanded the use of distance learning technologies, online educational platforms, and blended learning models. At the same time, the findings indicate that the implementation of digital educational practices in Ukraine remains uneven due to infrastructural limitations, insufficient institutional coordination, limited financing, and disparities in teachers' digital preparedness.

The comparative documentary analysis further demonstrated that the development of digital competencies among teachers and students is a critical prerequisite for the modernization of legal education related to foreign trade in agricultural products. The findings confirmed that the effective integration of Legal Tech tools, electronic certification systems, customs documentation platforms, and interactive simulations

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

into educational programs contributes to the formation of practical professional competencies required in the modern digital economy.

The study also revealed that the European experience of integrating digital technologies into vocational and legal education may serve as an important methodological and institutional reference point for Ukraine. In particular, the findings indicate the necessity of strengthening the institutional implementation of European digital competence frameworks, expanding teacher training in digital pedagogy, modernizing educational infrastructure, and increasing international academic cooperation.

The results of the structured comparative analysis allow the formulation of several practical recommendations for improving the Ukrainian system of legal education. These include the systematic integration of European digital education standards into curricula, the development of specialized digital learning platforms for agricultural trade law, the expansion of practical training using simulations and electronic trade systems, and the institutional support of continuous professional development for teachers.

Therefore, the findings suggest that the successful modernization of legal education in Ukraine requires a comprehensive approach combining technological innovation, methodological adaptation, institutional support, and alignment with European educational standards. Further scientific research should focus on the development of cross-border educational cooperation models, joint EU–Ukraine digital educational programs, and mechanisms for integrating advanced Legal Tech solutions into the professional training of future lawyers specializing in foreign trade and agricultural market regulation.

Limitation of the study

The study is limited by its documentary nature and does not include empirical surveys or interviews with educators and students. Future studies may complement the present findings through empirical assessment of digital legal education practices in EU and Ukrainian institutions.

Bibliographic references

- Bakhmat, N. V. (2022). Formation of professional competence of future primary school teachers in the digital educational environment. *Science and Technology Today (Pedagogy Series)*, 6(6), 89–100. Retrieved from <http://perspectives.pp.ua/index.php/nts/article/view/1830>
- Bakhmat, N., Kyrlyuk, O., Siasiev, A., Yurchuk, V., & Kozlovskyi, A. (2022). Digital transformation of education in the context of informatization of education and society against the background of Russian armed aggression: Current problems and vectors of development. *WISDOM*, 4(3), 14–21. doi: 10.24234/wisdom.v4i3.813
- Digital Skills and Jobs Platform. (2024). *The Digital Competence Framework (DigComp)*. Retrieved from <https://digital-skills-jobs.europa.eu/en/actions/european-initiatives/digital-competence-framework-digcomp>
- European Association for Viewers Interests. (2018). *How European education keeps up nowadays: E-learning and e-education*. Retrieved from <https://eavi.eu/how-european-education-keeps-up-nowadays-e-learning-and-e-education/>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

- European Commission. (2017). *Association Agreement between the European Union and its Member States, of the one part, and Ukraine, of the other part*. Retrieved from <https://eur-lex.europa.eu/EN/legal-content/summary/association-agreement-with-ukraine.html>
- European Commission. (2018). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the Digital Education Action Plan* (COM(2018) 22 final). Brussels, Belgium: Author. Retrieved from <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52018DC0022>
- European Commission. (2023). *DigCompEdu: Digital competence framework for educators*. Retrieved from <https://ec.europa.eu/jrc/en/digcompedu>
- European Commission. (2025). *A New Skills Agenda for Europe*. Retrieved from https://employment-social-affairs.ec.europa.eu/policies-and-activities/skills-and-qualifications/european-skills-agenda_en
- European Training Foundation. (2024). *Key policy developments in education, training and employment: Ukraine*. Turin, Italy: Author. Retrieved from https://www.etf.europa.eu/sites/default/files/2024-12/Country%20Fiche_Ukraine_2024_EN_web_0.pdf
- European Union. (2021). *Digital Education Action Plan 2021–2027*. Retrieved from <https://education.ec.europa.eu/focus-topics/digital-education/plan>
- European Union. (2023). European Declaration on Digital Rights and Principles for the Digital Decade. *Official Journal of the European Union*, C 23, 1–7. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:JOC_2023_023_R_0001
- Gisbert-Cervera, M., & Caena, F. (2022). Teachers' digital competence for global teacher education. *European Journal of Teacher Education*. Advance online publication. doi: <https://doi.org/10.1080/02619768.2022.2135855>
- Ivanenko, N., Boiko, A., Fedorchuk, L., Panchenko, I., & Marieiev, D. (2023). Development of educational policy in Ukraine in the context of European integration and digital transformation. *Revista Eduweb*, 17(2), 296–305. <https://doi.org/10.46502/issn.1856-7576/2023.17.02.25>
- Leu-Severynenko, S. (2022). *A short overview on vocational education and training in Ukraine*. Bonn, Germany: Federal Institute for Vocational Education and Training. Retrieved from https://datapool-bibb.bibb.de/pdfs/Snizhana_Overview_VET_in_Ukraine.pdf
- Mannila, L., Norden, L., & Pears, A. (2018). Digital competence, teacher self-efficacy, and training needs. In *Proceedings of the 2018 ACM Conference on International Computing Education Research* (pp. 78–85). New York, NY: Association for Computing Machinery. Retrieved from <https://doi.org/10.1145/3230977.323099>
- Radkevych, V. O., Pukhovska, L. P., Borodiienko, O. V., Radkevych, O. P., Bazeliuk, N. V., Korchynska, N. M., Leu, S. O., & Artemchuk, V. V. (2018). *Modern models of vocational education and training in the European Union: Comparative experience*. Kyiv, Ukraine: Institute of Vocational Education and Training of the National Academy of Educational Sciences of Ukraine.
- Starkey, L. (2020). A review of research exploring teacher preparation for the digital age. *Cambridge Journal of Education*, 50(1), 37–56. doi: <https://doi.org/10.1080/0305764X.2019.1625867>
- Turchyn, Y. B., Ivasechko, O. Y., Tsebenko, O. O., Sukhorolska, I. Y., Vovk, N. S., Markovets, O. V., Kasha, L. V., & Zabavska, K. Y. (2022). *Ukraine–EU: Digital transformation* (Methodological guidelines). Lviv, Ukraine: Lviv Polytechnic Publishing House. Retrieved from <https://lpnu.ua/sites/default/files/2022/pages/18734/metodichni->

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

<https://revistaeduweb.org/>

ISSN: 1856-7576

 Open Acces

rekomendacii-do-vikladannya-navchalnogo-kursu-ukraina-es-cifrova-transformaciya_0.pdf

Yatsukh, O. (2025). Educational innovations and digital technologies as an opportunity to improve the educational environment in Ukraine during martial law. *European Humanities Studies: State and Society*, 1(1), 68–81. <https://doi.org/10.38014/ehs-ss.2025.1.06>

World Trade Organization. (n.d.). *Agreement on Agriculture*. Geneva, Switzerland: World Trade Organization. Retrieved from https://www.wto.org/english/docs_e/legal_e/14-ag.pdf

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Tecnologías digitales y formación docente para la educación inclusiva

Digital technologies and teacher preparation for inclusive education

Vitalii Boichuk¹  Iryna Drozdova²  Ludmyla Konstantynenko³  Alina Ivanytsia⁴  Tetiana Tsehelnik⁵ 

Afiliación autor:

¹ Doctor of Pedagogical Sciences, Professor, Professor at the Department of Construction, Urban Planning and Architecture, Vinnytsia National Technical University, Ukraine. boichuk1974@ukr.net

² Doctor of Pedagogical Sciences, Professor, UNESCO Department of Philosophy of Human Communication and Social and Humanitarian Disciplines, State Biotechnological University, Ukraine. irina4410059@gmail.com

³ PhD in Biology, Associate Professor, Head of Department of Botany, Biological Resources and Conservation of Biological Diversity, Faculty of Natural Sciences, Department of Botany, Biological Resources and Conservation of Biological Diversity, Zhytomyr Ivan Franko State University, Ukraine. lkonstantynenko@ukr.net

⁴ Candidate of Pedagogical Sciences, Assistant of Department of Technologies of Correctional and Inclusive Education, Speech Therapy and Rehabilitation, Educational and Scientific Institute of Special and Inclusive Education, Poltava V.G. Korolenko National Pedagogical University, Ukraine. alinam05p05@gmail.com

⁵ Doctor of Philosophy, Associate Professor of the Department of Special and Inclusive Education, Faculty of Pedagogy and Psychology, Volodymyr Hnatyuk Ternopil National Pedagogical University, Ukraine. sveettana@ukr.net

Recibido: 23/04/26
Aceptado: 17/06/26

Cómo citar:

Boichuk, V., Drozdova, I., Konstantynenko, L., Ivanytsia, A., & Tsehelnik, T. (2026). Digital technologies and teacher preparation for inclusive education. *Revista Eduweb*, 20(2), 448-463. <https://doi.org/10.46502/issn.1856-7576/2026.20.02.26>



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



Open Acces

Resumen

El estudio investiga la efectividad de las tecnologías digitales en la preparación de futuros especialistas para trabajar en entornos educativos inclusivos. Se empleó un diseño de métodos mixtos que combinó enfoques teóricos, empíricos, experimentales y estadísticos. Los participantes incluyeron 90 estudiantes de educación superior, divididos en un grupo experimental (GE, n = 48) y un grupo de control (GC, n = 42). La intervención se basó en la creación de un entorno educativo digital inclusivo, la implementación de tecnologías de aprendizaje digital, trayectorias educativas individualizadas y métodos de enseñanza innovadores. La preparación para la actividad profesional en educación inclusiva se evaluó a través de componentes motivacionales, cognitivos y relacionados con la actividad. El análisis estadístico se realizó utilizando la prueba de chi-cuadrado de Pearson y el coeficiente de tamaño del efecto V de Cramer. Los resultados demostraron niveles de preparación sustancialmente más altos entre los estudiantes del GE en comparación con el GC. Al final del experimento, se identificó un alto nivel de preparación en el 73,8% de los estudiantes del GE frente al 19,2% de los estudiantes del GC, mientras que se observó una baja preparación en el 3,2% y el 32,1% de los estudiantes, respectivamente. Los valores t de Student obtenidos superaron el valor crítico ($t > 2$), lo que confirma un efecto experimental positivo. Los resultados indican que la integración de tecnologías digitales y condiciones pedagógicas específicas mejora significativamente la preparación de los futuros especialistas para trabajar en entornos educativos inclusivos.

Palabras clave: tecnologías digitales, educación inclusiva, preparación de futuros especialistas, educación especial.

Abstract

The study investigates the effectiveness of digital technologies in preparing future specialists to work in inclusive educational environments. A mixed-methods design combining theoretical, empirical, experimental, and statistical approaches was employed. The participants included 90 higher education students, divided into an experimental group (EG, n = 48) and a control group (CG, n = 42). The intervention was based on the creation of an inclusive digital educational environment, the implementation of digital learning technologies, individualized educational trajectories, and innovative teaching methods. Readiness for professional activity in inclusive education was assessed through motivational, cognitive, and activity-related components. Statistical analysis was conducted using Pearson's chi-square test and Cramer's V effect size coefficient. The results demonstrated substantially higher readiness levels among students in the EG compared with the CG. At the end of the experiment, a high level of readiness was identified in 73.8% of EG students versus 19.2% of CG students, while low readiness was observed in 3.2% and 32.1% of

students, respectively. The obtained Student's t-values exceeded the critical value ($t > 2$), confirming a positive experimental effect. The findings indicate that the integration of digital technologies and targeted pedagogical conditions significantly enhances future specialists' readiness to work in inclusive educational environments.

Keywords: digital technologies, inclusive education, readiness of future specialists, special education.

Introduction

The relevance and importance of inclusive education in the world stem from its role as a component of the social state's integral policy, reflecting global trends toward ensuring equal opportunities and rights for each individual. As a key factor in professional development and self-realization, higher education requires creating a barrier-free environment that ensures active participation in student life and access to knowledge, which are prerequisites for the successful socialization of each person. There are certain difficulties in many countries of the world in creating an inclusive educational environment and implementing inclusion tasks due to the inability of educational institutions to take into account and accept social challenges timely: to introduce pedagogical innovations, the latest digital technologies, in accordance with the nature and content of the organization of the educational process, new strategies for pedagogical interaction between students of the educational space and teachers based on personally oriented education, etc. (Ravichandran & Mahapatra, 2023).

In countries where inclusive education has only recently begun to be actively implemented, it is difficult to overcome socio-pedagogical stereotypes. After all, the creation of an inclusive educational environment and the implementation of an inclusive approach in education require an appropriate balance: each person with a disability receives appropriate educational services and feels a sense of personal significance in the educational environment (Veytia Bucheli et al., 2024).

Digital technologies contribute to the development of key competencies in future specialists in inclusive education. The use of digital technologies today is a tool, not just a requirement of the time, which allows: to expand the reach of quality education to vulnerable and remote population groups; to take into account the circumstances of each higher education seeker and their individual needs through the personalization of educational process methodologies and curricula; to quickly analyze and track the effectiveness of various approaches and pedagogical strategies, ensuring constant optimization of the educational process (Abdullah et al., 2025); easily integrate, creating inclusive flexible educational environments through the use of digital technologies, new resources, pedagogical tools and courses; use online platforms to provide social support and psychological assistance; maximize through digital optimization of management and educational processes in the education system through the use of available innovative resources.

In the field of inclusive education, the professional training of future specialists must address contemporary challenges by equipping them with the knowledge and skills necessary for effective practice. The integration of digital technologies into higher education enhances the quality of instruction by introducing innovative teaching methods and providing both technical and methodological support for learning (Espinosa Domínguez et al., 2025).

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

A key advantage of digital technologies in inclusive education is their ability to adapt learning to individual student needs. Through interactive resources, personalized curricula, and assistive digital tools, educators can ensure equal learning opportunities and support the successful inclusion of all students in the digital educational environment. Research highlights several benefits of digital technologies for inclusive education. These include overcoming communication barriers, increasing learner autonomy, providing flexible access to educational resources, and supporting the development of digital competence and communication skills. Digital tools also enable students to learn at their own pace, increase motivation and engagement, facilitate repeated practice through virtual simulations, and stimulate cognitive development (Page et al., 2021; Main et al., 2016).

Additional assistive technologies, including voice recognition systems and adapted text formatting, support learners with dyslexia, dysgraphia, and other learning difficulties (Taxiarchis, 2023).

Artificial intelligence further enhances inclusive education through chatbots, virtual assistants, and speech synthesis tools that facilitate communication and learning for students with diverse needs (Mohammed & Watson, 2019). The integration of such technologies contributes to the creation of inclusive digital learning environments where all students can participate fully and realize their potential (Elsin & Sathya, 2024).

Moreover, digital technologies support innovative teaching approaches, including interactive learning activities and personalized curricula. Their use promotes the development of essential competencies such as digital literacy, critical thinking, communication, and collaboration, thereby improving the quality and effectiveness of specialist training in inclusive education (Viner et al., 2022).

Despite the growing body of research on inclusive education and the integration of digital technologies into teaching and learning, limited attention has been devoted to the systematic development of future specialists' readiness to work in inclusive digital educational environments. Existing studies primarily focus on technological tools, accessibility issues, teachers' attitudes, or institutional factors, while insufficient evidence is available regarding pedagogical conditions that effectively foster motivational, cognitive, and practical readiness among future professionals.

The scientific contribution of this study lies in the development and experimental validation of a pedagogical model that integrates digital technologies with inclusive educational practices and evaluates its effectiveness through empirical and statistical analysis.

Literature Review

In the field of inclusive education, a wide range of research covers theoretical and methodological principles, practical aspects of its implementation, and the research of scientists, Rojas Gonzalez & Ramirez Sanchez (2025), which covers the influence of subjective factors on the success of integration, allowing for a comprehensive understanding of the challenges in the field and the current state of the educational process.

Researchers Long et al. (2025) focused on factors that significantly influence the implementation of inclusive education in general education institutions. The

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

researchers examined teachers' roles and attitudes, self-competence, and readiness to work in inclusive education. The researchers show the practical determinants and difficulties of successful integration, which are important today for understanding the basic mechanisms of creating an inclusive educational environment through the use of digital technologies.

Rubio-Pacheco & Fino (2023) analyze the role of digital technologies and innovation in transforming modern education through a documentary review. The study demonstrates that ICT integration significantly improves teaching and learning processes by creating flexible, interactive, personalized, and inclusive learning environments. The authors emphasize that digital tools have become essential components of contemporary educational ecosystems, contributing to higher educational quality and more effective student engagement and development.

Hernández Mendoza et al. (2025) emphasize that technology has transformed contemporary educational practices by enabling innovative models such as project-based learning, personalized education, and digital learning platforms. The authors argue that these approaches promote active student participation, collaboration, and engagement while allowing educators to adapt teaching strategies to learners' needs. The study also highlights challenges in teacher training and equitable access to technological resources, underscoring the importance of creating inclusive learning environments that foster students' critical and creative skills through effective use of technology.

Sánchez et al. (2024) examine the role of assistive technologies in distance and digital education for learners with disabilities through a literature review. The study highlights that assistive technologies enhance access, participation, autonomy, and independence in learning environments, particularly for individuals with visual and hearing impairments. The authors emphasize the importance of inclusive instructional design, teacher preparation, continuous professional development, and collaboration among educators, families, and communities. The findings also underscore the relevance of Universal Design for Learning and the need to address ongoing challenges in technological adaptation for inclusive digital education.

Thus, in the field of inclusive education, a wide range of research covers theoretical and methodological principles, practical aspects of its implementation, and pays insufficient attention to the development of future specialists' readiness to work in an inclusive educational environment through the use of digital technologies.

The reviewed studies consistently confirm the positive role of digital technologies in supporting inclusive education. Researchers emphasize that assistive technologies, adaptive learning systems, artificial intelligence tools, virtual learning environments, and digital educational resources improve accessibility, learner engagement, and educational outcomes for students with diverse educational needs. These findings suggest that digital technologies have considerable potential for enhancing inclusion in higher education.

However, the existing literature reveals several limitations and unresolved issues. First, many studies focus primarily on the effectiveness of specific technological tools rather than on the comprehensive preparation of future specialists for professional work in inclusive educational environments. While digital technologies are widely acknowledged as supportive instruments, there is limited evidence regarding how they contribute to the development of professional readiness, including motivational, cognitive, and practical competencies.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Previous studies report inconsistent findings regarding the effectiveness of digital technologies in inclusive settings. Some researchers highlight substantial improvements in accessibility, engagement, and individualized learning, whereas others point to barriers related to insufficient digital competence, inadequate pedagogical support, limited institutional resources, and resistance to educational change. These contrasting findings indicate that technology alone does not guarantee successful inclusion and that pedagogical conditions play a critical mediating role.

Although numerous studies investigate inclusive education and digital transformation separately, relatively few examine their integration within a unified framework for professional training. The literature lacks experimentally validated models that explain how digital technologies can be systematically incorporated into the preparation of future specialists for work in inclusive educational environments.

A significant research gap remains regarding the design and empirical validation of pedagogical conditions that effectively combine digital technologies with inclusive educational practices. Addressing this gap provides the rationale for the present study and justifies the implementation of the proposed experimental intervention.

Research objective. Formation of the readiness of future specialists to work in an inclusive educational environment through the use of digital technologies.

Methodology

The study employed a mixed-methods research design combining theoretical, empirical, experimental, and statistical approaches to investigate the formation of future specialists' readiness to work in an inclusive educational environment through the use of digital technologies. The methodological framework was grounded in the principles of inclusive pedagogy, digital transformation of education, competency-based learning, and learner-centered educational approaches.

Research Design

The research was conducted in three consecutive stages: organizational, design, and diagnostic. The study included both an experimental group (EG) and a control group (CG). Students in the control group studied according to the traditional methodology, whereas students in the experimental group were trained using specially developed pedagogical conditions and digital technologies aimed at enhancing readiness for inclusive educational practice.

Participants

The study involved 90 undergraduate students enrolled in teacher education and special education programs at three higher education institutions. Participants were recruited using purposive sampling because all students were preparing for future professional activities in inclusive educational settings. Eligibility criteria included: (a) enrollment in pedagogical or special education programs; (b) completion of at least one year of university studies; and (c) consent to participate in the research. Students who had previously completed specialized courses in inclusive digital education were excluded from participation.

The sample consisted of 62 females (68.9%) and 28 males (31.1%), aged between 18 and 23 years ($M = 20.4$, $SD = 1.3$). Participants were assigned to an experimental

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

group (EG, $n = 48$) and a control group (CG, $n = 42$). Prior to the intervention, no statistically significant differences were identified between groups regarding readiness levels for work in inclusive educational environments ($\chi^2(2) = 1.21$, $p = .546$), indicating initial comparability.

Research Instruments

Readiness for professional activity in inclusive digital educational environments was assessed using a comprehensive diagnostic framework consisting of three dimensions: motivational, cognitive, and activity-related readiness.

The motivational component was measured using a 15-item questionnaire assessing professional motivation, attitudes toward inclusive education, willingness to use digital technologies, and responsibility for educational decision-making. Responses were recorded on a five-point Likert scale.

The cognitive component was evaluated through a 30-item knowledge test covering principles of inclusive education, assistive technologies, digital learning tools, individualized educational trajectories, and inclusive instructional design.

The activity-related component was assessed through practical case-based tasks requiring participants to design inclusive digital learning activities, select appropriate digital tools, and propose educational adaptations for students with special educational needs.

Content validity of the instruments was established through expert evaluation involving seven specialists in inclusive education and educational technologies. The Content Validity Index (CVI) was .91. Internal consistency demonstrated satisfactory reliability: motivational scale (Cronbach's $\alpha = .87$), cognitive test (KR-20 = .84), and activity-related assessment (Cronbach's $\alpha = .89$). Pilot testing with 25 students not involved in the main study confirmed the clarity and applicability of all instruments.

Educational Intervention

The intervention was implemented during one academic semester (16 weeks) and consisted of four interconnected pedagogical conditions.

First, an inclusive digital educational environment was established using Moodle, Microsoft Teams, and Google Classroom. Students gained access to adapted learning materials, multimedia resources, discussion forums, and collaborative digital workspaces.

Second, digital learning technologies were systematically integrated into coursework. Participants used Mindomo for concept mapping, Khan Academy for self-paced learning, ClassDojo for feedback and monitoring, and assistive technologies such as text-to-speech software, screen readers, adaptive keyboards, and interactive whiteboards.

Third, individualized educational trajectories were developed for each participant. Students selected learning modules, completed differentiated assignments, and received personalized feedback according to their professional interests and competence levels.

Fourth, innovative instructional methods were employed, including project-based learning, case-study analysis, collaborative problem-solving, simulation exercises,

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

reflective practice, and microteaching activities focused on inclusive educational scenarios.

Throughout the intervention, participants completed practical tasks involving the design of inclusive lesson plans, development of digital learning resources for students with special educational needs, implementation of assistive technologies, and evaluation of accessibility in digital educational environments.

The control group followed the standard curriculum without additional digital-inclusive pedagogical conditions.

Components and Criteria of Readiness

The study identified three structural components of readiness for professional activity in an inclusive educational environment through digital technologies:

1. **Motivational component** – characterized by tolerance, initiative, stimulation, professional interest, awareness, and positive attitudes toward inclusive education.
2. **Cognitive component** – reflected the level of theoretical, methodological, and specialized knowledge related to inclusive education and digital technologies.
3. **Activity component** – included professional skills, practical application of digital tools, and the ability to organize inclusive educational interaction.

Three levels of readiness were distinguished: low, average, and high.

Research Methods

To achieve the research objective, the following methods were applied:

- **Theoretical methods:** analysis, synthesis, comparison, systematization, generalization, and interpretation of psychological, pedagogical, methodological, and scientific literature related to inclusive education and digital technologies.
- **Empirical methods:** observation, questionnaires, interviews, conversations, and reflection.
- **Experimental methods:** ascertaining and formative pedagogical experiments.
- **Statistical methods:** Pearson's chi-square criterion, Student's t-test, and correlation analysis for evaluating the effectiveness of the experimental intervention.

Experimental Procedure

At the ascertaining stage, participants' initial readiness levels were diagnosed through questionnaires and assessment tasks. The findings demonstrated insufficient motivation, low confidence in applying digital technologies in inclusive education, and inadequate preparedness for individualized educational practice.

During the formative stage, the experimental group was exposed to specially designed pedagogical conditions, including:

- Creation of an inclusive digital educational environment.
- Implementation of digital educational technologies.
- Use of individualized educational trajectories.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Application of innovative teaching methods.
- Stimulation of professional motivation and responsibility.
- Organization of collaborative learning based on partnership pedagogy.

The experimental methodology incorporated digital tools and platforms, including Microsoft Teams, Google Classroom, Moodle, Mindomo, Duolingo, ClassDojo, and Khan Academy. Assistive technologies, interactive whiteboards, visualization software, and adaptive digital resources were also integrated into the learning process.

Data Analysis

Quantitative data were analyzed using Pearson's chi-square test to compare the distribution of readiness levels between the experimental and control groups. To assess the practical significance of the obtained differences, Cramer's V was calculated as an effect size measure. Statistical significance was established at $p < .05$.

Results and Discussion

Experimental study of the formation of readiness of future specialists to work in an inclusive educational environment through the use of digital technologies.

To assess the readiness of future specialists to work in an inclusive educational environment through the use of digital technologies, three interconnected components were identified: motivational, cognitive, and activity-based.

The motivational component reflects students' willingness to engage in inclusive professional practice and is assessed through indicators such as aspiration, awareness, attitudes, interests, and the need for professional development. The cognitive component encompasses theoretical and specialized knowledge related to inclusive education and digital technologies, reflecting the understanding necessary for effective professional activity. The activity component refers to the practical application of knowledge and the development of professional skills required for work in inclusive digital learning environments.

Based on these components, three levels of readiness were distinguished: low, average, and high. The implementation of the proposed pedagogical conditions was carried out through three consecutive stages: organizational, design, and diagnostic.

Organization of the ascertaining stage of research and experimental work.

Let us present the results of the ascertaining experiment and describe the process of the research we conducted.

Thus, the following results were obtained for the question "Do you consider it necessary to create an inclusive educational environment through the use of digital technologies?":

- 13.0% of respondents answered "yes".
- 44.1% of respondents answered "no".
- 42.9% of respondents answered, "I do not know".

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Such results indicate a lack of awareness of the importance of creating an inclusive educational environment through digital technologies.

The answers to the question “Are you ready to use special methods to prepare for work in inclusive education, to take responsibility for the selection of digital technologies, innovative techniques, effective methods, forms, and means in inclusive education?” showed that most future specialists are not confident that they can take responsibility for the specified content components of inclusive education. We confirm this statement with the following results:

- 19.1% of respondents answered “yes”.
- 64.7% of respondents answered “no”.
- 16.2% of respondents answered, “I do not know”.

Answers to the question: “Are you ready for the individualization of the educational process, for building and developing an individual educational trajectory for each individual and for the cooperation of all subjects, taking into account the principles of partnership pedagogy?”

We received the following results:

- 12.9% of respondents answered “yes”.
- 54.9% of respondents answered “no”.
- 32.2% of respondents answered, “I do not know”.

Such survey results, collected at the ascertaining stage of the study, indicate insufficient motivation to increase their professional level in the field of study at higher education institutions during the study process.

Students are convinced that “To increase the level of their readiness for the outlined problem in the conditions of inclusive education, they need pedagogical conditions that we have developed and implemented in the EG. This is also emphasized by the results of the ascertaining stage on the levels of development of the identified components of the readiness of future specialists to work in an inclusive educational environment through the use of digital technologies.

The levels of formation of the identified components regarding the readiness of future specialists to work in an inclusive educational environment through the use of digital technologies at the ascertaining stage of the study:

- A low level was shown by 38.0% of respondents.
- An average level was shown by 53.1% of respondents.
- 8.9% of respondents indicated a high level, which indicates inefficiency in the traditional organization of professional training for specialists in higher education institutions in terms of the formation of the studied components.

To test the research hypothesis, we used non-parametric criteria and established parametric criteria: Pearson's correlation coefficient, Student's t-test, and correlation analysis.

Modern education seeks pedagogical conditions that would contribute to the formation of the specified readiness of future specialists and ensure the assimilation of a certain amount of information through digitalization, the implementation of

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

experimental methods, and the creation of an inclusive educational environment using digital technologies.

We have identified pedagogical conditions for the effectiveness of forming the readiness of future specialists to work in an inclusive educational environment through the use of digital technologies:

- Creation of an inclusive educational environment through the use of digital technologies.
- Use of special methods for preparing for work in inclusive education, taking responsibility for the selection of digital technologies, innovative techniques, effective methods, forms, and means in inclusive learning.
- Individualization of the educational process, to build and develop an individual educational trajectory for each individual.
- Cooperation of all subjects, taking into account the principles of partnership pedagogy.
- Stimulating future specialists to have a responsible and motivational attitude towards acquiring knowledge, skills, and abilities in inclusive education.
- Directing educational and pedagogical practice towards improving the inclusive educational environment through the use of digital technologies.

The modern range of digital resources and tools enables the design of a variety of pedagogical strategies within the created inclusive educational environment for teaching children with special needs. Let us name the possibilities and ways of using digital technologies in the inclusive process that were offered to EG students during their pedagogical practice:

- Compensatory purposes mean the use of digital technologies for support and technical assistance that allow students with special needs to engage in communication and interaction processes (e.g., help for a child with a motor impairment when writing, and for a child with vision problems when reading). Therefore, digital technologies can facilitate a person's interaction with the world and immediate environment, provide open access to educational information for a child, and partially replace the absence of or compensate for natural functions.
- For communication purposes, the use of digital technologies and the creation of an inclusive educational environment are tools that make it easier for people with communication disorders to exchange information more conveniently, can serve as intermediaries in communication between people with special needs, and can be alternative forms of communication.
- For didactic purposes, the inclusive educational environment enables the implementation of special services for geographically remote participants in the educational process through digital technologies.

Digital tools in the modern, inclusive educational environment within the context of higher education development play a key role and serve as a significant basis for ensuring the quality of education for applicants with special educational needs.

In EG, we implemented digital technologies within the newly created inclusive educational environment, thereby influencing the quality of inclusive and special education. The main ones were:

- Online platforms such as Microsoft Teams, Google Classroom, Moodle, and virtual classrooms, which allow students with disabilities to communicate with teachers and peers, and access educational materials, are necessary to ensure

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

equal conditions for all participants in the educational process, regardless of physical limitations or their place of residence.

- Visualization software: Mindomo and Inspiration, which significantly helped students with special needs to structure and organize information, significantly facilitating the educational process and making it more effective.
- Mobile applications designed for personal development and learning, such as Duolingo, ClassDojo, and Khan Academy, provided students with the opportunity to independently complete tasks and study materials at a time convenient for them. This approach to learning is important for students with special needs because it allows them to learn at their own pace and in accordance with their abilities.
- Assistive technologies, such as specialized keyboards and mice, text-reading software, and devices that control a computer with gaze, help students with cognitive or physical disabilities participate actively in the educational process. These technologies allow you to adapt educational materials to each applicant's individual needs, significantly increasing the efficiency of the educational process.
- Interactive whiteboards (SMART Board) allow you to conduct interactive lessons, involve applicants in active participation in the educational process, which contributes to the development and better assimilation of the material, and the formation of communication and cooperation skills.

The introduction of these digital tools into special and inclusive education has helped create an inclusive educational environment in which each applicant has the opportunity to realize their potential. Such digital tools help to improve the quality of education, providing applicants with special educational needs with individual support and an approach to learning.

The introduction of digital technologies into the newly created inclusive educational environment during the professional training of specialists requires a scientifically sound and systematic approach, as implemented in the EG.

Let us list the principles on which the inclusive educational digital environment is based, which were proposed in the EG:

- Equal access for all participants in the educational process and the provision of quality education by creating an inclusive digital educational environment.
- The use of digital innovative technologies.
- Creation by society of certain conditions for their implementation by each student, enabling them to determine and take into account the ability to quality learning.
- Adherence to partnership pedagogy with all participants in the educational space;
- Ensuring access to all digital resources and realizing each child's right to develop within the family circle.
- Development of individual child development programs, curricula, calendars, and thematic planning based on individual and personally oriented approaches.
- Implementation of the results of modern practices and research in the implementation of an inclusive model of learning in the educational digital environment.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

Formative experiment and results of research and experimental work.

At the stage of the experimental study, we implemented an experimental methodology, established pedagogical conditions for the formation of the specified readiness of future specialists, applied pedagogical and experimental influence by creating an inclusive educational environment using digital technologies, and monitored the development outcomes and processes of specific components of the studied qualities.

The results of the study showed that the levels of formation of the identified components regarding the readiness of future specialists to work in an inclusive educational environment using digital technologies at the formative stage of the study in the EG were significantly higher than at the ascertaining stage (Fig. 1):

In the EG:

- 3.2% of respondents had a low level of readiness of future specialists in inclusive education.
- 25.6% of respondents had an average level of readiness of future specialists in inclusive education.
- 73.8% of respondents had a high level of readiness of future specialists in inclusive education.

In the CG:

- 32.1% of respondents had a low level.
- 48.7% of respondents showed an average level.
- 19.2% of respondents showed a high level.

Thus, no significant changes were observed in the CG.

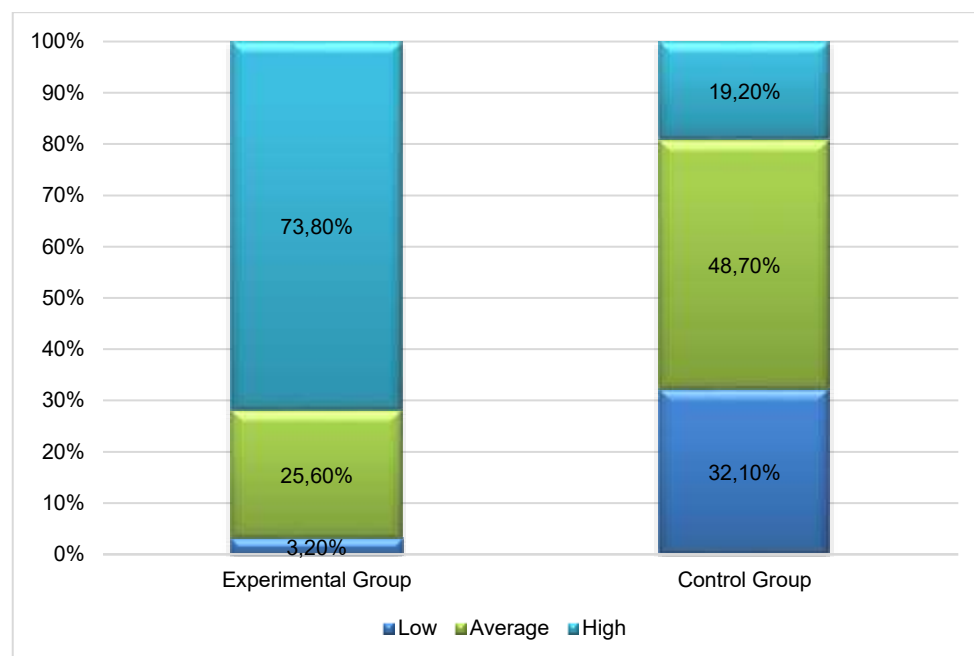


Figure 1. Readiness Levels of Future Specialists for Inclusive Education Using Digital Technologies (EG vs. CG)

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0 Internacional (CC BY 4.0)

The results of the formative experiment demonstrated substantial differences between the experimental group (EG) and the control group (CG). In the EG, 73.8% of participants achieved a high level of readiness, compared with 19.2% in the CG. At the same time, only 3.2% of EG students demonstrated a low level of readiness, whereas this proportion reached 32.1% in the CG.

To determine whether these differences were statistically significant, Pearson's chi-square test was applied. The analysis revealed a significant association between group membership and readiness level, $\chi^2(2, N = 90) = 24.86, p < .001$. The effect size, measured using Cramer's V, was 0.53, indicating a large practical effect. These findings confirm that the distribution of readiness levels differed significantly between the experimental and control groups.

The obtained results provide empirical evidence that the implementation of the proposed pedagogical conditions and digital technologies contributed substantially to the development of future specialists' readiness to work in inclusive educational environments.

In order to analyze the general level of students' readiness to work in an inclusive educational environment through the use of digital technologies in CG and EG, as well as to integrate the indicators of the outlined components, the following quantitative indicators were determined using the formula "averaged relative":

$$P = \frac{n_k + n_e + n_p}{3}$$

$$P = \frac{5,8 + 6,7 + 3,28}{3}$$

$$P = 2,6$$

P – in the % "average relative" indicator, which reflects, with the same level of formation of components, the number of future specialists, their readiness for the outlined phenomenon in the conditions of inclusive education.

n – the number of students of a certain level of readiness for the outlined phenomenon in the conditions of inclusive education.

Based on the readiness indicators, we calculated the "average relative" preparedness of future specialists for the phenomenon outlined in the context of inclusive education for the experimental and control groups.

The results of the evaluation of educational tasks and the survey questionnaire of respondents of the EG are higher than those of the students in the CG. Thus, the implementation of experimental methods in the EG, pedagogical conditions for the formation of the readiness of future specialists to work in an inclusive educational environment through the use of digital technologies, pedagogical and experimental influence through the creation of an inclusive educational environment through the use of digital technologies led to the understanding that such experimental training is necessary for EG students, which determines better indicators of the level of formation of all components of the readiness of EG respondents, compared to the corresponding results of CG respondents.

The findings of the present study are consistent with previous research emphasizing the positive role of digital technologies in inclusive education. In particular, the substantial increase in readiness levels among students in the experimental group

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

supports the conclusions of Rubio-Pacheco & Fino (2023), who reported that the integration of digital technologies contributes to more flexible, personalized, and inclusive learning environments. Similarly, the results corroborate the findings of Hernández Mendoza et al. (2025), who demonstrated that technology-enhanced educational models promote active participation, learner engagement, and the development of professional competencies.

The positive outcomes observed in the experimental group also align with the conclusions of Sánchez et al. (2024), who highlighted the importance of assistive technologies for improving accessibility, participation, and autonomy in inclusive educational settings. The implementation of digital platforms, adaptive resources, and assistive technologies in the present study appears to have contributed to the development of students' motivational, cognitive, and practical readiness for future professional activities.

At the same time, the present results partially extend previous research by demonstrating not only the educational benefits of digital technologies but also their contribution to the systematic formation of professional readiness among future specialists. While earlier studies primarily focused on accessibility, technological tools, or teachers' attitudes toward inclusion, the current study examined readiness as a multidimensional construct comprising motivational, cognitive, and activity-related components.

Nevertheless, several methodological limitations should be acknowledged. First, the study involved a relatively small sample ($N = 90$), which may limit the generalizability of the findings. Second, participants were recruited from a limited number of higher education institutions, and therefore the results may not fully represent future specialists from different educational contexts. Third, readiness levels were assessed using questionnaires and pedagogical assessments, which may be influenced by self-report bias and participants' subjective perceptions. In addition, the study evaluated outcomes immediately after the intervention; therefore, the long-term sustainability of the observed effects remains unclear.

Another factor that may have influenced the results is the increased engagement of students in the experimental group resulting from exposure to innovative digital tools and learning activities. Consequently, part of the observed improvement may be associated with the novelty effect rather than exclusively with the pedagogical conditions themselves. Future research should employ larger and more diverse samples, longitudinal designs, and validated measurement instruments to further examine the stability and transferability of the reported outcomes.

Overall, despite these limitations, the findings provide empirical evidence that the integration of digital technologies within purposefully designed pedagogical conditions can significantly enhance the readiness of future specialists to work in inclusive educational environments.

Conclusions

This study investigated the effectiveness of pedagogical conditions aimed at developing future specialists' readiness to work in inclusive educational environments through the use of digital technologies. The findings confirmed that the integration of digital technologies within a purposefully designed inclusive educational environment positively influences the formation of motivational, cognitive, and activity-related components of professional readiness.

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

The proposed pedagogical conditions, including the creation of an inclusive digital educational environment, the implementation of digital learning technologies, individualized educational trajectories, innovative teaching methods, and collaborative learning practices, contributed significantly to students' professional development. Participants in the experimental group demonstrated substantially higher readiness levels than those in the control group, indicating the effectiveness of the implemented intervention.

Statistical analysis confirmed significant differences between the experimental and control groups ($\chi^2(2, N = 90) = 24.86, p < .001$, Cramer's $V = 0.53$), demonstrating a strong association between participation in the experimental program and higher levels of readiness for professional activity in inclusive educational settings. These results provide empirical support for the integration of digital technologies as an effective means of preparing future specialists for inclusive practice.

The study contributes to the existing literature by extending current understanding of how digital technologies can be systematically incorporated into specialist training within inclusive education. Unlike previous studies that primarily focused on accessibility, assistive technologies, or individual digital tools, the present research examined a comprehensive pedagogical framework integrating motivational, cognitive, and practical dimensions of readiness.

Several limitations should be acknowledged. The relatively small sample size and the involvement of students from a limited number of higher education institutions may restrict the generalizability of the findings. Furthermore, the study assessed outcomes immediately after the intervention, making it difficult to determine the long-term sustainability of the observed effects.

Future research should focus on longitudinal evaluation of readiness development, validation of the proposed model across diverse educational contexts, and investigation of the role of emerging technologies, including artificial intelligence, learning analytics, adaptive learning systems, and immersive technologies, in enhancing professional preparation for inclusive educational practice.

Bibliographic references

- Abdullah, Hafeez, N., Sardar, K., Uroosa, F., Fatima, Z., Quintero Téllez, R., & Rodríguez, J. L. O. (2025). GrowMore: Adaptive tablet-based intervention for education and cognitive rehabilitation in children with mild-to-moderate intellectual disabilities. *Computers*, 14(11), 495. <https://doi.org/10.3390/computers14110495>
- Elsin, J. A., & Sathya, P. (2024). Adaptive learning technologies for inclusive education: Enhancing social development through personalized digital ecosystems. *International Journal of Scientific Research in Science and Technology*, 11(21), 6–12. <https://doi.org/10.32628/IJSRST24116502>
- Espinosa Domínguez, J. C., Saavedra Munar, L., Castillo Beltrán, P. A., Peláez Ayala, C. A., Solano Alegría, A. F., & Ospina Galindez, J. A. (2025). Inclusive interactive multimedia experiences in school contexts with learning analytics integration. *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje (IEEE-RITA)*, 20(1), 96–104. <https://doi.org/10.1109/RITA.2025.3554712>
- Hernández Mendoza, S. L., Olguín Guzmán, E., & Hernández Mendoza, J. M. (2025). Transformando la educación: Modelos innovadores y entornos de aprendizaje a través de la tecnología. *Etic@net: Revista Científica*

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)

- Electrónica de Educación y Comunicación en la Sociedad del Conocimiento*, 25(2), 452–459.
<https://doi.org/10.30827/eticanet.v25i2.32666>
- Long, Y., Sharma, U., & Subban, P. (2025). Teachers' attitudes and self-efficacy toward inclusive education in mainland China: A meta-analysis. *Cogent Education*, 12(1). <https://doi.org/10.1080/2331186X.2025.2526872>
- Main, S., Chambers, D. J., & Sarah, P. (2016). Supporting the transition to inclusive education: Teachers' attitudes to inclusion in the Seychelles. *International Journal of Inclusive Education*, 20(12), 1270–1285.
<https://doi.org/10.1080/13603116.2016.1168873>
- Mohammed, P. S., & Watson, E. N. (2019). Towards inclusive education in the age of artificial intelligence: Perspectives, challenges, and opportunities. In J. Knox, Y. Wang, & M. Gallagher (Eds.), *Artificial intelligence and inclusive education. Perspectives on rethinking and reforming education* (pp. 17–37). Springer. https://doi.org/10.1007/978-981-13-8161-4_2
- Page, A., Anderson, J., & Charteris, J. (2021). Including students with disabilities in innovative learning environments: A model for inclusive practices. *International Journal of Inclusive Education*, 27(14), 1696–1711.
<https://doi.org/10.1080/13603116.2021.1916105>
- Ravichandran, R. R., & Mahapatra, J. (2023). Virtual reality in vocational education and training: Challenges and possibilities. *Journal of Digital Learning and Education*, 3(1), 25–31. <https://doi.org/10.52562/jdle.v3i1.602>
- Rojas Gonzalez, J. M., & Ramirez Sanchez, A. (2025). Description of the factors that affect the implementation of inclusive education in the population of third and fourth grade children in an educational institution in Armenia, Quindío. *Revista Id Est Investigación, Desarrollo, Educación, Servicio*, 5(2), 47–56.
<https://revista.fundes.edu.co/index.php/revista/article/view/382>
- Rubio-Pacheco, L. V., & Fino, A. O. R. (2023). Transformación Educativa impulsada por la Tecnología digital. Revisión Documental. *Quaestiones Disputatae*, 16(33), 118–145.
<https://revistas.santototunja.edu.co/index.php/qdisputatae/article/view/2965>
- Sánchez, J., Reyes-Rojas, J., & Alé-Silva, J. (2024). What is known about assistive technologies in distance and digital education for learners with disabilities? *Education Sciences*, 14(6), 595. <https://doi.org/10.3390/educsci14060595>
- Taxiarchis, V. (2023). The use of ICT in the education of students with dyslexia. *Global Journal of Engineering and Technology Advances*, 16(2), 38–46.
<https://www.gjeta.com/article/the-use-of-ict-in-the-education-of-students-with-dyslexia>
- Veytia Bucheli, M. G., Gómez-Galán, J., Cáceres Mesa, M. L., & López Catalán, L. (2024). Digital technologies as enablers of universal design for learning: Higher education students' perceptions in the context of SDG4. *Discover Sustainability*, 5, 473. <https://doi.org/10.1007/s43621-024-00699-0>
- Viner, M., Singh, A., & Shaughnessy, M. F. (2022). Assistive technology to help students with disabilities. In *Handbook of research on diverse teaching strategies for the technology-rich classroom* (pp. 537–552). IGI Global. <https://doi.org/10.4018/978-1-6684-3670-7.ch033>

Este artículo no presenta ningún conflicto de intereses. Este artículo está bajo la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0). Se permite la reproducción, distribución y comunicación pública de la obra, así como la creación de obras derivadas, siempre que se cite la fuente original.



Creative Commons Attribution 4.0
Internacional (CC BY 4.0)



ONLINE ISSN: 2665-0223
PRINT ISSN: 1856-7576