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Designing the digital environment of higher education for the quality training of specialists

Diseñar el entorno digital de la educación superior para la formación de calidad de especialistas

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Abstract

The main characteristics and advantages of using the digital environment of higher education for the high-quality training of future specialists are presented. The main official documents necessary for using the digital environment of higher education for the high-quality training of future specialists are described. The primary educational technologies for the professional training of future specialists in the digital educational

environment of higher education are identified. The effectiveness of the developed author's system for designing the digital environment of higher education for the high-quality training of future specialists, as well as the author's pedagogical conditions, was experimentally tested. The final results of the implementation of the author's system determined that in the experimental group, where training was carried out according to the author's system for designing the digital environment of higher education for the high-quality training of future specialists and the author's pedagogical conditions developed and implemented, there was a more pronounced increase in the number of respondents who were prepared to work in a digital environment at high and medium levels compared to the achievements of respondents in the control group, where training was carried out according to the traditional scheme.

Keywords: design, digital environment, higher education, high-quality training of future specialists, case method.

Resumen

Se presentan las principales características y ventajas del uso de entornos digitales en la educación superior orientados a la formación de especialistas de alta calidad. Asimismo, se describen los documentos oficiales necesarios para su implementación y se exponen las principales tecnologías educativas aplicadas a la formación profesional en dichos entornos. De igual manera, se verifica experimentalmente la eficacia del sistema desarrollado por el autor para el diseño de un entorno digital de educación superior, destinado a la formación de futuros especialistas, y se desarrollan e implementan las condiciones pedagógicas correspondientes. Los resultados finales de la implementación del sistema evidencian que, en el grupo experimental —donde la formación se realizó conforme al modelo propuesto por el autor—, se registró un incremento significativo en el número de participantes con niveles alto y medio de preparación para desenvolverse en entornos digitales. Este resultado contrasta con el grupo de control, en el cual la capacitación se llevó a cabo mediante el enfoque tradicional.

Palabras clave: diseño, entorno digital, educación superior, formación de alta calidad de futuros especialistas, método de caso.

Introduction

The educational process in higher education institutions is increasingly permeated by digitalization in various aspects, including the implementation of digital infrastructure, the use of digital technologies, and changes in the ways of interaction between educational process participants, as well as the creation of modern information products. Scientific and pedagogical workers, applying innovative teaching methods, digital content, and digital technologies, as well as contemporary forms of organization in a modern digital environment of higher education, involve higher education applicants in practical, research-based, active educational, cognitive, and other types of activities. The digital modern educational environment of higher education designed in these conditions is characterized by flexibility, accessibility, openness, interactivity, multimedia, networking, and digital technologies (open electronic resources, cloud applications, educational portals, educational game applications, learning management platforms, etc.) are rapidly developing.

The educational space of higher education must meet the trends of social development both in the future and today, work ahead, therefore, the integration of digital technologies into the educational process, the transition to digital interaction of higher education students and scientific and pedagogical workers from traditional learning through the use and design of a digital educational environment is a relevant process that is limited to the implementation of technologies, contains scientific and methodological support, comprehensive solutions of an infrastructural, innovative nature.

The introduction of innovative methods in the modern digital environment of higher education is due to the needs of those who study, the challenges of the digital society, which includes cloud technologies, blended

and distance learning, interactive and multimedia content, virtual and augmented reality tools, and gamification (Buestán Klein et al., 2024).

Based on the dependence of the current generation of students on social media platforms and technologies, it is necessary to use e-learning platforms in education in the modern digital environment of higher education to strengthen communication between teachers and students and increase their success, as well as improve the quality of training of future specialists (Alenezi, 2020). The modern digital environment of higher education encourages students to be active, explore modern industries, and develop competencies in the field of digital technologies.

Literature Review

In the context of higher education entering the digital society, it is relevant to examine the findings of scientists' research and their achievements in the digitalization of the educational process.

Darling-Hammond et al. (2017) studied the professional development of specialists as structured professional training. Scientists have identified the following progressive conditions in the educational process: active learning, collaboration, learning strategies, coaching and expert support, the use of models of effective practice, and reflection and feedback.

Gaebel & Morrisroe (2023) summarized the ideas of the DIGI-HE project, its results, regarding the improvement of digital learning in European higher education institutions, particularly the implementation of collaborative learning practices and the analysis of digital skills among specialists in developing a high-quality educational environment. To form professional communities and facilitate a mutual educational process, scientists emphasized the need to support cooperation between academic institutions throughout the entire society.

Additionally, Caena & Redecker (2019) analyzed digital skills among specialists in developing a high-quality educational environment, comparing the competences of specialists with the tools of thinking and their associated activities. Thus, according to the researchers, a competent specialist has the willingness to perform professional activities properly.

Forero-Arango et al. (2023) believe that in the application of digital technologies, it is the digital competence of a specialist that demonstrates their skill. Therefore, scientists emphasize that teachers, taking into account innovative pedagogy, must be able to critically assess the capabilities of digital technologies and utilize them consistently to design the digital environment of higher education for the high-quality training of future specialists. In particular, educational materials should be developed in digital format, taking into account students' readiness to work with technology. According to scientists, this approach will enable teachers to serve as mentors for students in both virtual and traditional learning environments.

The introduction of innovative teaching methods is accompanied by the reform of the higher education system, developing professionally significant personal values, relying on both the acquisition of knowledge and its application in practice. Claro et al. (2018) substantiated the connection between teaching methods and the results of education seekers' attitudes toward the cognitive process, as well as their academic success.

García's (2016) study describes ways to design a digital educational environment based on a project as a process, using multifaceted projects as a central organizational strategy for learning. The scientist explains the main characteristics of such learning, including the application of knowledge and its integration, a problem whose solution requires a time investment, learning methods, planning, management tools, reporting, and implementation, as well as the readiness and activity of students to work in the digital environment of higher education. The hypothesis is proven that for the quality training of future specialists, implementing a project task by students of higher education makes the learning process more conscious.

C. García substantiated the methods for developing project tasks in virtual groups, outlined the stages of their implementation, and formulated a conclusion based on the analysis of students' knowledge after the implementation of project activities aimed at improving the quality of their learning.

Analyzing project-based learning in higher education, scientists Guo et al. (2020) confirmed the improvement of students' knowledge and skills and justified the increase in the success of higher education applicants. The researchers described the characteristics of project-based learning (focus on educational goals, problem-based questions, use of digital technologies, cooperation between education applicants) and proved the necessity and importance of implementing project-based learning.

In the pursuit of a thorough study of the issues above, despite the fruitful scientific activity of scientists, some issues remain unresolved. In particular, the problem of designing a digital environment for higher education that facilitates the quality training of future specialists has not been fully investigated, as it is a relatively new area of study.

Research objective – designing a digital environment of higher education for the quality training of future specialists by developing an author's system and pedagogical conditions.

Methodology

The achievement of the goal was made possible by the use of a set of research methods:

- **Theoretical**: systematic and comparative analysis of psychological, pedagogical and philosophical sources to clarify the state of development of the problem of designing a digital environment of higher education for the quality training of future specialists by developing a system and pedagogical conditions; analysis of scientific and methodological works in the field of education to determine the content and essence of the basic concepts of the study; analysis of the studied pedagogical experience; open access resources to generalize the basics of professional training of future specialists.
- **Empirical**: observations, interviews, questionnaires, testing, peer evaluation, expert evaluation to outline the directions of project, research, educational, cognitive, and other types of activities, the use of digital technologies.
- **Statistical**: verification of statistical hypotheses, descriptive statistics of the educational process to process the data obtained during the study; analysis in the process of learning of different groups of education seekers to identify statistically significant differences.

The design of the digital environment of higher education involved the development of a system and pedagogical conditions, the application of which would contribute to the implementation of digital education innovations and, as a result, to increasing the efficiency of learning.

Let us reveal the algorithm of statistical analysis:

1. Formation of groups – experimental group (EG), control group (CG), which will be homogeneous in composition with respect to each indicator under study.
2. Fixing, for each of the samples, the results of the studied indicator.
3. Determining the results of applying statistical criteria for estimating variances (Fisher's test) and estimating means (Chi-square test).
4. Conducting the study according to the following rule:

    - Record the value 0 (insignificant difference) – if the hypothesis $H0$ is accepted.
    - Record the value 1 (significant difference) – if the hypothesis $H1$ is accepted.

5. Qualitative analysis of the results by comparing pairs – "assessment of samples by the Chi-square test" and "assessment of samples by the Fisher test".

The formulated hypothesis is that high-quality student learning is ensured by implementing a system for designing a digital environment in higher education that facilitates the high-quality training of future specialists. This system comprises the following components: value-motivational, cognitive, activity, diagnostic, reflective, and the development of pedagogical conditions for its implementation.

At the ascertaining stage, an experimental group (EG) and a control group (CG) of higher education applicants were determined.

To determine the dynamics of component and indicator development in each group (EG and CG), respondents were surveyed using questionnaires and tests.

When creating groups of respondents, the following conditions were taken into account: the number of applicants was approximately the same in the groups (in the CG – 68 respondents, in the EG – 67 respondents); the level of academic achievements of the respondents was approximately the same (by analyzing the results of previous assessment and examination sessions, the entry level of students was compared). A total of 135 higher education applicants participated in the experiment. Using the Fisher criterion, the correctness of the group selection was assessed. The application of the Fisher criterion involves checking the equality of mean values in two samples. At the same time, the discrepancy in indicators on average does not exceed 3% in the CG and EG at this stage of the experiment; therefore, we considered that we have two qualitatively homogeneous samples.

At the formative stage of the experiment, we investigated the components of the readiness of education applicants to utilize the built-in authoring system for designing the digital environment of higher education, aiming for high-quality training of future specialists. We developed and implemented pedagogical conditions and relationships between them. Selected forms of control and diagnostic tools were used according to the chosen criteria and indicators.

Taking into account the results of scientific and pedagogical research, we have chosen low, medium, and high levels of readiness formation for specialists to use the digital environment design system, according to all criteria for high-quality training of future specialists.

At the ascertaining stage of the experiment, the null hypothesis (H0) is accepted. The alternative hypothesis (H1) is rejected, that the levels of formation of all criteria for respondents at the ascertaining stage of the EG and CG are approximately the same. Therefore, the groups selected according to all requirements are considered equivalent.

At the control stage, the same means of diagnosing the level of formation of the readiness components in respondents were used for each of the groups as at the ascertaining stage of the experiment, which did not cause additional error; there was no significant impact on the results obtained due to their different characteristics (validity and reliability).

At the control stage, the alternative hypothesis (H1) is accepted that the levels of formation of all specified criteria of respondents of the experimental and control groups are different due to the implementation of the author's system for designing a digital environment of higher education for the high-quality training of future specialists and the development and implementation of the author's pedagogical conditions. The null hypothesis (H0) states that the levels of formation of all criteria of respondents of the experimental group and the control group are approximately the same (the proportion of respondents in the experimental group is not greater than in the control group and is at medium and high levels).

To conduct a comparative analysis of the samples before and after the experiment, the Chi-square statistical coefficient was calculated.

A comparison of the level of indicators at the formative stage of the study (fe) and the ascertaining ($f0$) stage was carried out, and the results were obtained.

For all indicators of all criteria, the empirical values for respondents of the CG do not exceed the critical value. In contrast, for respondents of the EG, the empirical values for all indicators significantly exceed those of the control group, indicating a significant increase in the results of the experimental group respondents relative to those of the control group.

The effectiveness of the developed author's system for designing a digital environment of higher education for the high-quality training of future specialists and the development and implementation of the author's pedagogical conditions was experimentally tested. During the pedagogical experiment, the levels of students' readiness to work in the system for designing a digital environment of higher education for their high-quality training, according to criteria and indicators, using methods that focus on testing skills, abilities, knowledge, and reveal a value attitude and creativity to learning in a digital educational environment. The final results of the implementation of the author's system determined that in the experimental group, where training was conducted according to the author's system of designing a digital environment of higher education for the quality training of future specialists and the author's pedagogical conditions developed and implemented, there was a more pronounced increase in the number of respondents who were prepared to work in a digital environment at high and medium levels compared to the achievements of respondents in the control group, where training was conducted according to the traditional scheme. However, a slight increase of 3–5% was also observed in them.

On average, in the EG, there was an increase in the level of formation of respondents' readiness to use a digital educational environment for the quality training of future specialists by 15–18%, taking into account the permissible measurement error (5%).

Research limitations.

The implementation of the pedagogical experiment was carried out in three stages during 2023-2025: preparatory, main, and final.

At the preparatory stage (2023), the goal and objectives of the study were determined, the experimental plan was developed, the methods of measuring and processing the results were determined, the control and experimental groups were selected, and their homogeneity was checked.

At the main stage (2024), the experiment was conducted.

At the final stage (2025), the results of the experiment were analyzed, their reliability was confirmed, and conclusions were drawn about the pedagogical effect of the experiment.

Research relies largely on the accuracy and reliability of data. The following digital data collection tools were useful in the study: MS Excel and SPSS (Statistical Package for Social Science).

The total sample size in the article is 135 respondents. The sample of respondents was formed by random selection using the technical procedure for calculating the selection step.

During the experimental study, diagnostic data on the levels of social competence of higher education applicants were determined through information influence and divided into a control group (68 students) and an experimental group (67 students).

The study was implemented by applying methods and various forms: multimedia technologies (projector, multimedia board, video and audio equipment), software that combines animation, graphic, text, video and sound data and information, their simultaneous use in the information space; mobile devices, personal

computers, web-based resources that are freely available and free of charge (YouTube, author's website, specialized sites, social networks, cloud technologies, social network technologies), etc.

The limitations of this study allowed for the following impact on the results: improving the qualitative characteristics of the material, optimally specified goals and objectives, and increasing the effectiveness of the results.

Results and Discussion

Main characteristics and advantages of using a digital environment of higher education for the quality training of future specialists.

Let us name the main characteristics of the digital environment of higher education: personalization (individual learning activities of users); integration and interoperability (storage of information, open access to it); analytics, assessment and consulting (presentation of learning outcomes, measurement tools); interaction (communication, collaboration); universal design and accessibility (convenient, using different devices, organization of learning).

Next Generation of Digital Learning Environment (NGDLE) is a confederation of IT systems, including a wide range of digital applications, content, and analytical mechanisms.

Since digital technologies ensure interaction between their participants, they should be a component of all teaching methods. Scientists characterize the Next Generation of Digital Learning Environment (NGDLE) as the interdependence of teachers and students. The digital environment of higher education should be formed independently by each individual and institution, selecting technologies, applications, content, and platforms, using the "Lego approach" (Bortolozo et al., 2018).

Let us outline the key advantages of utilizing the digital environment in higher education: harmonization of digital education infrastructure, integration of digital technologies and educational content, transcending academic institution boundaries, redistribution of roles among educational process participants, and interaction with external entities. The digital educational space, utilizing innovative technologies, enables the transformation of its subjects' roles, shapes the learning process, and facilitates seamless and secure cooperation.

When designing the educational space, scientists emphasize the absence of organizational boundaries in it – the educational network unites institutions and is not limited to the campus of the educational institution. The educational process utilizing digital technologies creates a modern digital educational environment that fosters interaction between students and teachers, thereby expanding their access to educational content (Manrique-Losada et al., 2020).

Digital technologies are being integrated at an accelerated pace into public organizations, playing a crucial role in all aspects of their operations, and requiring specialists who will create digital content and coordinate the use of technologies (Snow et al., 2017).

Institutions that fundamentally study theoretical and practical issues of improving the digital environment of higher education for high-quality training of future specialists are the European Association for Digital Technologies, the European Centre for the Development of Vocational Education, the European Commission, which have developed documents that reflect the trends in the implementation of digitalization tools, the acquisition of digital skills, the use of computer technology for practical use and the development of digital technologies.

Official documents necessary for the application of the digital environment of higher education for high-quality training of future specialists.

Among the official documents developed, the European Digital Education Plan is significant – it formulates the main tasks and defines the strategy for the digitalization of education in Europe, in particular: a secure digital educational environment, cloud applications, increasing students' digital literacy, supporting innovations in education, integrating digital technologies into educational processes, developing infrastructure for online learning, creating a secure digital environment of higher education for high-quality training of future specialists.

To develop digital skills of higher education students at all levels, it is proposed that all educational programs focus on improving students' digital literacy, as outlined in the European Skills Agenda.

The development of digital technologies and ways of their implementation in education are reflected in the Digital Europe Strategy, which outlines them in three areas: skills development, informed professional career; diagnosing skills and qualifications; improving the quality of skills; and providing educational institutions with the introduction of digital innovations and high-speed Internet.

The Digital Teaching Professional Framework defines three levels of competence: adaptation (the development and application of digital skills in practice); learning (the development of basic digital skills and the assimilation of new information); and leadership (a critical approach to the choice of technologies and the transfer of acquired knowledge).

The National Educational Technology Plan (NETP), developed in 2024, is promising, containing resource materials and examples of the use of digital technologies, on the way to supporting learning, considers barriers and indicates ways to overcome them in three aspects: the digital access gap, the digital design gap, and the digital use gap.

The European Commission's Digital Education Report states that for a successful professional life, teachers must possess digital skills and actively participate in digital society, demonstrating responsible, critical, and confident use of digital technologies (Eurydice, 2019).

Basic educational technologies for professional training of future specialists in the digital educational environment of higher education. Functions of project activity. Learning based on the case method.

The introduction of innovative teaching methods is accompanied by the reform of the higher education system, contributing to the practical application of knowledge acquisition and the development of professionally significant personal values in students.

The spread of creation and interactive content, which predicts the use of digital tools to support online interaction, focuses on the labor functions of the future specialist. The use of projects and cases is pedagogically appropriate and justified.

The educational process is enhanced by the project activities of higher education applicants.

We understand the project as a developed structure of the teacher's actions, a system of innovations for the implementation of a specific pedagogical task with the clarification of the place of each action, the role of the time of implementation of these actions, the role of participants in the educational process and the conditions necessary for the effectiveness of the innovative system of actions; a set of certain innovative ideas, texts for creating a subject, a real object, various kinds of practical and theoretical product.

Project activity is a productive and constructive process aimed at achieving a result through planning, goal-setting, project implementation, and solving a significant problem, achieved by completing a professional task, and is focused on the outcome.

Project activity in conditions of uncertainty considers pedagogical situations, focusing on achieving a project result that is applied in practical reality. This is a process of consistent change of states, and not just activity. At the same time, the student masters new types of activities, knowledge, and a degree of information orderliness.

Project-based education is a learning process that utilizes multifaceted projects as the central organizational strategy in the digital educational environment of higher education (García, 2016).

Where necessary, it is worth encouraging teachers in higher education institutions to implement project-based learning, which supports students' autonomous activity when completing tasks, promotes the implementation of educational innovations, and emphasizes the construction of knowledge in an authentic professional context by solving real-world problems (Cerutti & Baldo, 2020).

Project activities in the digital educational environment of higher education are cognitive, creative, and exploratory in nature. Skills for teamwork using digital technologies are formed by students' work with joint online projects (planning work in a virtual environment, processing, storing, and distributing digital messages, selecting and searching for information on the Internet, online communication strategies, etc.) (Pérez-Mateo et al., 2014).

To design a digital environment for higher education that facilitates high-quality training of future specialists, it is essential to consider the functions of project activity, including predictive, constructive, analytical, research, educational, and productive. Let us briefly present their content.

The predictive function outlines the effectiveness and consistency in the actions of higher education applicants, reveals the content of various types of activity planning, and updates their capabilities, as well as communication regarding the definition of common approaches to describing expected results and planning.

The constructive function is aimed at fostering a responsible attitude towards decision-making, determining methods, means, and resources, isolating and solving subtasks, achieving the project goal, organizing activities, and meeting deadlines.

The analytical function has a predictive nature, which, ahead of the solution procedure, describes the expected result.

The research function creates conditions for working on the project, including formulating a hypothesis, observing the stages of scientific research, confirming or refuting a hypothesis, and reasoning from the general to the specific, from the abstract to the concrete, etc.

The educational function, by acquiring new knowledge, giving it effectiveness, and combining it with previously formed knowledge, reflects the implementation of the project.

The productive function aims to present the expected educational product and summarize.

Learning based on the case method is a purposeful process of developing decision-making skills, discussing problems during discussions, analyzing the situation, and working out educational and didactic content. The use of cases should be justified and pedagogically appropriate, oriented to the content of the digital environment of higher education, to provide high-quality training for future specialists.

The connections between research and training should be in the following areas: the use of certain elements of a case study to enrich scientific work and vice versa, the use of cases in the educational process of higher education for research purposes, and the enrichment of case studies with elements of research work (Bento, 2024).

We classify cases by the number of participants (group or individual) and by the nature of the dominant activity (research, educational, or creative).

Working with a case for the quality training of future specialists is one of the main priorities in the digital environment of higher education, describing the activities of a specialist in designing, planning, collecting, processing, distributing, and analyzing (Mayor-Peña et al., 2024). In the digital environment of higher education, a holistic cognitive process is formed for the high-quality training of future specialists with diverse connections between the stages of activity.

The use of the digital educational environment of higher education in the organization of pedagogical practice of future specialists.

Pedagogical practice creates conditions for utilizing the digital environment to provide high-quality training for future specialists, offering students the opportunity to perform practical tasks, collaborate with teams, and use digital technologies.

Scientists describe the pedagogical practice of higher education students from the position of mastering such types of values: openness (providing the opportunity to comment on the opinions of others, explaining progressive ideas); cooperation (finding compromise solutions, valuing teamwork); social concern (common interests); effectiveness (assessing activities, analyzing results); communication (with students, colleagues); protection of personal data; organization of the digital environment of higher education (promoting the digital development of students, creating digital content) (Ghomi & Redecker, 2019).

Work in the digital environment of higher education for the quality training of future specialists is as follows: with digital tools for documentation (cloud applications for developing presentations and portfolios, electronic educational materials, electronic libraries of pedagogical resources, online questionnaires for data collection, etc.).

The generalization of descriptions enables the consideration of pedagogical practice as a necessary component of the digital environment in higher education for the quality training of future specialists, as a form of combining scientific research, educational and cognitive activities, professional activities of students, and the implementation of the educational process through cooperation with teams.

Experimental design of the digital environment of higher education for the quality training of future specialists. Components of student readiness in the system of professional training.

The design of the digital environment in higher education involved the development of a system and pedagogical conditions, the use of which would contribute to the implementation of digital education innovations and, as a result, increase learning efficiency.

Visualization of the goals of high-quality training for future specialists using Internet resources in cloud environments enables the prediction of learning, comparison of reflections, identification of shortcomings and advantages of working with specific digital technologies, informed decision-making, and critical understanding of information. The use of cloud technologies expands the means of visualization, allowing you to form a theoretical basis for facts, establish relationships, and focus on essential information, which contributes to the systematization and comprehension of knowledge. The use of a “tag cloud” develops digital competence and has a positive effect on student motivation.

We consider the value-motivational component as an in-depth motivation to acquire a specialty, stimulating a sense of duty, cognitive interest, and responsibility, creating conditions for learning, awareness of educational needs, and the development of mental activity.

Value-motivational factors in the area of training specialists in the digital environment of higher education differ, specifically: interest in professional activities, awareness of the need to acquire new knowledge, interest in digital education, and interest in educational innovations.

In the formation of the value-motivational component, attention was paid to free sites for readiness for activity in the digital society, self-assessment of the level of digital competence:

- **The Digital Teacher** – a resource of the University of Cambridge; defines by categories the areas of improvement of digital skills that reflect the content of digital pedagogy (digital teacher, digital classroom, digital world, learning design, evaluation of results); for experienced users and beginners, it contains courses posted on the FramerSpace platform.
- **Digital Competence Wheel** – based on the European DIGCOMP project, the test, using several features, assesses the level of digital competence of students (security, search and information, collaboration, critical evaluation, programming, dissemination and creation of information, monitoring, etc.), and also provides recommendations for increasing the level of digital competence of an individual.

The cognitive component of readiness is considered to outline the processes of learning and cognition for education seekers.

A significant role in the readiness of specialists to utilize the digital environment of higher education is given to the versatile connections of the cognitive component with other subsystems, as a specialist needs to possess psychological and pedagogical, methodological, subject, technological, and methodological knowledge acquired through the use of digital technologies.

The activity component of the readiness of specialists to utilize the digital environment of higher education highlights the involvement of education seekers (who use digital technologies) in engaging in various types of activities, which involve gaining experience, applying knowledge, and developing skills and abilities.

The activity component includes: organizational forms of cooperation (collective and group, individual work, laboratory and practical classes); methods of cognition (reflective and active); types of activity (project, independent, educational and cognitive, pragmatic, research, etc.).

We consider the diagnostic component of the readiness of specialists to use the digital environment of higher education as one in which we determine subjectively significant results, interpret diagnostic data, and evaluate students' academic achievements.

We understand students' academic achievements as a productive characteristic, which is determined by the set of competencies, skills, abilities, and knowledge formed during professional training in the digital environment of higher education.

In the digital environment of higher education, academic achievements acquire new features: they are characterized by flexibility and dynamism, and feedback is anticipated, which involves discussing learning outcomes. To determine the level of academic achievement, taking into account Bloom's taxonomy, higher education applicants were given a test that included tasks of varying complexity, including understanding, knowledge, analysis, synthesis, and application. Different forms of test questions were used: open-ended, with the choice of several or one correct answer, to establish the proper sequence, and to establish correspondence.

The reflective component of the readiness of specialists to utilize the digital environment of higher education is represented by reflection as a personal integral formation that provides processes of self-assessment, self-knowledge, and self-analysis; resolution of professional contradictions through reflection and rethinking; awareness; and assessment and selection of an adequate strategy for professional activity. That is why the development of a system for designing the digital environment of higher education for the high-quality training of future specialists and pedagogical conditions has included a reflective component of readiness, the content of which determines the attitude of the student as a future specialist, as an individual, to the activity performed and obtaining its results.

The digital era has brought both advantages and problems to social life; therefore, students need to develop a reflective and critical attitude towards digital technologies and the processes of their application (O'Byrne & Ward, 2023).

In our study, as a means of systematizing successful projects and visualizing them in the digital society, the popular electronic portfolio was utilized. Therefore, we at EG suggested that students develop an electronic portfolio, considering it from the position of: an education seeker and employers (publication and systematization of achievements, generalization, comprehension, planning of further actions) to demonstrate the competence of higher education seekers, the level of readiness for the use of the digital environment by specialists.

Organizational and pedagogical conditions for the implementation of a higher education digital environment design system in a higher school for the high-quality training of future specialists.

The effective implementation of a system for designing a digital environment in higher education, aimed at providing high-quality training for future specialists, requires the selection of justifications for pedagogical conditions.

The pedagogical conditions for implementing the system are as follows:

- Students' ability to work with digital technologies and study in a digital environment.
- Providing the higher education institution with digital infrastructure, software, high-speed Internet connection, etc.
- Application of digital technologies, diversification of content, forms, and methods of involving students in performing all types of activities.
- Designing a digital environment of higher education through information and educational and methodological support for future specialists.

Pedagogical conditions are implemented in the EG in connection with the components of the system's readiness for designing a digital environment of higher education, which supports high-quality training of future specialists. These components are integrated into the educational process, complementing each other. For a deeper understanding of the content of pedagogical conditions, the principles of education (individual learning trajectory, professional mobility, professional orientation, combination of collective, group, and personal learning, interactivity, etc.) were selected.

Organization and stages of pedagogical experiment.

The first stage of the pedagogical experiment – preparatory – focused on clarifying the state of the digital environment in higher education, the readiness of students to engage with it, and the search for possible ways to improve it. For this purpose, the literature was analyzed, and the experience of training future specialists in the digital environment of higher education was studied.

The second stage of the pedagogical experiment – exploratory – involved: revealing the conceptual framework of the research, substantiating the relevance of the research problem, developing an author's

system for designing the digital environment of higher education to support high-quality training of future specialists, and establishing pedagogical conditions for its implementation.

The first two stages of the study were combined into the ascertaining stage of the experiment.

The third stage of the pedagogical experiment – approbation – included the formative stage of the experiment: collection and analysis of empirical data; approbation of components and systems for designing the digital environment of higher education for high-quality training of future specialists; pedagogical conditions were specified.

The fourth stage of the pedagogical experiment – the generalized stage – included the following activities: conducting a pedagogical experiment at the control stage, statistical processing of empirical data, generalization of the analysis of the research results, and outlining further scientific research.

Let us reveal the algorithm of statistical analysis:

1. Formation of groups – experimental group (EG), control group (CG), which will be homogeneous in composition with respect to each indicator under study.
2. Fixing, for each of the samples, the results of the studied indicator.
3. Determining the results of applying statistical criteria for estimating variances (Fisher's test) and estimating means (Chi-square test).
4. Conducting the study according to the following rule:
6. Record the value 0 (insignificant difference) – if the hypothesis $H0$ is accepted.
7. Record the value 1 (significant difference) – if the hypothesis $H1$ is accepted.
5. Qualitative analysis of the results by comparing pairs – "assessment of samples by the Chi-square test" and "assessment of samples by the Fisher test".

The declarative stage of the experiment.

The purpose of the ascertaining stage of the experiment is to clarify the state of students' professional training.

At this stage of the experiment: the experimental program was developed; the theoretical and methodological basis of the study was worked out; the criteria and levels of students' readiness to use the digital environment of higher education were determined (combining and creating digital educational content; selecting digital educational resources; using online environments to design activities and implement them; using game applications for educational purposes, etc.); initial data were collected and diagnostic tools were selected.

Additionally, the pedagogical conditions for implementing a system to design the digital environment of higher education for high-quality training of future specialists were determined.

The hypothesis formulated at the ascertaining stage of the experiment is that high-quality student learning is ensured by implementing a system for designing a digital environment of higher education for high-quality training of future specialists, which contains the following components: value-motivational, cognitive, activity, diagnostic, reflective, and the development of pedagogical conditions for its implementation.

At the ascertaining stage, an experimental group (EG) and a control group (CG) of higher education students were determined.

To determine the dynamics of component and indicator development in each group (EG and CG), respondents were surveyed using questionnaires and tested.

When creating groups of respondents, the following conditions were taken into account: the number of students in the groups was approximately the same (in the CG – 68 respondents, in the EG – 67 respondents); the level of academic achievements of the respondents was roughly the same (by analyzing the results of previous assessment and examination sessions, the entry level of students was compared).

A total of 135 higher education applicants participated in the experiment. Using the Fisher criterion, the correctness of the group selection was assessed. The application of the Fisher criterion consists of checking the equality of mean values in two samples. At the same time, the discrepancy in indicators on average does not exceed 3% in the CG and EG at this stage of the experiment; therefore, it was believed that we have two qualitatively homogeneous samples.

The formative stage of the experiment.

The formative stage of the experiment was based on the results of the ascertaining experiment.

At this stage, the following tasks were addressed: the organization of the student learning process in the EG was carried out using the author's system for designing the digital environment of higher education, aimed at providing quality training for future specialists, and by developing and implementing pedagogical conditions. Therefore, digital technologies were selected, and educational and methodological content was created. In the CG, the learning process was organized for students using traditional teaching methods.

At the formative stage of the experiment, we investigated the components of readiness among education seekers to utilize the built-in authoring system for designing the digital environment of higher education, aiming for quality training of future specialists. We developed and implemented pedagogical conditions and the relationships between them. Selected forms of control and diagnostic tools were used according to the chosen criteria and indicators.

By introducing various forms of designing the professional work of future specialists, we expanded students' ideas about their work functions, deepened practical knowledge about the work of the digital environment, and formed skills for effective performance in groups, individually, collectively, using educational game applications, online environments, open educational resources, and other digital technologies.

The control stage of the experiment.

The purpose of the control stage of the experiment is focused on comparing the learning outcomes of the two groups, final assessment of the achievements of higher education applicants, generalization of the results, correction of individual research provisions, formulation of the main conclusions regarding the effectiveness of the author's system for designing the digital environment of higher education for the high-quality training of future specialists and the development and implementation of the author's pedagogical conditions, presentation of experimental data on the components of the readiness of specialists to use the digital environment design system.

Taking into account the results of scientific and pedagogical research, we have selected three levels of readiness among specialists to utilize the digital environment design system, based on all criteria for high-quality training of future specialists.

The effectiveness of implementing the digital environment design system in higher education for high-quality training of future specialists was tested by determining the level of readiness of students according to the selected components, criteria, and indicators for the use of the digital educational environment in higher schools.

Results of the pedagogical experiment.

Fisher's angular transformation was used by us when comparing two empirical distributions to identify differences in the distribution of the characteristic. We assumed that “the effect exists” when the respondents' answers were assessed as medium or high and “there is no effect” when the respondents' answers were assessed as low. Therefore, it was concluded that “the effect exists” if the respondent scored enough points for the medium and high level, and “there is no effect” if the respondent had a low level according to his/her scores.

Hypotheses were formulated − a statistical hypothesis may be correct or incorrect; therefore, there is a need to test it:

H0 – the hypothesis is that the levels of formation of all criteria of the respondents of the experimental and control groups are approximately the same (the proportion of students who are at a high level and medium level in the CG is not greater than in the EG).
H1 – the hypothesis is that for all criteria, the initial levels of readiness to work in the digital environment of higher education for the qualitative training of future specialists of higher education applicants, CG and EG are different.

Note: None of the formed samples equals zero; in both samples, the number of observations exceeds 20.

Therefore, we conclude that the experimental data fully satisfy the restrictions imposed by the Fisher angular criterion.

So, at the ascertaining stage of the experiment, the null hypothesis (H0) is accepted. The alternative hypothesis (H1) is refuted, that the levels of formation of all criteria of respondents at the ascertaining stage of EG and CG are approximately the same. Therefore, the groups selected according to all requirements are considered equivalent.

Implementation of the system for designing a digital environment of higher education for the qualitative training of future specialists involves the formation of students' readiness to process digital content; the use of digital technologies in both education and professional activities, in particular value-motivational, cognitive, activity, diagnostic, and reflexive components, according to indicators, criteria, and levels of their formation. Methods, forms, and means contributed to the implementation of the tasks of the formative stage of the study.

At the control stage, the same means of diagnosing the level of formation of the respondents' readiness components were used for each group, as at the ascertaining stage of the experiment, which did not result in additional error; there was no significant impact on the results obtained due to their different characteristics (validity and reliability).

When comparing two empirical distributions of the feature, Fisher's angular transformation was used to identify differences. We assume that when the respondents' answers are assessed as high, sufficient, and average, then "the effect exists", and "there is no effect" when the respondents' answers are assessed as low.

Let's formulate hypotheses at the control stage:

H0 – the hypothesis is that the levels of formation of all criteria of respondents of the experimental group and the control group are approximately the same (the proportion of respondents in the experimental group is not greater than in the control group and is at medium and high levels).
H1 – the hypothesis is that the levels of formation of all specified criteria of respondents of the experimental and control groups are different due to the implementation of the author's system for designing the digital

environment of higher education for high-quality training of future specialists and the development and implementation of the author's pedagogical conditions.

We obtained that $\Phi^*_{emp} > \Phi^*_{cr}$ 0.01, and therefore it is in the significance zone at the level of 0.01, the obtained value of $\Phi^*_{emp} = 2.974$.

Therefore, at the control stage, the alternative hypothesis (H1) is accepted that the levels of formation of all specified criteria of respondents of the experimental and control groups are different due to the implementation of the author's system for designing the digital environment of higher education for the high-quality training of future specialists and the development and implementation of the author's pedagogical conditions. The null hypothesis (H0) states that the levels of formation of all criteria of respondents of the experimental group and the control group are approximately the same (the proportion of respondents in the experimental group is not greater than in the control group and is at medium and high levels).

To conduct a comparative analysis of the samples before and after the experiment, the Chi-square statistical coefficient was calculated.

The corresponding critical values:

$\chi^2_{cr} = 9.21$ (p=0.01)
$\chi^2_{cr} = 5.99$ (p=0.05).

By calculating using the formula:

$$\chi^2 = \sum \frac{(f_0 - f_e)^2}{f}$$

A comparison of the levels of indicators for the identified components was conducted at the formative stage (fe) and the ascertaining stage ($f0$) of the study and the results were obtained.

For all indicators of the identified components, we observe statistical significance of the differences in the results of the EG, which indicates a significant increase in their results relative to the control group.

For all indicators, the empirical values for the CG respondents do not exceed the critical value. In contrast, for the EG respondents, the empirical values are significantly higher, indicating a notable increase in the results of the experimental group respondents compared to the control group respondents (Table 1, Figure 1).

Table 1.
Summary values of the χ^2 criterion for indicators of all criteria

	Components	CG	Conclusion	EG	Conclusion	χ^2cr
1.	Value-motivational	2,963	$\chi^2_{emp} < \chi^2_{cr}$	31,500	$\chi^2_{emp} > \chi^2_{cr}$	5,99
2.	Cognitive	2,956	$\chi^2_{emp} < \chi^2_{cr}$	33,596	$\chi^2_{emp} > \chi^2_{cr}$	5,99
3.	Activity	8,360	$\chi^2_{emp} < \chi^2_{cr}$	87,055	$\chi^2_{emp} > \chi^2_{cr}$	9,21
4.	Diagnostic	1,151	$\chi^2_{emp} < \chi^2_{cr}$	27,904	$\chi^2_{emp} > \chi^2_{cr}$	5,99
5.	Reflective	2,705	$\chi^2_{emp} < \chi^2_{cr}$	25,960	$\chi^2_{emp} > \chi^2_{cr}$	5,99

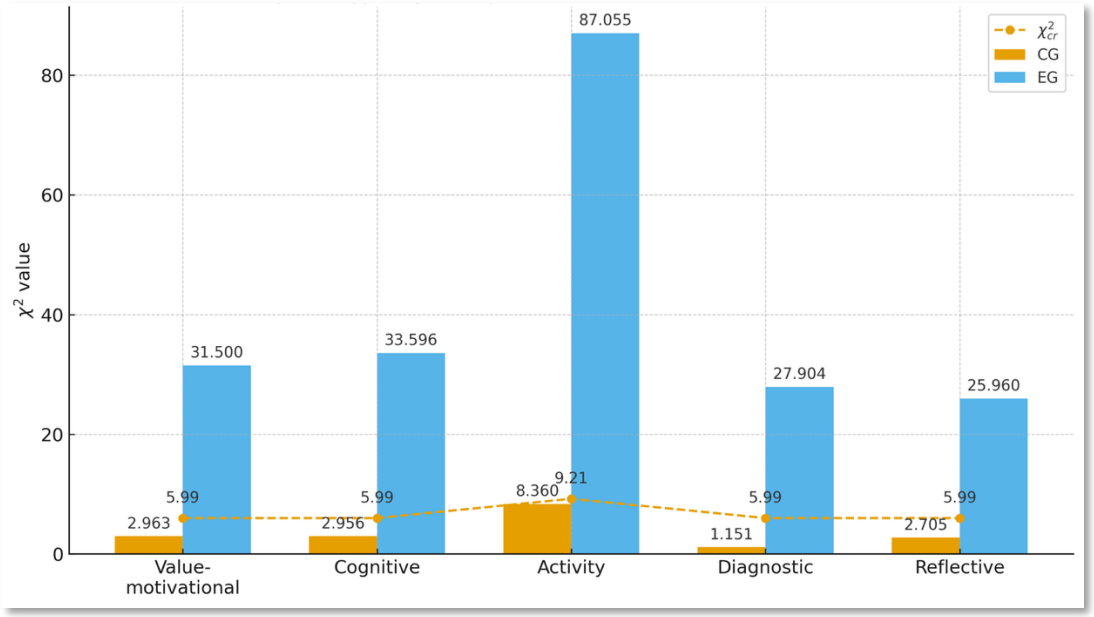

Figure 1. Chi-square (χ^2) by component: CG vs EG with critical values

The effectiveness of the developed author's system for designing the digital environment of higher education for the high-quality training of future specialists was experimentally tested, and the author's pedagogical conditions were developed and implemented. During the pedagogical experiment, the levels of students' readiness to work in the system for designing the digital environment of higher education for their high-quality training were determined, according to criteria and indicators, using methods that focus on testing skills, abilities, knowledge, and reveal a value attitude and creativity to learning in a digital educational environment. The final results of the implementation of the author's system determined that in the experimental group, where training was conducted according to the author's system of designing a digital environment of higher education for the high-quality training of future specialists and the author's pedagogical conditions developed and implemented, there was a more pronounced increase in the number of respondents who were prepared to work in a digital environment at high and medium levels compared to the achievements of respondents in the control group, where training was conducted according to the traditional scheme. However, a slight increase of 3–5% was also observed in them.

On average, in the EG, there was an increase in the level of formation of respondents' readiness to use a digital educational environment for the high-quality training of future specialists by 15–18%, taking into account the permissible measurement error (5%).

Conclusions

The main characteristics and advantages of using the digital environment of higher education for the high-quality training of future specialists are presented. The main official documents necessary for using the digital environment of higher education for the high-quality training of future specialists are described. The primary educational technologies for the professional training of future specialists in the digital educational environment of higher education are identified. The functions of project activity are defined, and the main advantages of learning based on the case method are proposed. The ways of utilizing the digital educational environment in higher education for organizing the pedagogical practice of future specialists are demonstrated.

The design of the digital environment of higher education provided for the development of a system and pedagogical conditions, the use of which would contribute to the implementation of innovations in digital education and, as a result, to increasing the efficiency of training.

The hypothesis formulated at the ascertaining stage of the experiment is that high-quality student learning is ensured by implementing a system for designing a digital environment of higher education for high-quality training of future specialists, which contains the following components: value-motivational, cognitive, activity, diagnostic, reflective, and the development of pedagogical conditions for its implementation.
At the ascertaining stage, an experimental group (EG) and a control group (CG) of higher education applicants were determined.

To determine the dynamics of component and indicator development in each group (EG and CG), respondents were surveyed using questionnaires and tested.

Using the Fisher criterion, the correctness of the selection of groups was checked; the application of the Fisher criterion predicts a check in two samples of equality of mean values. At the same time, the discrepancy in the indicators on average does not exceed 3% in the CG and EG at this stage of the experiment; therefore, it was believed that we have two qualitatively homogeneous samples.

At the formative stage of the experiment, we investigated the components of the readiness of education seekers to use the constructed author's system for designing the digital environment of higher education, aiming to provide high-quality training for future specialists. We developed and implemented pedagogical conditions and relationships between them. We employed selected control and diagnostic tools according to the chosen criteria and indicators.

The effectiveness of the developed author's system for designing the digital environment of higher education for the high-quality training of future specialists was experimentally tested, and the author's pedagogical conditions were developed and implemented. The final results of the implementation of the author's system determined that in the experimental group, where training was conducted according to the author's system of designing a digital environment of higher education for the high-quality training of future specialists and the author's pedagogical conditions developed and implemented, there was a more pronounced increase in the number of respondents who were prepared to work in a digital environment at high and medium levels compared to the achievements of respondents in the control group, where training was conducted according to the traditional scheme. However, a slight increase of 3–5% was also observed in them. On average, in the EG, there was an increase in the level of formation of respondents' readiness to use a digital educational environment for the high-quality training of future specialists by 15–18%, taking into account the permissible measurement error (5%).

We consider it appropriate to design an educational system in the future for implementing the principles of digital education in the professional training of applicants for the second (master's) level of education.

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