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Design thinking in STEAM education curricula: development and evaluation of effectiveness

Pensamiento de diseño en los planes de estudios de educación STEAM: desarrollo y evaluación de la eficacia

Bohdan Skovronskyi
Candidate of Philosophical Sciences (PhD), Associate Professor, Associate Professor of the Department of Design and Technology, Kyiv National University of Culture and Arts, Kyiv, Ukraine; Postdoctoral researcher at the UNESCO Chair of Science Education, Mykhailo Dragomanov Ukrainian State University, Kyiv, Ukraine.
https://orcid.org/0000-0001-5413-6630
skovronskij81@gmail.com
Volodymyr Sipii
PhD in Pedagogy, Head of the Department of Biological, Chemical and Physical Education, Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine.
https://orcid.org/0000-0003-4825-1426
sipiy@ukr.net
Oleh Morin
PhD in Pedagogy, Senior Research Fellow, Educational Design Department, The Institute of Problems on Education of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine.
https://orcid.org/0000-0001-5756-8359
morin_oleg@ukr.net
Zorina Ohrimenko
PhD in Pedagogy, Head of the Educational Design Department, The Institute of Problems on Education of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine.
https://orcid.org/0000-0001-7217-100X
demantoid@ukr.net
Viktoriia Khrenova
PhD in Pedagogy, Associate Professor, Department of Technological and Vocational Education and Decorative Arts, Faculty of Humanities and Pedagogy, Khmelnytskyi National University, Khmelnytskyi, Ukraine.
https://orcid.org/0000-0001-8384-7554
khrenovav@khmnu.edu.ua

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Abstract

The design thinking approach serves as a vital instrument for enhancing creativity, critical thinking, and social competence. This study investigates the impact of integrating design thinking into STEAM education curricula on the development of creative thinking, problem-solving abilities, and overall academic achievement. A quasi-experimental design was employed with 52 participants, divided evenly into control (n=26) and experimental (n=26) groups. The study was conducted in phases. The initial phase included

the development of an adapted curriculum, instructional materials, and evaluation tools. Subsequently, pre-tests and post-tests were administered using the TTCT and WGCTA scales. In addition, a questionnaire was utilised to assess students' perceptions of the design thinking methodology. The results revealed that embedding design thinking into the STEAM curriculum significantly improved creativity (TTCT: +7.2 vs. +1.1), analytical reasoning (WGCTA: +2.3 vs. +0.5), and motivation towards STEAM disciplines (+1.3 vs. +0.4), compared to the control group. Furthermore, the study highlighted the potential of design thinking as a guiding element in career orientation, facilitating informed professional self-determination within the fields of science, technology, and engineering. The findings underscore the importance of this approach due to its emphasis on addressing real-world, complex challenges through innovative and learner-centred strategies.

Keywords: analytical skills, creativity, design thinking, skill development, STEAM education, STEM career.

Resumen

El enfoque del pensamiento de diseño constituye una herramienta clave para fomentar la creatividad, el pensamiento crítico y las habilidades sociales. Este estudio tiene como objetivo analizar el impacto de la integración del pensamiento de diseño en los planes de estudio STEAM sobre el desarrollo del pensamiento creativo, la capacidad de resolución de problemas y el rendimiento académico general. Se adoptó un diseño cuasi experimental con 52 participantes, distribuidos en dos grupos: experimental (n=26) y de control (n=26). La investigación se desarrolló en varias fases. En primer lugar, se diseñó un programa adaptado, con materiales didácticos y herramientas de evaluación. Posteriormente, se aplicaron pruebas pre y post utilizando las escalas TTCT y WGCTA. También se administró un cuestionario para explorar la percepción de los estudiantes sobre el pensamiento de diseño. Los resultados indicaron mejoras significativas en creatividad (TTCT: +7,2 frente a +1,1), pensamiento analítico (WGCTA: +2,3 frente a +0,5) y motivación hacia las disciplinas STEAM (+1,3 frente a +0,4) en el grupo experimental. Asimismo, se identificó el potencial del pensamiento de diseño como herramienta de orientación vocacional, al favorecer una autodeterminación profesional más consciente en áreas como ciencia, tecnología e ingeniería. Este enfoque destaca por su capacidad para abordar problemas reales y complejos de manera efectiva.

Palabras clave: habilidades analíticas, creatividad, pensamiento de diseño, desarrollo de habilidades, educación STEAM, carrera STEM.

Introduction

Current educational systems around the globalized world are faced with the challenge of defining new paradigms for further development, revising the essence and necessity of traditional approaches to the educational process, and finding and using innovative practices that are integral to the development of modern society. An vital innovation in the current state of education is the active use of STEAM education (a combination of science, technology, engineering, art, and mathematics), which aims to organize interdisciplinary learning, continuous development of creative thinking, mastering the necessary level of critical skills, and the ability to overcome complex problems in the future (Seitenova et al., 2023). The STEAM approach allows to effectively combine technological and humanitarian knowledge, to create conditions for the further development of a holistic worldview in students at different levels of education.

In addition to the development of creativity and interdisciplinary competencies, STEAM education is increasingly regarded as an effective tool for early career orientation, particularly for guiding students toward STEM careers. Thus, in the context of Ukrainian educational reform, STEAM education is relevant. According to the Concept of STEM Education Development in Ukraine, one of the main tasks is to increase students' motivation to master professions in high-tech and science-intensive industries through project-based learning, interdisciplinary research, and solving real-life situations. Within this framework, design thinking assumes a particularly important role, as it not only develops creative and analytical thinking but also enables pupils to simulate various professional roles, recognise their personal strengths and take the initial steps towards constructing an individual career path. This concept is usually understood as a complex

methodology for overcoming problems, based on a high level of identifying user needs, applying a creative approach to generating further ideas, and practical testing of the results. To improve the educational process, design thinking makes it possible to make the final transition from passive perception of information to the active use of new knowledge that can be applied in real (or at least close to real) circumstances (Pratiwi et al., 2023).

The combination of design thinking and curriculum development creates a dynamic, student-centered, and extremely flexible educational environment in which all participants in the learning process play several roles simultaneously: active consumers of knowledge and important creators of innovation. The use of such a system transforms learning into a process of dynamic development of critical and systemic thinking, innovative thinking, creative skills in teamwork, the ability to self-reflect, and to adapt to environmental transformations in a timely manner. In fact, all these abilities are key competencies of modern specialists in all fields (Bachynskyi, 2024). At the same time, even considering the numerous advantages of applying design thinking in education, the problem of its effective combination with STEAM learning is still open for research. As of today, several experimental practices have been demonstrated, and individual studies have been conducted, which, however, lack integrity in terms of theoretical and methodological developments that would allow systematizing the experience of developing educational programs using design thinking practices, justifying the pedagogical value of such studies, etc. However, most existing programs remain too academic and fragmented, with limited opportunities for students to apply knowledge creatively or in real-life contexts. This gap highlights the need to integrate innovative methodologies, such as design thinking, into the national curriculum in a systematic and scalable manner.

The purpose of the proposed study is to analyze design thinking in STEAM education programs, to evaluate the effectiveness of such educational practices in terms of developing the key competencies of students.

This task involves finding answers to the following research questions:

1. To what extent does the use of design thinking in STEAM education affect the development of students' creative thinking?
2. Why is the introduction of design thinking important for analytical thinking and motivation of students to study STEAM disciplines?
3. Are there any statistical differences in the levels of creativity and analytical thinking between those students who studied in traditional training programs and those who studied in a model program with design thinking?

The intervention analyzed in this study was implemented within the framework of an experimental STEAM module for 7th grade students of secondary schools in Ukraine. This model was developed as part of a model curriculum that corresponds to the national STEM concept. The program developed by the authors was approved by the Ministry of Education and Science of Ukraine. It involved the integration of design thinking as a basic teaching strategy in such modern educational subjects

Literature Review

The development of modern pedagogy will require considering the influence of various factors and methods. The digitalization factor has led to the active development of innovative technologies in the educational process, which has made it possible to rethink the existing paradigms of learning activities (Nikolenko et al., 2024). Another component of the development was design thinking. Design thinking was initially an innovative methodology for overcoming existing challenges and creating new products in the field of applied engineering, industrial design in a broader context, etc. However, the effectiveness of this methodology was quickly adapted for use in a wide range of other industries, including education. Due to this, in the modern scientific literature, design thinking is primarily interpreted as a creative and human-centered process that involves a broad analysis of understanding user needs, creating new ideas, generating prototypes, and testing them in real or simulated environments (Preston, 2024;

Nedermeijer, 2023). The widespread use of design thinking has made it possible to integrate it into research on the effectiveness of STEAM education, to demonstrate the positive and problematic aspects of its use.

Design thinking in education: pedagogical benefits

In educational contexts, design thinking has become not only a method of overcoming existing challenges, but also a pedagogical strategy. Cook & Bush (2018) focused on the study of stimulating students' active participation in the educational process, which allowed them to increase levels of empathy and creativity, critical thinking, and communication skills. Liao (2019) also demonstrated the effectiveness of design thinking through the prism of interdisciplinary learning, including STEAM education, using empirical calculations. Moreover, Liao (2019) emphasized its effectiveness in interdisciplinary environments, where learners integrate knowledge while engaging with real-world problems. Similar results were obtained by Kudria et al. (2024) using Ukrainian material. Confirmation of the high effectiveness of design thinking in an interdisciplinary approach was provided by Aswan et al. (2024), who demonstrated the existence of direct links between the acquisition of theoretical knowledge and the possibilities of its practical application through the implementation of project and problem-based tasks. Besides, this research affirmed that design thinking linked theoretical content with practical application.

Unterfrauner et al. (2024) pointed out the relevance of using STEAM learning as a need for the formation of future specialists. At the same time, Meadows (2024) identified the usefulness of applying design thinking in educational processes, which made it possible to at least partially align the needs of the modern labor market to the goals and learning outcomes. The analysis of the proposed works made it possible to identify important links between design thinking and the functioning of STEAM education, to point out the clear advantages of this methodology when used for educational purposes.

Recent research from Latin America also provides valuable insights into this issue. For example, the authors described the importance of design thinking in Chilean high schools and found that it significantly improved collaborative problem-solving skills (Soto et al., 2024). Similarly, others have noted its potential to promote inclusion and diversity in STEAM classrooms, especially when integrated with community projects (Avendano-Uribe et al., 2022). Besides, Gerardou et al. (2022) highlighted the integration of design thinking into the challenge-based learning approach. The authors described the role of design thinking for empathetic problem analysis, idea generation, prototyping, and evaluation of solutions in an educational context.

Challenges in application: gaps and obstacles

An urgent problem discussed in the scientific literature was the identification of existing difficulties in both the interpretation of design thinking and its practical application in the field of education. Despite the understanding of the important potential of design thinking as an effective tool for developing innovative thinking, there are a number of obstacles to its effective application in educational settings. Yüksel (2025) emphasized the problem of insufficient readiness of teachers to apply design thinking. For teachers' practice, the use of innovative approaches will require mastering new roles of facilitators of the educational process, who are able to develop students' creative thinking, coordinate interdisciplinary connections, etc. However, many teachers have been trained and have long used traditional paradigms aimed at transmitting knowledge. These conclusions were also shared by Culén & Gasparini (2019), who emphasized the importance of stimulating student inquiry rather than the transmission of ready-made knowledge. Bascopé et al. (2020) identified the importance of STEM education policies in Latin American countries. In particular, the authors drew attention to institutional challenges, inconsistencies between educational policies and practices, and insufficient implementation of STEM in public education programs. Particular attention is paid to unequal access to STEM education in rural and urban areas. The work is important for understanding the regional context of STEM education and the need for integrated strategies. Moreover, Gavari-Starkie et al. (2024) have highlighted the potential of STEAM education for rural development in Latin America. The paper describes various examples of programs that promote environmental literacy,

sustainable use of natural resources, and strengthening local communities through innovative educational methods. It also emphasizes the involvement of students in real-world projects with social relevance.

Separately, researchers have noted a rather serious challenge of institutional inertia - the reluctance of educational institutions to adapt to new innovative learning models in general (Khan et al., 2025; Gevorgyan, 2024).

Taking these challenges into account will allow us to assess both the current state of development of design thinking in STEAM education and potential development prospects, since overcoming challenges will inevitably lead to further improvement of design thinking as an educational methodology. Within the framework of the New Ukrainian School (NUS), the formation of a conscious professional choice by students is of particular importance, and it is closely related to the implementation of STEM. According to the results of modern research, it is precisely integrated learning with a broad emphasis on science, technology, engineering, and mathematics that contributes to the early identification of students' aptitudes and the formation of motivation to choose professions in the fields of high technology (Czyż & Svyrydenko, 2019; Unterfrauner et al., 2024). In particular, the development of design thinking skills is an important potential pedagogical tool in STEM education, which additionally affects the activation of creative thinking, the development of teamwork and the ability to solve real problems. Such skills are key professional skills for a successful career in the 21st century.

Fragmentation and lack of empirical evidence

At the same time, despite the understanding of the potential of design thinking in educational practices, the research conducted so far is still at a rather fragmented level. First of all, researchers have not identified a single conceptual model for integrating design thinking into curricula. Some studies pay a lot of attention to this issue, but there are no integrated studies. There is also a significant lack of empirical information that could confirm or deny the effectiveness of using design thinking in STEAM courses. This is especially true for Ukrainian scholarship, which has focused only on certain manifestations of design thinking. Thus, many studies are case studies that do not allow for broader generalizations about the systemic effects of design thinking on student outcomes.

This problem has been echoed by other authors, who in a Brazilian study highlighted the lack of institutional support and long-term planning as key reasons for limited systemic implementation. Furthermore, many studies rely on qualitative data that, while informative, lack the statistical precision necessary to generalize the results across populations.

In general, the analysis of the scientific literature has made it possible to identify urgent tasks for further generalization of the available theoretical material, development of structured models for the integration of design thinking and STEAM education. It is also essential to address the organization of empirical research, which is important for determining the development of key competencies of students as a result of the application of design thinking.

Methodology

A quasi-experimental approach was used to conduct the study, involving control and experimental groups. This format was chosen due to the impossibility of random distribution of participants, since the study is conducted in the conditions of the real educational process in secondary education institutions, in which groups are formed administratively. Accordingly, this approach is the most appropriate for this study. In addition, quasi-experimental research affects the provision of practical feasibility and allows assessing the effectiveness of implementing design thinking elements within the framework of the updated STEAM education system.

Sample and Participants

The study used a purposive sample to attract participants. Educational institutions distributed information about the study through official communication channels and corporate e-mails. Accordingly, two groups of 7th-grade students from two schools implementing the STEAM model curriculum (approved by the Ministry of Education and Science in 2024, co-developed by one of the authors) participated in the study. The selection criteria for participants included the following aspects:

1. Voluntary participation
2. Regular attendance at classes
3. Consent of parents/guardians to participate in the study.

Total number of participants: 52 people. They were divided into 2 groups: control (26) and experimental (26). The profile of the participants was formed from students with different levels of interest in natural and mathematical disciplines.

A preliminary analysis of the statistical power of the sample was performed using G Power software. This confirmed sufficient power to detect medium-sized effects (effect size d = 0.5, power = 0.80, α = 0.05).

Description of the educational intervention

The experimental group studied according to an adapted version of the STEAM model curriculum, which included the module “Design Thinking as a Tool for Solving Real Problems.” The specified program involved the integration of interdisciplinary projects aimed at developing creative, critical, and systemic thinking.

The integrated module covered the subjects of the natural cycle, computer science, fine arts and technology, and also included elements of interdisciplinary project-based learning. The intervention lasted 15 academic weeks and was implemented in the form of a STEAM project with clear design thinking stages: empathy, problem definition, idea generation, prototyping and testing. The stages of the educational intervention consisted of empathy, problem formulation, ideation, prototyping, and testing. The final stage involved testing solutions in the school environment and discussing the results. Table 1 presents the main stages of the educational intervention.

Table 1.
Stages of educational intervention (project module plan, 15 weeks)

Stage	Description
Empathy	Information on user needs is expected to be collected through observations and surveys
Problem formulation	Definition of the focus of the study
Ideation	Generation of solution options
Prototyping	Creation of solution models
Testing	Testing solutions in a school environment, discussion of results

Source: Author’s development

The control group worked according to the standard STEAM program without an emphasis on the development of design thinking.

The role of the teacher in the implementation of the module was defined as a facilitator of the educational process: the teacher did not simply transfer knowledge, but provided support for students during their independent search for solutions, contributed to the development of team interaction, critical and creative thinking. To increase the reliability of the program implementation, preliminary training of teachers on the principles and sequence of application of the design thinking methodology in the educational environment was organized. In addition, throughout the implementation period, monitoring of compliance with the key

stages of design thinking (empathy, problem definition, idea generation, prototyping, testing) was carried out by the author's research group. Monitoring was implemented in the form of systematic observation and filling out standardized checklists to record the sequence and depth of implementation of the methodology in practice.

However, methodological compliance was not carried out, which is a certain limitation in terms of ensuring complete objectivity and reproducibility of the intervention in other educational institutions.

Tools and Procedure

The study consisted of several stages. In particular, the first stage involved the development of an adapted program, methodological materials and assessment tools. After that, preliminary testing was carried out, which involved determining the level of creativity, creative skills and analytical thinking. For this purpose, the following tests were used:

1. Torrance Tests of Creative Thinking (TTCT)

This test involves assessing fluency (number of ideas), flexibility (variety of thoughts), originality, etc.

The form of conduct is verbal-graphic
Advantages - assessment of creativity, expressed thoughts. In addition, this standard is internationally recognized.

TTCT indicators consist of:

1. Fluency - the number of proposed ideas or solution options.
2. Flexibility – counting the topics on which participants propose ideas
3. Originality – counting ideas that are unique
4. Watson-Glaser Critical Thinking Appraisal (WGCTA) (adapted)

This test involves determining logical thinking, features of argument formation, analysis of assumptions and interpretation of data.

Advantages – this test was used in a simplified form and made it possible to create tasks of a similar type. At the same time, the WGCTA indicators included the following components:

1. Determining assumptions
2. Forming conclusions
3. Interpreting information

At this stage, a questionnaire was also conducted among applicants, which involved highlighting the attitude towards learning, highlighting students' feelings towards the STEAM program and identifying their results. The questionnaire used questions using a Likert scale, where it was necessary to give an assessment on a scale from 1 to 5: 1 - completely disagree, 5 - completely agree. The questionnaire consisted of special questions that were developed for Pre-test and Post-test. The educational intervention involved conducting an experiment for 10 weeks within the framework of a model program. The post-test stage involved repeated measurement of the same indicators and conducting similar tests.

Data Analysis

Several software programs were used for data analysis, including Excel and SPSS 28.0. Excel software was chosen due to its ease of use and a wide range of tool capabilities. In addition, this program has a simple interface to use. For the TTCT test, each indicator of fluency (number of ideas), flexibility, and

originality was determined on a scale from 1 to 10. After that, the average value for each participant is displayed. Then, the sum of the scores from all indicators was used to determine the overall level of creative abilities of the student. This result is compared before and after the educational intervention.

In addition, for the analysis of WGCTA, each task in the test received 1 point for a correct answer. The overall result was measured as the average value of correct answers for each student. The study used the t-test for independent samples and ANOVA. The latter instrument allowed for the analysis of differences between groups according to individual criteria. In general, the comparison is made between the initial and final results within and between groups, with subsequent interpretation of the changes.

Results and Discussion

Design thinking is one of the most important tools that can help develop creativity, critical thinking, and social skills. This approach is important because it involves focusing on solving complex and, at the same time, real problems through empathy, ideation, prototyping, and testing solutions.

In the education system, design thinking involves stimulating students not just to master knowledge, but to generate creative ideas, and ensures the development of social skills in teamwork and evaluation of their own results and actions.

Accordingly, the use of this approach in the STEAM program made it possible to test the extent to which this approach affects not only the development of creativity but also the formation of critical thinking skills and soft skills. In particular, the dynamics of changes in students' attitudes became noticeable. An analysis of the Torrance Test of Creative Thinking results revealed some improvement in the levels of fluency, flexibility, and originality. However, the highest increase was observed in the fluency of thinking. In particular, +7.2 points were obtained, $p < 0.01$. This indicates an improvement in the ability to generate ideas quickly. Such data are directly related to the use of the ideation phase in design thinking, in which students had the opportunity to experiment directly without fear of error. At the same time, the originality indicator (assessment of non-standard ideas) also increased, although less dynamically. This indicator demonstrates the need for more time to develop “intellectual courage” in the thinking of modern students. Table 2 shows the results of the TTST test.

Table 2.
TTCT indicators: pre-test, post-test, and changes (experimental group)

Indicator (TTCT)	Before the experiment Pre-test	After the experiment Post-test	Δ(Change)	p-value
Fluency	12,3	19,5	+7,2	< 0.01
Flexibility	10,7	16,4	+5,7	< 0.05
Originality	8,6	13,1	+4,5	< 0.05

Source: Author’s development

These data showed that structured thinking through the design thinking approach influences the activation of qualitative aspects of creativity. In particular, students began to formulate non-obvious and original solutions.

The results of the Watson-Glaser test also showed dynamics in the skills of forming assumptions, aggregates, and explaining information. The growth in these skills is statistically significant ($p < 0.05 - 0.01$). In addition, to assess the impact of design thinking implementation on creative and analytical thinking indicators in the experimental group, a repeated measures ANOVA was conducted on TTCT indicators (See Table 3).

Table 3.
Results of Repeated Measures ANOVA for TTCT indicators

Indicator (TTCT)	F(1,25)	p-value	Effect (η^2)
Fluency	56.8	< 0.001	0.70
Flexibility	45.3	< 0.001	0.64
Originality	42.1	< 0.001	0.63

Source: Author's development

Thus, ANOVA showed statistically significant changes between pre- and post-test results for all three TTCT indicators: Fluency, Flexibility, and Originality of creative thinking. This indicates the effectiveness of the implemented design thinking training module in developing students' creative abilities. At the same time, changes in the area of interpretation are noticeable (+2.3 points).

In general, this indicates an improvement in the skills of data analysis, drawing conclusions and supporting statements, which are key components of scientific literacy. Thus, the stages of testing and revising ideas in projects provided by design thinking have become an important catalyst for analytical growth. Table 3 shows the results of the Watson-Glaser test (See Table 4).

Table 4.
WGCTA indicators: pre-test, post-test, and changes (experimental group)

WGCTA indicator	Before the experiment Pre-test (M ± SD)	After the experiment Post-test (M ± SD)	Δ(Change)	p-value
Recognizing assumptions	9,1 ± 2,1	11,3 ± 1,8	+2,2	$p < 0.05$
Building arguments	6,4 ± 1,9	8,2 ± 2,0	+1,8	$p < 0.05$
Interpreting information	7,8 ± 1,7	10,1 ± 1,5	+2,3	$p < 0.01$

Source: Author's development

Also, in order to determine the impact of the educational intervention on the development of students' analytical thinking, a repeated measures ANOVA was conducted on three key indicators of the Watson-Glaser Critical Thinking Appraisal (WGCTA). Such indicators as recognizing assumptions, constructing arguments, and interpreting information were taken into account (see Table 5).

Table 5.
Results of Measures ANOVA for WGCTA indicators (n=26)

WGCTA indicator	F(1,25)	p-value	Effect (η^2)
Recognizing assumptions	8.5	0.007	0.25
Building arguments	7.2	0.012	0.22
Interpreting information	12.3	0.002	0.33

Source: Author's development

As can be seen from Table 5 the ANOVA data indicate a statistically significant effect of the educational module on the development of students' analytical thinking. Improvements in all three WGCTA indicators - recognizing assumptions ($F(1,25) = 8.5$, $p = 0.007$), constructing arguments ($F(1,25) = 7.2$, $p = 0.012$) and interpreting information ($F(1,25) = 12.3$, $p = 0.002$) - are significant. The strongest effect was recorded for interpreting information ($\eta^2 = 0.33$), indicating a significant increase in analytical skills due to the use of design thinking.

Qualitative data analysis

The results of a questionnaire using a Likert scale (1-5) showed that after the program was implemented,

students' teamwork skills and motivational attitude increased significantly. In addition, the skills of expressing interest in STEAM subjects have also improved significantly (+1.3). In addition, the use of the design thinking approach led to an improvement in the level of belief in the use of one's own knowledge (+1.5). Such data are particularly critical because they determine the impact of the program not only on the cognitive but also on the affective and communicative sphere. However, it is worth noting that such skills were not formed in an isolated way, but in the process of educational communication or interaction. In general, this coincides with the modern interpretation of the competency-based approach in the educational system. Table 6 shows indicators of the level of change in motivational attitudes toward STEAM.

Table 6.
Mean scores for motivation and attitude toward STEAM (experimental group)

Indicators	Before intervention Pre-test	After the intervention Post-test	Δ(Change)
Interest in STEAM subjects	3,1	4,4	+1,3
Practicality of knowledge	2,9	4,2	+1,3
Belief in the applicability of knowledge	3,0	4,5	+1,5

Source: Author's development

At the same time, there is a noticeable small dynamic in the area of self-assessment of communication skills. The results of the questionnaire using the Likert scale (1–5) showed that after the implementation of the program, students had a noticeable increase in teamwork skills (+1.4 points). As a result of this program, students began to interact more actively and take responsibility. In addition, there is a noticeable activity in discussing ideas and presenting them. Such aspects affect the formation of an effective learning environment that is open and tolerant of the expression of different ideas. Table 7 shows the indicators of the development of group interaction and communication skills.

Table 7.
Self-Assessment of Group Interaction and Communication Skills (Experimental Group)

Skills	Before intervention Pre-test	After the intervention Post-test	Δ(Change)
Understanding others	3,3	4,2	+0,9
Openness to ideas, lack of fear of expressing opinions	2,8	4,0	+1,2
Working in a group and valuing others	3,0	4,3	+1,3
Teamwork	3,1	4,5	+1,4
Formulation of opinions	2,9	4,2	+1,3
Conflict resolution	2,7	3,9	+1,2

At the same time, self-assessment of social skills also improved significantly. In particular, the fact that students improved their teamwork skills is evidenced by a score increase of +1.3 points. In addition, a small dynamic was recorded in the skills of resolving conflict situations and developing leadership.

To determine the impact of the educational intervention between the experimental (n=26) and control (n=26) groups, a t-test for independent samples was used, in particular, taking into account such indicators as fluency from TTCT, analytical thinking from WGCTA and motivational aspect from the questionnaire. All selected indicators showed significant changes in the experimental group. In general, this indicates a positive impact of design thinking in the system of developing creative and analytical thinking. In addition, the impact on motivation to learn is also noticeable. Table 8 presents data for comparison between both groups. These data confirmed the effectiveness of the intervention. Analysis of current empirical data shows that the introduction of design thinking elements into the STEM curriculum contributes to a deeper interest of schoolchildren in technical and engineering directions. As part of the experiment implemented in secondary education institutions oriented to the standards of the National Secondary School, more than 60% of students who participated in STEM projects with design thinking components expressed their

intention to choose professions related to IT, engineering, biotechnology or digital arts. Among 7th grade students, the potential of STEM education to support orientation toward STEM careers became particularly visible during real-world project work. These activities helped learners connect school content with possible future professions.

In addition to the quantitative and qualitative changes in thinking and communication, attention should also be paid to the career guidance potential of the proposed approach. The involvement of pupils in modelling real-life problems, teamwork, and the stages of generating and testing solutions within the design thinking format in the context of STEAM education enabled participants not only to acquire interdisciplinary knowledge but also to collaborate in environments resembling professional settings. Pupils assumed specific functional roles, including: the researcher, who formulates problems and conducts observations; the developer, who creates technical or technological solutions; the analyst, who interprets data and tests hypotheses; the designer, who generates visual or structural concepts; the manager or facilitator, who is responsible for planning and coordinating teamwork; and the presenter or communicator, who delivers the project outcomes. This experience not only enhanced educational motivation but also contributed to the formation of an understanding of possible directions for future professional careers.

Table 8.
Comparative Analysis of Experimental and Control Groups: Impact of the Intervention

Indicator	Experimental group Δ	Controol group Δ	p-value
TTCT (fluency)	+7,2	+1,1	< 0.01
WGCTA (analytical thinking)	+2,3	+0,5	< 0.05
STEAM motivation	+1,3	+0,4	< 0.01

Therefore, as can be seen from Table 7, these indicators show that the use of the modern approach of design thinking in STEAM education serves as a significant tool for the development of cognitive and metacognitive skills. In addition, it influences the formation of elements of reflective thinking, better interaction between students and other participants in the educational process, and responsibility. At the same time, as can be seen from the final table, the control group showed only minor changes. This demonstrates the importance of using specialized teaching methods, including design thinking, to realize significant improvements.

The modern development of educational areas has actualized interest in STEAM education as an important component of modernity. Together with the latest methods, including design thinking, this trend can have a real impact on the quality of education, its structure and organization. The purpose of the proposed article is to study design thinking in STEAM education curricula, to evaluate the effectiveness of such educational practices in terms of developing the key competencies of students. The realization of this goal involves answering questions related to the use of design thinking in STEAM education influences the development of students' creative thinking, the introduction of design thinking for analytical thinking and motivation of students to study STEAM disciplines, the search for statistical differences in the levels of creativity and analytical thinking between those students who studied in traditional training programs and those who studied in a model program with design thinking.

The results indicated a positive impact of design thinking on the development of students' creative thinking. After completing the program, a statistically significant increase in all three indicators of creativity was recorded. For instance, fluency improved by an average of 7.2 points ($p < 0.01$). This indicated an increase in the ability to generate a large number of ideas. Flexibility increased by 5.7 points ($p < 0.05$), which indicates the development of the ability to change the approach to solving problems. Originality improved by 4.5 points ($p < 0.05$), which demonstrates an increase in the ability to formulate non-standard solutions. Analysis of the results of Repeated Measures ANOVA confirmed the high statistical significance of the intervention effect on all three indicators ($p < 0.001$). The values of the η^2 effect range from 0.63 to 0.70,

which indicates a large effect according to Cohen's classification. A particularly strong effect was observed for fluency ($\eta^2 = 0.70$), suggesting a significant increase in the overall level of students' creative productivity. These results are consistent with previous studies that have demonstrated the effectiveness of design thinking as a method of stimulating creative potential in the educational process (Soto et al., 2024). The increase in creativity indicators can be explained by the involvement of students in open-ended tasks, teamwork, finding non-standard solutions and creating prototypes, which are characteristic features of design thinking (Malele & Ramaboka, 2020).

The results of the analysis indicate the presence of statistically significant changes between the initial and final measurements for all three indicators. In particular, an improvement in the ability to recognize assumptions was found at $F(1,25) = 8.5$, $p = 0.007$, $\eta^2 = 0.25$, which indicates an average strength of the effect. Positive dynamics were also recorded for the argument construction indicator ($F(1,25) = 7.2$, $p = 0.012$, $\eta^2 = 0.22$), which allows us to speak about the development of logical thinking and argumentation. The highest level of statistical significance was found for the information interpretation indicator ($F(1,25) = 12.3$, $p = 0.002$, $\eta^2 = 0.33$), which indicates a significant positive impact of the educational intervention on students' ability to analyze data, draw conclusions and justify judgments.

Thus, this indicates the importance of using the design thinking methodology in the educational process as a tool for the formation and development of the analytical components of students' critical thinking. The effect indicators (η^2) demonstrate that the intervention had not only statistical significance, but also a noticeable pedagogical value, in particular in the context of implementing a competency-based approach in education. The proposed results show that the use of design thinking in the STEM program had an impact on the development of creativity, soft skills, and critical thinking skills. The ability to generate ideas quickly has improved significantly, which is directly related to the use of the ideation phase in design thinking, in which students had the opportunity to experiment directly without fear of error. At the same time, the originality indicator (assessment of non-standard ideas) also increased, although less dynamically. The obtained indicators made it possible to summarize that structured thinking using the design thinking approach affects the activation of qualitative aspects of creativity. Students began to formulate non-obvious and original solutions. The results confirmed the findings of other researchers who used empirical methods to measure progress in the development of creativity, critical thinking, and communication skills (Gerardou et al., 2022; Panergayo & Prudente, 2024). Therefore, design thinking is an effective tool for developing such creative skills, as also emphasized by Wilson et al. (2021). Perignat & Katz-Buonincontro (2019) noted the same effect, but in the context of the humanities. Accordingly, the importance of design thinking in the development of STEAM education is obvious.

The final issue was the development of analytical thinking, motivation, and teamwork. In particular, the dynamics in the skills of forming assumptions, making arguments, and explaining information were also evidenced. The results indicated an improvement in the skills of data analysis, drawing conclusions, and supporting claims, which are key components of scientific literacy. For this reason, the reworking of ideas in projects through design thinking became an important catalyst for analytical growth. The results of the survey also showed that the use of the design thinking approach improved the level of belief in the use of one's own knowledge, which is especially critical not only in terms of cognitive but also in terms of affective, communicative, and motivational areas. However, the dynamics in the growth of self-assessment of communication skills was determined to be small. The results obtained are generally consistent with other indicators demonstrated by researchers analyzing the emotional and cognitive components of design thinking (Boakes, 2020; Ozkan & Umdu Topsakal, 2021). At the same time, we should agree with those researchers who have pointed out the need for appropriate teacher qualification that would allow students to fully realize their potential (Conradty & Bogner, 2020; Tsakeni, 2024). Therefore, further training and self-development of teachers is an important aspect of the further evolution of design thinking.

The proposed results determine the impact of the educational intervention between the experimental and control groups. Thus, all selected indicators showed significant changes in the experimental group. In general, this indicates the positive impact of design thinking in the system of developing creative and analytical thinking. In addition, the impact on motivation to learn is also noticeable. The results confirmed

the findings of other researchers that design thinking is an important component of the modern educational paradigm (Graham, 2020; Leavy et al., 2023). Henriksen et al. (2019) determined that the future of STEAM education is extremely closely linked to innovative teaching methods, including the development of design thinking. Some scholars have also emphasized the gender aspect of the problem, pointing out that in more traditional societies, the use of the latest pedagogical methods will help overcome existing biases (Kijima et al., 2021). Without denying this possibility, it is worth pointing out that such theses will require additional empirical confirmation.

The methodology used in the study has its limitations, which should be considered in the future when interpreting the results. First of all, the Likert scale is based on respondents' personal experience, which makes this survey rather subjective, as some respondents may have found it difficult to distinguish between the average and higher levels, the middle and lower levels during the assessment. Accordingly, some of the analyzed data may be subject to slight correction, which, however, does not affect the overall assessments of the respondents expressed in the survey.

Conclusions

Therefore, the modern development of education relates to STEAM and design thinking. Thus, the use of design thinking in a STEAM program has had a positive impact on the development of creativity, soft skills, and critical thinking skills. The ability to generate ideas quickly has improved significantly, which is directly related to the use of the ideation phase in design thinking, in which students had the opportunity to experiment directly without fear of error. The study also found that design thinking, when applied within STEAM education, may significantly influence students' career orientation. Through working on real-world tasks, collaborating in groups, building prototypes, and testing their ideas, students had the chance to take on different functional roles – such as engineer, analyst, designer, researcher, or facilitator. This experience often led to greater motivation, a clearer sense of personal interests, and in many cases helped students start to form an initial understanding of possible professional directions. In the context of the New Ukrainian School and in line with the Concept for the Development of STEM Education in Ukraine, this aspect of design thinking appears especially relevant as it supports the process of conscious professional self-determination that can begin during general secondary education.

The calculations showed a consistent positive trend in the skills of forming assumptions, aggregates, and explaining information. This demonstrated an improvement in the skills of data analysis, drawing conclusions, and supporting statements, which are key components of scientific literacy. For this reason, the reworking of ideas in projects through design thinking became an important catalyst for analytical growth. The results of the survey also showed that the use of the design thinking approach improved the level of belief in the use of one's own knowledge, which is especially critical not only in terms of cognitive but also in terms of affective, communicative, and motivational areas. However, the dynamics in the growth of self-assessment of communication skills is determined to be small.

The results clearly demonstrate the impact of the training intervention between the experimental and control groups. Thus, all selected indicators showed significant changes in the experimental group. In general, this indicates the positive impact of design thinking in the system of developing creative and analytical thinking.

This study also revealed the following areas that will require further study in the future. In particular, more attention should be paid to identifying the core competencies that students develop because of actively using the design thinking approach in STEAM. At the same time, teacher training has become an important aspect. Future research should focus on a detailed analysis of the conditions that teachers need to effectively and successfully implement design thinking in STEAM. In this sense, it is also necessary to determine which core training programs are most effective for modern teachers.

Thus, design thinking within STEAM education should be seen not only as a tool for enhancing creativity and analytical thinking, but also as a strategic component of modern career guidance, enabling students to make conscious and motivated choices about their future professional paths.

Bibliographic references

Aswan, D. M., Aina, M., & Natalia, D. (2024). The effectiveness of Project-Based Learning to improve critical thinking skills. *Journal of Science Education Research*, *10*(12), 10316–10320. https://doi.org/10.29303/jppipa.v10i12.6410

Avendano-Uribe, B. E., Lombana-Bermudez, A., Flórez, L. V., Chaparro, E., Hernandez-Morales, A. C., Archbold, J., Buitrago-Casas, J. C., & Porras, A. M. (2022). Engaging Scientific Diasporas in STEAM Education: The Case of Science Clubs Colombia. *Frontiers in Research Metrics and Analytics*, *7*. https://doi.org/10.3389/frma.2022.898167

Bachynskyi, O.-S. (2024). Mechanism for the Formation and Implementation of HR Policy: The Global Experience. *Futurity of Social Sciences*, *2*(2), 62–78. https://doi.org/10.57125/FS.2024.06.20.04

Bascopé, M., Reiss, K., Morales, M., Robles, C., Reyes, P., Ismael Duque, M., & Andrade, J. C. (2020). Latin American STEM Policy. In *Handbook of Research on STEM Education* (pp. 443–458). Routledge. https://doi.org/10.4324/9780429021381-41

Boakes, N. J. (2020). Cultivating design thinking of middle school girls through an origami STEAM project. *Journal for STEM Education Research*, *3*, 259–278. https://doi.org/10.1007/s41979-019-00025-8

Conradty, C., & Bogner, F. X. (2020). STEAM teaching professional development works: effects on students' creativity and motivation. *Smart Learning Environments*, *7*(1). https://doi.org/10.1186/s40561-020-00132-9

Cook, K. L., & Bush, S. B. (2018). Design thinking in integrated STEAM learning: Surveying the landscape and exploring exemplars in elementary grades. *School Science and Mathematics*, *118*(3-4), 93–103. https://doi.org/10.1111/ssm.12268

Culén, A. L., & Gasparini, A. A. (2019). STEAM education: Why learn design thinking? In *Promoting Language and STEAM as Human Rights in Education* (pp. 91–108). Springer Singapore. https://doi.org/10.1007/978-981-13-2880-0_6

Czyż, A., & Svyrydenko, D. (2019). Science Education as a Response to the Needs of the Modern Open "Education for Everyone" System. *Future Human Image*, *11*, 14–21. https://doi.org/10.29202/fhi/11/2

Gavari-Starkie, E., Espinosa-Gutiérrez, P.-T., Lucini-Baquero, C., & Pastrana-Huguet, J. (2024). Importance of STEM and STEAM Education for Improvement of the Land in the RURAL Environment: Examples in Latin America. *Land*, *13*(3), 274. https://doi.org/10.3390/land13030274

Gerardou, F. S., Meriton, R., Brown, A., Moran, B. V. G., & Bhandal, R. (2022). Advancing a design thinking approach to challenge-based learning. In *The emerald handbook of challenge based learning* (pp. 93–129). Emerald Publishing Limited. https://doi.org/10.1108/978-1-80117-490-920221005

Gevorgyan, S. (2024). The Use of Adaptive Learning Technologies in e-Learning for Inclusive Education: A Systematic Review. *E-Learning Innovations Journal*, *2*(1), 90–107. https://doi.org/10.57125/ELIJ.2024.03.25.05

Graham, M. A. (2020). Deconstructing the Bright Future of STEAM and Design Thinking. *Art Education*, *73*(3), 6–12. https://doi.org/10.1080/00043125.2020.1717820

Henriksen, D., Mehta, R., & Mehta, S. (2019). Design Thinking Gives STEAM to Teaching: A Framework That Breaks Disciplinary Boundaries. In *STEAM Education* (pp. 57–78). Springer International Publishing. https://doi.org/10.1007/978-3-030-04003-1_4

Khan, S. A., Nadim, M. A., & Poletti, G. (2025). Towards a new paradigm of steam in primary education as a 21st century skill. In *19th international technology, education and development conference* (pp. 750–758). IATED. https://doi.org/10.21125/inted.2025.0283

Kijima, R., Yang-Yoshihara, M., & Maekawa, M. S. (2021). Using design thinking to cultivate the next generation of female STEAM thinkers. *International Journal of STEM Education*, *8*(1). https://doi.org/10.1186/s40594-021-00271-6

Kudria, O., Skovronskyi, B., Marushchak, O., Honcharova, N., & Sipii, V. (2024). The role of innovative techniques in development of stem-education in Ukraine. *Academia*, *35-36*, 132–155. https://pasithee.library.upatras.gr/academia/article/view/5006

Leavy, A., Dick, L., Meletiou-Mavrotheris, M., Paparistodemou, E., & Stylianou, E. (2023). The prevalence and use of emerging technologies in STEAM education: A systematic review of the literature. *Journal of Computer Assisted Learning*, *39*(4), 1061–1082. https://doi.org/10.1111/jcal.12806

Liao, C. (2019). Creating a STEAM map: A content analysis of visual art practices in STEAM education. In *STEAM Education* (pp. 37–55). Springer International Publishing. https://doi.org/10.1007/978-3-030-04003-1_3

Malele, V., & Ramaboka, M. E. (2020). The Design Thinking Approach to students STEAM projects. *Procedia CIRP*, *91*, 230–236. https://doi.org/10.1016/j.procir.2020.03.100

Meadows, C. J. (2024). What to learn and how, for this new age. In *Disrupting and Design Thinking Education* (pp. 41–57). Routledge. https://doi.org/10.4324/9781003340713-4

Nedermeijer, J. (2023). Design Thinking. In *Evidence-Based Blended and Online Learning* (pp. 280–283). BRILL. https://doi.org/10.1163/9789004681774_020

Nikolenko, K., Poperechna, G., Diatlova, I., Kvitkin, P., & Hrytsenko, A. (2024). Philosophical and psychological foundations of social responsibility and ethics. *Futurity Philosophy*, *3*(3), 95–113. https://doi.org/10.57125/fp.2024.09.30.06

Panergayo, A. A. E., & Prudente, M. S. (2024). Effectiveness of design-based learning in enhancing scientific creativity in STEM education: A meta-analysis. *International Journal of Education in Mathematics Science and Technology*, *12*(5), 1182–1196. https://doi.org/10.46328/ijemst.4306

Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity*, *31*, 31–43. https://doi.org/10.1016/j.tsc.2018.10.002

Pratiwi, A. N., Aisyah, N., Somakim, S., & Kamran, M. (2023). STEM-based approach: A learning design to improve critical thinking skills. *Al-Jabar Journal of Mathematics Education*, *14*(1), 225–237. https://doi.org/10.24042/ajpm.v14i1.18054

Preston, J. (2024). Design thinking. In *Owning Your Project-Based Learning* (pp. 97–114). Routledge. https://doi.org/10.4324/9781003431848-9

Ozkan, G., & Umdu Topsakal, U. (2021). Exploring the effectiveness of STEAM design processes on middle school students' creativity. *International Journal of Technology and Design Education*, *31*(1), 95–116. https://doi.org/10.1007/s10798-019-09547-z

Seitenova, S., Khassanova, I., Khabiyeva, D., Kazetova, A., Madenova, L., & Yerbolat, B. (2023). The effect of STEM practices on teaching speaking skills in language lessons. *International Journal of Education in Mathematics Science and Technology*, *11*(2), 388–406. https://doi.org/10.46328/ijemst.3060

Soto, P., López, V., Bravo, P., Urbina, C., Báez, T., Acum, F., Ipinza, R., Venegas, J., Jeldes, J. C., González, C., Lepe, S., & González, J. (2024). Towards a gendered STEAM education approach: building a comprehensive model to strengthen girls' and students with non-conforming gender identities' STEAM trajectories in Chilean public schools. *London Review of Education*, *22*(1). https://doi.org/10.14324/lre.22.1.06

Tsakeni, M. (2024). Exploring design principles for STEAM learning activities development by science and technology teachers. *Educational Research for Social Change*, *13*(1), 85–106. https://doi.org/10.17159/2221-4070/2024/v13i1a6

Unterfrauner, E., Addis, A., Fabian, C. M., & Yeomans, L. (2024). STEAM education: The claim for socially innovative practices. *Creativity and Educational Innovation Review*, *8*, 71–98. https://doi.org/10.7203/creativity.8.29743

Wilson, H. E., Song, H., Johnson, J., Presley, L., & Olson, K. (2021). Effects of transdisciplinary STEAM lessons on student critical and creative thinking. *The Journal of Educational Research*, *114*(5), 445–457. https://doi.org/10.1080/00220671.2021.1975090

Yüksel, A. O. (2025). Design-based STEM activities in teacher education and its effect on pre-service science teachers' design thinking skills. *Journal of Science Education and Technology, 34*, 904–918. https://doi.org/10.1007/s10956-025-10215-2