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Generative Artificial Intelligence and the Development of Creative Thinking among University Students in Creative Disciplines

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ABSTRACT: The rapid advancement of artificial intelligence (AI) technologies has transformed higher education by expanding opportunities for personalized learning, creative exploration, and digital innovation. Despite growing interest in AI in education, limited research has examined its role as a pedagogical tool for developing students' creative thinking, particularly within creative disciplines and in emerging educational contexts. This study investigates the impact of generative artificial intelligence tools on the development of creative thinking among students of creative specialties in higher education institutions in Kazakhstan. Drawing on theories of divergent thinking and creativity, the research adopts a mixed-methods design integrating quantitative and qualitative approaches to examine how AI-supported learning influences students' fluency, flexibility, originality, and elaboration of ideas. The study involved the use of generative AI tools, including ChatGPT, Midjourney, DALL-E, and AIVA within the educational process of students in creative disciplines. The findings demonstrate positive changes in key dimensions of creative thinking, particularly in idea fluency, cognitive flexibility, and originality, when AI tools are integrated with structured pedagogical guidance and reflective learning activities. At the same time, the results indicate that the effectiveness of AI depends on meaningful pedagogical mediation, as unstructured use may encourage superficial creative engagement. The study contributes to the literature by positioning artificial intelligence not merely as a technological innovation but as a cognitive and pedagogical partner that can support the development of higher-order creative competencies. Furthermore, the research expands empirical understanding of AI integration in the context of Kazakhstan's higher education system and provides practical implications for the design of AI-supported creative learning environments in developing educational systems.

Keywords: Artificial intelligence, Creative thinking, Generative AI, Higher education, Digital pedagogy.

I. INTRODUCTION

In the context of the digital transformation of society and the rapid development of information technology, artificial intelligence (AI) is becoming one of the key factors in the modernization of educational systems. Modern artificial intelligence technologies are actively used to personalize learning, automate the assessment of academic achievements, support independent learning activities of students and develop skills of the 21st century. In recent years, special attention has been paid by researchers to the possibilities of using AI in higher education, where it is considered not only as a technological tool, but also as a means of pedagogical support

that promotes the development of critical and creative thinking of students. The concept of artificial intelligence was first introduced by John McCarthy in 1956 at the Dartmouth Conference, which initiated the systematic scientific study of intelligent machines. McCarthy considered intelligence as the computational ability of a system to achieve goals in a complex environment [1]. Further development of the theoretical foundations of AI is associated with the works of G. Simon and A. Newell, who considered intelligent systems as models of human cognition and problem solving [2]. These studies have formed the foundation for the development of modern intelligent systems, including neural networks, machine learning, and generative algorithms.

In recent decades, artificial intelligence has begun to actively integrate into the field of art and creative industries. One of the first examples of such interaction was the AARON system, developed by artist Harold Cohen, which allowed algorithmically generating artistic images [3]. Later, the development of generative algorithms led to the emergence of more complex systems, such as DeepDream, Midjourney, and DALL-E, capable of creating visual and multimedia works based on text descriptions. These technologies have significantly expanded the possibilities of the creative process and have become the subject of active scientific discussion.

Modern research shows that artificial intelligence can act not only as an automation tool, but also as a cognitive partner supporting the processes of idea generation and creative search. In this context, theories of creativity developed within the framework of educational psychology are of particular importance. According to the concept of divergent thinking by J. Gilford, creativity is manifested through the ability to generate many original solutions and alternative ideas [4]. In turn, the component model of creativity is Amabile emphasizes the role of three key factors: subject knowledge, creative skills, and motivation [5]. The use of intelligent technologies can contribute to the development of these components, acting as a tool to stimulate ideas and expand the cognitive space of creativity.

Despite the active development of research in the field of artificial intelligence in education, most of the work focuses on the technological aspects of AI implementation or on the analysis of digital literacy of students. Much less attention is paid to the study of AI as a pedagogical tool for the purposeful development of students' creative thinking, especially in the context of higher education of a creative profile. Against the background of these changes, the question of the role of AI becomes particularly relevant not as a competitor to humans, but as a tool that promotes the development of creative thinking among students. In the educational context, AI is increasingly viewed not only as an object of study or an auxiliary automation tool, but also as a cognitive partner that expands students' creative abilities. This is especially important for the preparation of students of creative specialties, for whom the development of creative thinking, imaginative flexibility, originality and the ability to interdisciplinary synthesis is a key professional competence.

There is an increase in research in the global scientific literature on the use of AI in education, including an analysis of its impact on student motivation, personalization of learning, and the formation of 21st century skills. At the same time, a significant part of the work focuses either on the technical aspects of AI application, or on assessing the creative abilities of students as a result of the educational process. Significantly less attention is paid to the consideration of artificial intelligence as a pedagogical tool for the purposeful development of students' creative thinking, especially in the context of higher education of a creative profile.

In the Kazakh higher education system, this problem is gaining additional importance in connection with the implementation of state programs for digitalization, modernization of educational content and orientation towards the formation of competitive human capital. Despite the existence of separate studies on digital technologies in education, the issues of integrating AI into the educational process of universities in Kazakhstan in order to develop creative thinking among students of creative specialties remain insufficiently developed and require theoretical understanding and pedagogical concretization. In this regard, the necessity of scientific analysis of the potential of artificial intelligence as a tool for developing creative thinking of students of creative specialties in the conditions of higher education in Kazakhstan is actualized. Of particular interest is the identification of those AI capabilities that can stimulate the generation of ideas, variability of thinking, reflection and creative independence of students, without replacing a person's own creative activity.

In the Kazakh higher education system, this issue is becoming more relevant in connection with the implementation of state programs for digitalization and modernization of the educational environment.

Strategic documents for the development of education emphasize the need to form innovative and creative human capital capable of working effectively in the digital economy. However, research on the pedagogical integration of artificial intelligence into the educational process of Kazakh universities remains limited, which creates a scientific gap in this field. Thus, there is a need to explore the possibilities of using artificial intelligence as a pedagogical tool for developing creative thinking among students of creative specialties in higher education.

At the same time, existing studies show mixed results, which requires a more critical analysis. Thus, a number of empirical studies show that the use of generative models of artificial intelligence contributes to an increase in the number of ideas and an acceleration of the conceptualization stage [6], while other studies indicate the risk of reducing the depth of cognitive processing and formalization of creative activity in the absence of pedagogical support [7]. Similarly, research in the field of art education demonstrates that AI can stimulate experimentation and variability of solutions, but it does not always lead to increased originality at the conceptual level, especially in conditions of insufficient reflection on the part of students. Thus, in modern scientific literature, there is a contradiction between the potential of artificial intelligence as a tool for expanding creativity and the risks of its superficial use, which emphasizes the need for a pedagogically sound integration of AI into the educational process. In the context of global research in the field of AI in education, this study is positioned as an empirical attempt to overcome existing limitations through the use of mixed research design (mixed-methods), which allows not only to record quantitative changes in indicators of creative thinking, but also to identify the mechanisms of their formation. Unlike most studies that focus on either technological aspects or general educational effects, this study focuses on specific components of creative thinking (fluency, flexibility, originality, and sophistication), which allows for a more accurate assessment of the impact of AI tools.

The study is particularly important for its implementation in the context of higher education in Kazakhstan. Unlike the educational systems of countries with a high level of digital maturity, where the integration of AI is already systemic, Kazakhstan's higher education system is at the stage of active digital transformation. This creates unique conditions for monitoring the process of introducing innovative technologies in dynamics, as well as for identifying pedagogical factors that affect the effectiveness of their use. In addition, the specifics of the preparation of students of creative specialties in Kazakhstan, combining traditional artistic approaches and modern digital practices, allows us to consider this context as a model of a transitional educational space, in which both the advantages and limitations of using artificial intelligence in the development of creative thinking are particularly pronounced. Thus, the scientific contribution of this study is not only to expand the empirical base of research in the field of AI in education, but also to identify pedagogical conditions for the effective integration of artificial intelligence into the educational process in the context of developing educational systems, which is important for the international scientific community.

The purpose of this study is to theoretically substantiate and empirically verify the possibilities of using artificial intelligence technologies in the educational process of the university for the development of creative thinking of students of creative specialties.

To achieve this goal, the following research objectives were formulated:

- to analyze modern scientific approaches to understanding the creative potential of artificial intelligence;
- consider artificial intelligence as a pedagogical tool in the higher education system;
- to determine the directions of using AI for the development of creative thinking of students of creative specialties;
- to empirically assess the impact of using AI tools on the indicators of students' creative thinking.
- In accordance with the theoretical foundations of the study, the following hypotheses were formulated:
- H1 the use of artificial intelligence tools in the educational process helps to increase students' thinking fluency.
- H2: The use of AI tools increases the flexibility of students' thinking, expressed in the variety of solutions offered.
- H3: The use of generative models helps to increase the originality of students' ideas.

- H4: The use of AI contributes to the development of students' ability to modify and further develop initial ideas.

The scientific novelty of the research lies in the consideration of artificial intelligence not only as a technological phenomenon, but also as a means of pedagogical influence aimed at developing the creative thinking of students of creative specialties. The practical significance of the work lies in the possibility of using the findings in the development of educational programs, training courses and methodological recommendations for the introduction of AI in the educational process of higher education institutions in Kazakhstan. Despite the rapid development of research on the use of artificial intelligence in education, the existing scientific literature demonstrates several significant limitations. Firstly, a significant part of the research focuses mainly on the technological aspects of the introduction of artificial intelligence, such as learning automation, adaptive educational systems and educational data analysis. At the same time, the impact of AI on the development of cognitive and creative abilities of students, especially in the context of artistic and creative education, has been studied in much less detail.

Secondly, most of the existing research is conducted at universities in North America, Western Europe, and East Asia. This creates a certain geographical imbalance in the scientific literature and limits the possibility of generalizing the results for educational systems in other regions. In particular, research on the use of artificial intelligence in the higher education system of Central Asian countries remains extremely limited. Thirdly, existing publications often lack a clear link between the use of specific artificial intelligence tools and the development of individual components of creative thinking. In most cases, creativity is considered as a general educational result, without analyzing such indicators as thinking fluency, flexibility of ideas, originality and elaboration of solutions. In addition, many studies are predominantly descriptive in nature and do not use experimental or quasi-experimental methods, which makes it difficult to identify cause-and-effect relationships between the use of AI and the development of students' creative thinking. Thus, there is a lack of empirical research in the modern scientific literature that:

- analyze the impact of generative artificial intelligence tools on the development of students' creative thinking;
- use mixed research methods (mixed-methods design);
- Consider the educational context of countries with developing digital educational systems.

The present study aims to fill this scientific gap by empirically analyzing the impact of using generative artificial intelligence tools on the development of creative thinking among students of creative specialties in higher education in Kazakhstan.

II. RELATED WORK

Modern research in the field of artificial intelligence and education demonstrates a steady increase in interest in exploring the possibilities of AI as a tool for developing creative thinking. In contrast to early approaches that considered AI primarily as a technical automation tool, modern work increasingly interprets it as a cognitive partner capable of supporting the processes of idea generation and expanding the creative potential of students [5, 8, 9]. The theoretical basis of the analysis is the integration of J. Guilford's theory of divergent thinking and T. Amabile's component model of creativity, according to which creativity is determined by the ability to generate a variety of alternative solutions, show flexibility of thinking and create original ideas [4, 5]. Within the framework of these approaches, artificial intelligence can be considered as a tool that expands the cognitive space of ideas and stimulates divergent thinking through quick access to a variety of alternative solutions.

In recent years, special attention has been paid to generative models of artificial intelligence and their application in educational practice. For example, a study by Dwivedi et al. [6] shows that generative language models can significantly accelerate the process of conceptualization and empower students to generate ideas. Similar results are presented in the work of Z. Yan and T. Qianjun [10], where it was found that the use of AI tools in educational activities leads to an increase in creativity indicators by increasing the variability of solutions and stimulating an experimental approach. Additional empirical data is confirmed by research in the

Kazakh educational context, where the use of AI tools contributes to the development of students' writing skills, reflection and cognitive flexibility [11], as well as improves the quality of educational interaction and confidence of future teachers in the process of professional training [12].

At the same time, a number of studies emphasize that the effectiveness of AI in education depends on the pedagogical design of the educational process. Holmes, Bialik and Fadel [7] note that without methodically verified scenarios for the use of AI, there is a risk of reducing students' cognitive activity and formalizing creative activity. In such conditions, AI can be used as a means of automation, rather than as a tool for developing thinking. Similar findings are presented in the study by Smailova et al. [13], which emphasizes that generative AI is effective only under the condition of its meaningful pedagogical support and integration into the educational process. A systematic review of Q. Xia indicates that most research in the field of artificial intelligence in education is conceptual or descriptive in nature [14]. Despite a significant increase in publications, the number of empirical studies using rigorous experimental or quasi-experimental designs remains limited. This is especially true for research aimed at studying the impact of AI on the development of creative thinking.

A separate area of research is related to the use of AI in creative industries and art education. Z. Yan and T. Qianjun [10] demonstrate that the integration of AI technologies contributes to the development of experimentation with new visual and multimedia forms. In turn, McCormack et al. [15] emphasize that the interaction of humans and AI in the creative process requires a rethinking of the concepts of authorship, originality and the role of the subject of creativity. Practical examples of the integration of AI into creative activity are also presented in the media sphere, where Kazakhstani students are already creating full-fledged AI-generated products, including digital publications [16], which indicates the transformation of traditional forms of creativity under the influence of technology.

From the standpoint of creativity theory, these results can be interpreted through the distinction between combinatorial, exploratory, and transformational creativity. Generative systems effectively support the first two types of creativity, expanding the space of ideas and allowing you to explore new combinations. However, as Boden [8] notes, transformational creativity, associated with the creation of fundamentally new conceptual frameworks, remains primarily a human ability. Despite the significant growth of international research, a number of significant scientific gaps remain in this area.

First, most empirical research is conducted in educational systems in Europe, North America, and East Asia, which limits the possibility of direct extrapolation of the results to other educational contexts [8, 17]. Secondly, there is a lack of research using experimental and quasi-experimental designs to establish causal relationships between the use of AI and the development of creative thinking [8]. Thirdly, there is insufficient evidence in the existing literature of research aimed specifically at students of creative specialties, where creative thinking is a key professional competence [10]. In this context, the research conducted in the higher education system of Kazakhstan is of particular importance. This educational context is characterized by active digital transformation, which creates unique conditions for the introduction of innovative technologies, including artificial intelligence. The analysis of the use of AI in this environment allows not only to expand the empirical base of international research, but also to identify the pedagogical conditions for the effective integration of AI into the educational process.

III. MATERIAL AND METHOD

The methodological basis of the research was the provisions of the theory of creative thinking, the concept of developmental learning, as well as modern approaches to the integration of artificial intelligence technologies into the educational process of higher education. Within the framework of these theoretical approaches, artificial intelligence is considered as a cognitive tool capable of stimulating the processes of idea generation, supporting experimentation with various creative solutions and expanding the space of divergent thinking.

The empirical part of the study was conducted at the Faculty of Professional and Creative Education of Aktobe Regional University named after K.Zhubanov, where educational programs involving a combination

of technological skills and artistic and design activities (design, multimedia, digital technologies and design) are implemented. The choice of this educational environment is due to the fact that vocational and creative education requires the development of not only technical competencies, but also creative thinking as an important component of the professional training of future specialists. The study used a mixed methodological approach (mixed-methods design), combining quantitative and qualitative research methods. The use of mixed design made it possible to simultaneously assess objective changes in the indicators of students' creative thinking and analyze their educational experience of interacting with artificial intelligence tools.

1. DATA COLLECTION

A set of complementary data collection methods was used in the research process. Diagnostic techniques (pre- and post-testing) were used to quantify the level of creative thinking of students before and after the introduction of artificial intelligence tools into the educational process. The survey revealed the students' attitude to the use of AI and their subjective assessment of its impact on creative activity. The analysis of educational products (design projects, visual concepts, multimedia materials) provided an opportunity to assess the quality and originality of the work performed. Students' reflective written reports allowed them to record their individual experience of interacting with AI, and semi-structured interviews contributed to a deeper understanding of students' perception of the role of artificial intelligence in educational activities.

Generative artificial intelligence tools were integrated into the educational process of the experimental group, including ChatGPT (generation of ideas and text concepts), Midjourney and DALL-E (creation of visual solutions), as well as AIVA (development of audiovisual elements of projects). The use of these tools was carried out within the framework of specially developed pedagogical recommendations aimed at developing divergent thinking, originality of solutions and reflective analysis of results.

2. RESEARCH DESIGN

The study used a mixed research design (mixed-methods) combining quantitative and qualitative approaches. The choice of this design is due to the complex nature of the phenomenon being studied, since the development of creative thinking cannot be fully assessed solely through quantitative indicators or only qualitative analysis. The mixed approach made it possible to combine the objective measurement of the dynamics of creative indicators with the analysis of the subjective educational experience of students.

The study employed two primary research methods systematic literature analysis and a pedagogical experiment conducted with students of a professional and creative faculty at a higher education institution in Kazakhstan. In accordance with the research objectives, the first stage involved the selection and analysis of scientific sources related to artificial intelligence in education and creative thinking development. The search was conducted using international databases such as Scopus and Web of Science, focusing on publications from 2020–2025 to ensure the relevance and scientific validity of the theoretical framework. At the second stage, a quasi-experimental pedagogical study was carried out to investigate the impact of artificial intelligence tools on the development of creative thinking among students of creative specialties.

The pedagogical intervention lasted for one academic semester (16 weeks) and consisted of approximately 48 classroom hours. It included a structured system of lectures, workshops, and project-based learning sessions integrating both theoretical and practical components. The theoretical part covered topics such as fundamentals of creative thinking, divergent thinking strategies, and ethical aspects of artificial intelligence in creative industries. The practical component involved AI-supported activities, including idea generation, visual experimentation, rapid prototyping, and reflective evaluation. Students in the experimental group used generative AI tools (ChatGPT, Midjourney, DALL•E, and AIVA) to develop creative projects. Each session incorporated guided reflection and discussion to enhance critical thinking and awareness of AI-generated content. The study was conducted in accordance with ethical standards for educational research. The Ethical Committee of the K. Zhubanov Aktobe Regional University, Kazakhstan has granted approval for this study on 5th of December 2024 (Ref. No. 80-16-2023).

2.1 Research Participants

The study involved 122 undergraduate students enrolled in the 2nd and 3rd years of study in creative-oriented programs (design, multimedia, and digital technologies). Among the participants, 78 were female and 44 were male, with an average age of approximately 20 years. The participants were divided into two groups Experimental Group (EG): 62 students and Control Group (CG): 60 students. Group assignment was based on existing academic cohorts, which corresponds to a quasi-experimental design. Pre-test results confirmed that both groups were comparable in terms of initial levels of creative thinking.

All participants were informed about the purpose and procedures of the study and provided voluntary written informed consent. Participation was anonymous, and all data were processed and stored in aggregated form without personal identifiers.

2.2 Research Procedure and Instruments of Data Collection

The research was conducted in three main stages. At the first stage, a pre-test assessment of students' creative thinking was carried out. The assessment was based on adapted tasks derived from the Guilford Alternative Uses Task (AUT) and Torrance criteria. Four indicators were measured: fluency (number of ideas), flexibility (variety of idea categories), originality, and elaboration (level of detail and development of ideas). At the second stage, the pedagogical intervention was implemented. The experimental group completed creative tasks using AI tools (ChatGPT, Midjourney, DALL·E, AIVA), while the control group performed similar tasks using traditional methods such as brainstorming, sketching, and independent concept development.

The instructional design of the intervention included:

- structured idea generation sessions using AI tools;
- visual concept creation and prototyping;
- iterative refinement of creative projects;
- reflective analysis of AI-generated outputs.

Data collection included:

- quantitative data: results of pre- and post-tests;
- qualitative data: reflective reports, semi-structured interviews, and analysis of creative projects.

Self-assessment was supplemented with instructor evaluation using standardized criteria to ensure objectivity and reduce bias.

At the third stage, a post-test assessment was conducted using the same measurement tools. The results were compared to determine the dynamics of creative thinking development.

2.3 Validity and Reliability Tests

To ensure the validity of the research instruments, content validity was established through expert evaluation by specialists in pedagogy, creative education, and educational technologies. The experts confirmed the alignment between the assessment tools and the theoretical framework of the study. Construct validity was ensured by grounding the measurement model in established theories of creativity, including Guilford's theory of divergent thinking and Amabile's componential model of creativity. The reliability of the quantitative instrument was assessed using Cronbach's Alpha, which yielded a value of $\alpha = 0.82$, indicating a high level of internal consistency. Prior to the main study, a pilot test was conducted with a group of 15 students not included in the final sample. Based on the pilot results, minor adjustments were made to improve clarity and interpretation of tasks.

For qualitative data, reliability was ensured through inter-rater agreement. Coding was performed by two independent researchers, and the Cohen's kappa coefficient was 0.79, indicating substantial agreement. The combination of validated instruments, pilot testing, and triangulation of data sources ensured the robustness, reliability, and scientific credibility of the study. A key element of the research design was the introduction of structured pedagogical scenarios that ensure the reproducibility of research. The educational activities of the students of the experimental group were organized in stages and included the generation of ideas using AI, visual experimentation, prototyping and reflective evaluation of the results. The teacher acted as a facilitator

and methodological coordinator, guiding the students' activities and providing a critical understanding of the results obtained with the help of artificial intelligence.

2.4 Quantitative Research Design

The quantitative part of the study was implemented in the form of a quasi-experimental design with elements of pre- and post-testing. The study participants were divided into experimental and control groups, comparable in basic demographic characteristics, which allowed minimizing the influence of external factors. Before the start of the pedagogical intervention, both groups underwent a pre-test aimed at assessing the initial level of creative thinking. During the semester, students in the experimental group performed creative tasks using artificial intelligence tools, while the control group performed similar tasks using traditional methods (brainstorming, hand sketches, and visual reference search).

After the end of the experimental period, a post-test was conducted, which allowed us to record changes in the indicators of creative thinking. The assessment was based on four key indicators: fluency of ideas, flexibility of thinking, originality of solutions and development of concepts. Statistical data processing included the calculation of mean values (Mean), standard deviation (SD) and comparative analysis of the results of pre- and post-testing. This approach made it possible to identify the dynamics of changes and determine the impact of the use of artificial intelligence on the development of students' creative thinking. To increase the validity of the results, methodological triangulation was used, as well as an expert assessment of the tasks performed by the students.

2.5 Qualitative Research Design

The qualitative component of the research was aimed at an in-depth understanding of the students' educational experience and the specifics of their interaction with artificial intelligence tools. Within the framework of this approach, methods of qualitative pedagogical research were used, including semi-structured interviews, analysis of reflexive written reports and analysis of educational products. Special attention was paid to the study of changes in students' creative thinking strategies, the nature of their interaction with AI, the level of awareness of technology use, as well as the formation of a critical and reflective attitude to the results generated by artificial intelligence.

The development of a conceptual research model is based on modern theories of creative thinking and research on the use of artificial intelligence in education. A number of scientific papers indicate that generative technologies can act as cognitive tools that empower students in the process of generating ideas and creative experimentation [5, 18, 8]. In this paper, it is assumed that the use of artificial intelligence tools in the educational process can contribute to the development of key components of students' creative thinking. The conceptual research model includes three main blocks:

a. Independent Variable

The independent variable of the study is the use of generative artificial intelligence tools within the educational process. The study incorporated several AI-based technologies that support content generation, visual creativity, and multimedia production. These tools included ChatGPT, Midjourney, DALL-E, and AIVA. These technologies were selected due to their relevance to creative educational activities and their capacity to support diverse forms of idea generation and artistic experimentation.

b. Educational Intervention (Learning Process)

The educational intervention involved the systematic integration of artificial intelligence tools into creative learning activities and project-based educational tasks. AI technologies were incorporated as supportive instruments to facilitate students' creative exploration, design development, and reflective analysis throughout the learning process. The intervention included the following learning activities:

- generation of project ideas and concepts;
- development of visual and multimedia solutions;
- creation of prototypes of art and design works;
- analysis and editing of the results.

Through these activities, students engaged in iterative creative processes that combined human creativity with AI-assisted generation and editing capabilities.

c. Dependent Variables

The dependent variables of the study relate to the development of key dimensions of students' creative thinking. The research focused on assessing the extent to which AI-supported learning environments contribute to enhancing the following components:

- fluency of thinking, referring to the ability to generate multiple ideas;
- flexibility of thinking, reflecting the capacity to approach problems from different perspectives;
- originality of ideas, representing the production of novel and unique creative outcomes.
- elaboration of ideas, referring to the ability to expand, refine, and develop ideas in greater detail.

These dimensions were selected based on established creative thinking frameworks and served as the primary indicators for evaluating the educational impact of AI integration on students' creative development.

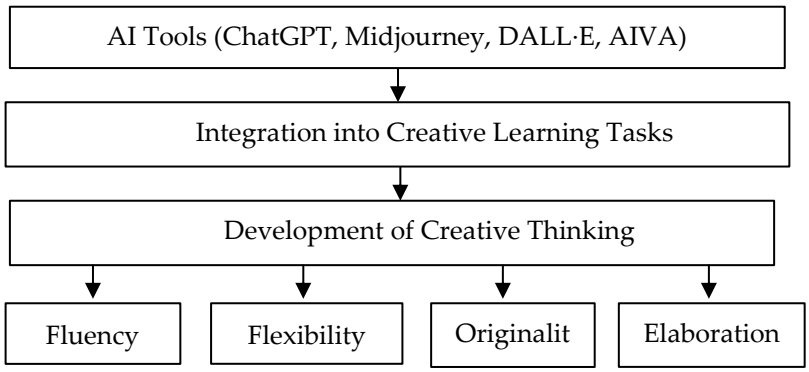

FIGURE 1. Conceptual framework of the study.

Table 1. Creativity indicators and measurement scale.

Creativity Indicator	Description	Measurement Method	Scale
Fluency	Number of ideas generated by a student	Counting ideas proposed during tasks	0–10
Flexibility	Variety of categories of proposed solutions	Expert evaluation of idea diversity	0–10
Originality	Degree of novelty and uniqueness of ideas	Expert assessment of creative originality	0–10
Elaboration	Level of detail and development of ideas	Analysis of project complexity	0–10
Creativity Indicator	Description	Measurement Method	Scale

The final indicator of creative thinking was calculated as the average of all four indicators.

d. Results

Testing Research Hypotheses. The results of the quantitative analysis allowed us to test the hypotheses of the study regarding the impact of using artificial intelligence tools on the development of students' creative thinking.

Table 2. Quantitative results of the experiment.

Creativity Indicator	Control Group (Pre-test)	Control Group (Post-test)	Experimental Group (Pre-test)	Experimental Group (Post-test)	Change (%)
Fluency	4.8	5.2	4.9	6.7	+28%
Flexibility	4.6	5.0	4.7	6.2	+24%
Originality	4.7	5.1	4.8	6.0	+20%
Elaboration	4.5	5.0	4.6	6.5	+32%

Hypothesis testing was conducted to examine the relationships between the study variables and evaluate the impact of artificial intelligence tools on the development of students' creative thinking skills. Statistical methods were applied to determine the significance of the proposed relationships within the conceptual research framework.

- H1: AI tools improve fluency of thinking-The results of the study showed that the average index of thinking fluency in the experimental group increased from 4.9 to 6.7 points, which corresponds to an increase of about 28%. In the control group, the increase was only 8%. Thus, the H1 hypothesis is confirmed.
- H2: AI tools improve flexibility of thinking-The index of flexibility of thinking in the experimental group increased from 4.7 to 6.2 points, which corresponds to an increase of about 24%, while in the control group the increase was only 9%. Therefore, the H2 hypothesis is confirmed.
- H3: AI tools increase originality of ideas-The analysis of the results showed an increase in the index of originality of ideas from 4.8 to 6.0 points in the experimental group (an increase of about 20%). In the control group, the increase was about 7%. This confirms the hypothesis of H3.
- H4: AI tools improve improvement of ideas-The most significant changes were observed in terms of the development of ideas. In the experimental group, the indicator increased from 4.6 to 6.5 points, which corresponds to an increase of about 32%, while in the control group the increase was 11%. Therefore, the H4 hypothesis is confirmed.

The results obtained indicate that the use of generative artificial intelligence technologies in the educational process contributes to the development of key components of students' creative thinking. The most significant changes were revealed in the indicators of fluency and elaboration of ideas, which indicates an expansion of the space for generating creative solutions and an improvement in the ability of students to develop initial ideas. The results obtained are consistent with a number of foreign studies on the use of artificial intelligence in the educational process.

In general, the results of the study confirm the conclusions of Boden [6] that artificial intelligence is able to support the processes of combinatorial and exploratory creativity, but transformational creativity is still a predominantly human ability. Thus, the use of AI in the educational process can be considered as an effective tool for developing students' creative thinking, provided that these technologies are pedagogically integrated into educational activities. The analysis of qualitative data was carried out by the method of thematic analysis, which made it possible to identify key semantic categories reflecting the pedagogical potential of using artificial intelligence. These categories included the expansion of the ideological space, the acceleration of the conceptualization process, the development of critical selection and editing skills, as well as the risks of formal dependence on AI in the absence of pedagogical support. Thus, the use of mixed research design provided a holistic analysis of the impact of artificial intelligence on the development of students' creative thinking and allowed us to consider AI as an effective pedagogical tool in the higher education system.

IV. DATA ANALYSIS

The data analysis was aimed at identifying the impact of using artificial intelligence tools on the development of creative thinking among students of the Faculty of Professional and Creative Sciences. In accordance with the convergent parallel mixed-methods research design, quantitative and qualitative data were analyzed separately, after which they were integrated at the interpretation stage. Methods of descriptive

and inferential statistics were used for quantitative analysis: mean values (M), standard deviations (SD), Student's t-test for independent samples, paired t-test, confidence intervals (95% CI) and effect size (Cohen's d). To assess creative thinking, an adapted version of the tasks based on the Guilford Alternative Uses Task (AUT) and Torrance criteria (fluency, flexibility, originality, and refinement) was used. The reliability of the scale was Cronbach's $\alpha = 0.82$, which indicates a high internal consistency.

1. QUANTITATIVE DATA ANALYSIS

The quantitative analysis was aimed at identifying changes in the level of creative thinking of students of the professional and creative faculty under the influence of the use of artificial intelligence tools, as well as at establishing statistically significant differences between the experimental and control groups. The analysis was based on pre- and post-test data using descriptive and inferential statistics methods, including the calculation of averages (M), standard deviations (SD), Student's t-test, significance level (p), confidence intervals (95% CI), and effect size (Cohen's d).

In the experimental group, students performed creative tasks using the following artificial intelligence tools: ChatGPT to generate ideas, conceptual solutions and text descriptions; Midjourney to create visual images and concepts; DALLE to generate images based on text descriptions; AIVA to create musical and audiovisual elements of projects. Additionally, technologies based on convolutional neural networks (CNN) were used, including image styling tools (for example, Deep Art), which allow combining visual styles and creating hybrid artistic solutions. The students of the control group performed similar tasks without using AI tools, using traditional methods of idea generation and design (brainstorming, hand sketches, search for references and collective discussions).

The quantitative assessment of creative thinking was carried out according to the following indicators: fluency of thinking (number of ideas), flexibility of thinking (variety of categories of solutions), originality of ideas and elaboration (ability to refine and transform ideas). At the stage of the primary analysis, the average values of the indicators before and after the pedagogical intervention, as well as their relative changes, were calculated. The results showed that there was a more pronounced positive trend in the experimental group: thinking fluency increased by an average of 25-35%, flexibility by 20-30%, originality by 15-25%, and sophistication by 30-40%. In the control group, the increase in indicators was significantly lower and ranged from 5-12%. To confirm the statistical significance of the differences, an inferential analysis was performed, the results of which are presented in Table 3.

Table 3. Pre-test and post-test results (Mean, SD, Effect Size).

Indicator	Group	Pre-test M (SD)	Post-test M (SD)	t	p	Cohen's d	95% CI
Fluency	Exp	6.4 (1.3)	9.1 (1.2)	8.21	<0.001	1.45	[2.1–3.3]
	Ctrl	6.3 (1.4)	7.1 (1.3)	2.11	0.04	0.32	[0.1–0.9]
Flexibility	Exp	4.8 (1.2)	7.2 (1.1)	7.95	<0.001	1.38	[1.9–3.0]
	Ctrl	4.7 (1.3)	5.4 (1.2)	1.98	0.05	0.28	[0.0–0.8]
Originality	Exp	3.6 (1.1)	5.9 (1.0)	8.45	<0.001	1.52	[1.8–2.8]
	Ctrl	3.5 (1.2)	4.1 (1.1)	1.76	0.08	0.22	[-0.1–0.7]
Elaboration	Exp	4.2 (1.2)	6.5 (1.1)	7.88	<0.001	1.34	[1.7–2.9]
	Ctrl	4.1 (1.3)	4.9 (1.2)	2.02	0.04	0.30	[0.1–0.8]

The results obtained demonstrate that statistically significant differences in all indicators were observed in the experimental group ($p < 0.001$). The effect size (Cohen's $d > 1.3$) indicates a strong influence of pedagogical intervention based on the use of AI tools. This indicates the high efficiency of integrating artificial intelligence into the educational process for the development of creative thinking. In the control group, the changes are limited (Cohen's $d < 0.3$), which confirms the lower effectiveness of traditional teaching methods in the context of the development of creative competencies. Thus, the results of the quantitative analysis convincingly confirm

the hypothesis that the use of artificial intelligence tools has a significant positive impact on the development of creative thinking among students of a professionally creative profile, providing both a quantitative increase in ideas and a qualitative complication of creative solutions.

2. QUALITATIVE DATA ANALYSIS

Qualitative data analysis was aimed at identifying the features of interaction between students of the professional and creative faculty with artificial intelligence tools, as well as analyzing changes in creative thinking strategies and the perception of AI as an educational tool. The following sources of qualitative data were used as an empirical base: students' reflective written reports on working with AI tools (ChatGPT, Midjourney, DALL-E, AIVA); semi-structured interviews with students of the experimental group; as well as educational products, including design projects, visual works, multimedia and audiovisual materials created by using AI.

The data was analyzed using a theoretically based thematic analysis in accordance with the approach of Braun and Clarke [19], which ensured the consistency and reproducibility of interpretation. The analysis procedure included several successive stages: open coding (initial coding), aimed at identifying primary semantic units; axial coding, which combines codes into larger categories; and the formation of themes (theme development), reflecting stable semantic structures in the data. To improve the reliability of the analysis, coding was carried out by two independent experts. The level of coding consistency was Cohen's kappa = 0.79, which indicates a high degree of inter-expert reliability. Data saturation was achieved at the stage of analyzing 18 interviews, after which no new semantic categories were identified, which confirms the sufficiency of the sample for qualitative analysis. As a result of the analysis, key thematic categories were identified that reflect the impact of using artificial intelligence on students' creative thinking.

Table 4. Thematic categories and their theoretical interpretation.

Topic	Description	The theoretical basis
Expanding the ideological space	Increasing the number and variety of ideas	Theory of Divergent Thinking (Guilford)
Speeding up prototyping	Reducing the time needed to conceptualize projects	Constructivism
Critical evaluation	Development of reflection and editing	The component model of creativity (Amabile)
The risk of AI addiction	Formalization of thinking	Theory of cognitive load

The results showed that the use of AI tools contributes to the expansion of the ideological space, which is manifested in an increase in the number of alternative solutions and a more active use of divergent thinking strategies. This effect is consistent with the theory of J. Gilford [4], according to which creativity is directly related to the variability and flexibility of thinking. It was also found that the use of AI significantly accelerates the rapid prototyping stage of projects, allowing students to move faster from an idea to its visualization. This corresponds to the provisions of the constructivist approach, in which learning is considered as a process of actively building knowledge through practical activities.

Of particular importance is the identified category of critical evaluation and editing of AI-generated content. Students demonstrated the development of skills in selecting, analyzing, and processing the results of artificial intelligence, which corresponds to T. Amabile's component model of creativity [5], in which a combination of creative skills and critical thinking plays a key role. At the same time, a qualitative analysis revealed an important pedagogical risk formal dependence on AI, manifested in a decrease in the depth of independent study of ideas in the absence of pedagogical support. This effect can be interpreted from the perspective of cognitive load theory, according to which excessive reliance on external tools can reduce active cognitive activity.

Special attention was paid to the perception of artificial intelligence by students. It was found that the majority of participants consider AI as an auxiliary tool that helps generate ideas and accelerate the creative process, rather than as a substitute for their own creative activities. However, in some cases, there is a tendency to delegate creative solutions to algorithms. An analysis of educational products has shown that the use of AI promotes more active experimentation with visual and conceptual forms, which confirms the development of exploratory and combinational types of creativity. At the same time, transformational creativity, associated with the creation of fundamentally new ideas, remains primarily a human ability. Thus, the qualitative analysis not only confirmed the results of the quantitative study, but also made it possible to identify the pedagogical conditions for the effective use of artificial intelligence. It has been established that the development of students' creative thinking using AI is possible if the following conditions are met: the presence of clearly structured learning scenarios, the inclusion of reflective tasks, as well as an orientation towards the author's processing of the results obtained. In general, qualitative data demonstrate that artificial intelligence does not act as a substitute for the creative process, but as a tool for its expansion, provided that the active role of the student and pedagogical support of educational activities are maintained.

3. MIXED-METHODS DATA ANALYSIS

The integrative data analysis was carried out within the framework of a mixed research design and aimed at comparing and interpreting quantitative and qualitative research results. The purpose of this stage of the analysis was to identify the consistency between the objective dynamics of creative thinking indicators and the subjective educational experience of students when using artificial intelligence in educational activities. Integrative data analysis was carried out within the framework of a mixed research design using a convergent parallel mixed-methods design [20], which involves simultaneous (parallel) analysis of quantitative and qualitative data, followed by their comparison and interpretation at the stage of integration of the results.

The main purpose of this stage was to identify the consistency between the objective dynamics of students' creative thinking indicators and the subjective educational experience of their interaction with artificial intelligence tools. Quantitative data reflected changes in key components of creative thinking (fluency, flexibility, originality, and elaboration of ideas), while qualitative data revealed the mechanisms, conditions, and features of these changes. The data integration procedure included several successive stages and was implemented using the principles of methodological triangulation:

- comparison of quantitative results with thematic categories obtained in the course of qualitative analysis;
- verification of consistency (convergence) and identification of discrepancies (divergence) between data types;
- interpretation of the obtained coincidences and differences based on theoretical models of creativity (J. Guilford's divergent thinking, T. Amabile's component model [4,5]) and modern approaches to the use of AI in education;
- integration of the results into a single interpretative model explaining the impact of AI on the development of creative thinking.

The results of the integrative analysis showed a high degree of consistency between quantitative and qualitative data. It was found that a statistically significant increase in creative thinking indicators in the experimental group correlates with qualitative changes in students' educational activities. Thus, the growth of indicators of fluency and flexibility of thinking was accompanied by an expansion of the ideological space, an increase in the number of alternative solutions and the active use of various strategies for generating ideas. These results are confirmed by the analysis of student projects and reflective reports, which show an increase in the variability and depth of the study of concepts.

The increase in the indicator of the originality of ideas is quantitatively consistent with qualitative data indicating the active experimentation of students with visual, conceptual and multimedia forms when using AI tools. Students more often went beyond the standard solutions, combining different styles and approaches. Of particular importance in integrative analysis is the indicator of elaboration and the ability to transform ideas. His significant growth in the experimental group is reflected in high-quality data demonstrating the development of students' skills in critical selection, editing and authoring of content generated by artificial

intelligence. This indicates the transition from passive use of AI to conscious and reflexive interaction with it. At the same time, a qualitative analysis revealed a number of pedagogical risks that are not quantified. In particular, there was a tendency towards formal dependence on AI in the absence of clearly structured educational scenarios and reflective tasks. This highlights the need for pedagogical support for the use of AI.

Table 5. Mixed-methods integration.

Quantitative result	Qualitative data	Interpretation
↑ Fluency of thinking	Expansion of the ideological space	AI promotes the generation of more ideas
↑ Flexibility of thinking	Increasing the diversity of solutions	and the development of divergent thinking
↑Originality	Experimenting with forms and meanings	Enhancing creativity
↑ Development	Editing and refinement skills	Development of reflection and critical thinking

The integration of quantitative and qualitative data allowed not only to confirm the effectiveness of using artificial intelligence as a tool for developing students' creative thinking, but also to reveal the pedagogical mechanisms of this influence. Thus, the results of the mixed analysis allow us to make the following generalizations:

- artificial intelligence acts as a cognitive enhancer (cognitive augmentation), expanding the possibilities of creative activity of students;
- the effectiveness of its use depends on the quality of pedagogical design and the availability of reflective practices.;
- integration of various types of data provides a higher level of research validity due to triangulation;
- the combination of quantitative and qualitative analysis increases the interpretative depth of the results and allows you to explain not only "what has changed", but also "why and how the changes occurred."

In general, the use of the convergent model of mixed methods has made it possible to provide a comprehensive understanding of the impact of artificial intelligence on the development of students' creative thinking and to increase the scientific validity of the findings.

4. LIMITATIONS AND FUTURE RESEARCH

Despite the significant results obtained, the present study has a number of limitations that must be taken into account when interpreting the conclusions. First, the study sample was limited to students from one faculty and one higher education institution, which reduces the level of external validity and limits the possibility of direct generalization of the results to other educational contexts, including other disciplinary areas and institutional settings. Secondly, the study was conducted during one academic semester (16 weeks), which does not allow us to fully assess the sustainability of the identified effects and their long-term impact on the development of students' creative thinking. Creativity as a complex cognitive characteristic is formed over a long period of time, which requires longer observations. Thirdly, the study used a limited set of artificial intelligence tools (ChatGPT, Midjourney, DALL•E, AIVA), which may narrow the interpretation of the results obtained. Different types of AI systems have different pedagogical potential, which requires a broader comparative analysis. Fourth, the quasi-experimental design of the study, despite its practical applicability in the educational environment, does not provide complete randomization, which can lead to the influence of uncontrolled variables (for example, the level of digital competence of students or individual characteristics of creativity). Finally, despite the use of validated approaches to evaluating creative thinking, measuring creativity remains a methodologically challenging task, which may affect the accuracy of interpreting quantitative indicators.

The prospects for further research are related to the deepening and expansion of the results obtained. First of all, it seems advisable to expand the empirical base by including students of various educational fields (including technical, humanitarian and interdisciplinary programs), as well as conducting multicenter research, which will increase the generalizability of the results. Of particular importance are longitudinal studies aimed

at studying the sustainability of the effects of using artificial intelligence and its impact on the formation of creative thinking in the long term. A promising area is the comparative analysis of various models of pedagogical integration of AI, including variations in the level of student autonomy, the degree of pedagogical support and the types of digital tools used. This will help determine the most effective educational strategies. Of additional scientific interest is the study of the differentiated influence of certain types of AI tools on specific components of creative thinking (fluency, flexibility, originality and elaboration of ideas), as well as their combined use in educational practice. An equally important area is the development of methodological recommendations and validated tools for evaluating learning outcomes in conditions of active use of artificial intelligence, including the integration of criteria for digital creativity. Special attention should be paid to ethical aspects related to the use of AI in education, including issues of authorship, academic integrity, transparency of algorithms, and the formation of digital responsibility for students.

In general, the results obtained confirm the expediency of further studying and introducing artificial intelligence technologies into the educational process of higher education institutions as an effective tool for developing students' creative thinking and forming their professional readiness to work in the digital economy.

V. CONCLUSION

The present study was aimed at exploring the possibilities of using artificial intelligence as a tool for developing creative thinking among students of creative specialties in professionally oriented higher education. The theoretical analysis carried out and the results of empirical research confirm the high pedagogical potential of artificial intelligence with its purposeful and methodically sound integration into the educational process.

The results of the quantitative analysis demonstrated statistically significant positive dynamics of key indicators of creative thinking of the students of the experimental group, including fluency, flexibility and originality of thinking, as well as the ability to develop and transform ideas. Compared to the control group, the students who used artificial intelligence tools showed a higher level of productivity at the stages of generation and conceptualization of creative solutions. This confirms that the use of generative AI tools helps to expand the cognitive space of ideas and activate the processes of divergent thinking, which is consistent with the results of modern research demonstrating the influence of generative systems on the development of both divergent and convergent thinking in the process of creative design [21].

The qualitative analysis made it possible to deepen the interpretation of the results obtained and identify the mechanisms of artificial intelligence's influence on the educational process. It has been established that students perceive AI primarily as an auxiliary tool that facilitates the search for ideas, accelerates the creative process and stimulates experimentation. At the same time, it has been revealed that the effectiveness of using AI directly depends on pedagogical design: the greatest educational effect is achieved in the presence of structured learning scenarios aimed at developing critical thinking and a reflexive attitude to the results generated by artificial intelligence. In the absence of such support, there is a risk of formalizing creative activity and reducing the level of students' authorial involvement.

The results obtained confirm that artificial intelligence at the present stage of development does not act as a substitute for human creativity, but performs the function of a cognitive enhancer, expanding the possibilities of creative activity. Generative systems effectively support the processes of combinatorial and exploratory creativity; however, transformational creativity associated with the creation of fundamentally new semantic and artistic concepts remains primarily for humans. At the same time, the development of artificial intelligence is accompanied by a number of socio-economic and professional challenges. The most significant risks are not related to direct competition between humans and algorithms in the field of creativity, but to the possible displacement of specialists from certain segments of the creative industries associated with routine or template tasks (for example, illustration, advertising design, media content). This requires rethinking professional training and strengthening the role of creative, critical and reflective competencies.

The practical significance of the research lies in the development of pedagogical approaches to the integration of artificial intelligence into the educational process. In particular, the results of the study allow us to formulate the following recommendations: The integration of AI tools (ChatGPT, Midjourney, DALL-E,

AIVA) should be carried out within the framework of structured pedagogical scenarios aimed at developing creative thinking, rather than automating learning activities. It is necessary to include elements of digital literacy and ethics of using artificial intelligence in educational programs. It is important to develop students' skills in critical analysis and editing of AI-generated content, as well as to form an informed attitude towards the results of algorithms. Thus, the study confirms that artificial intelligence should be considered as a means of pedagogical support and cognitive enhancement, rather than as an autonomous subject of creative activity. Its effective use is possible only if the leading role of a person in the process of creating a creative product is preserved.

In general, the integration of artificial intelligence into educational practice opens up new prospects for the development of students' creative thinking, expands the boundaries of artistic and design creativity and creates conditions for the emergence of new educational and professional models in the context of digital transformation of society.

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Author Contributions

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Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data presented in this study are available from the corresponding author upon reasonable request.

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