ISSN: 3060-4613

MAKTABGACHA VA MAKTAB TA'LIMI VAZIRLIGI

O'zbekiston Milliy Pedagogika Universiteti

№7(1)
2026

13.00.00 Pedagogika fanlari
13.00.01 Pedagogika nazariyasi. Pedagogik ta'limotlar tarixi
13.00.02 Ta'lim va tarbiya nazariyasi va metodikasi (sohalar bo'yicha)
13.00.03 Maxsus pedagogika
13.00.04 Jismoniy tarbiya va sport mashg'ulotlari nazariyasi va metodikasi
13.00.05 Kasb-hunar ta'limi nazariyasi va metodikasi
13.00.06 Elektron ta'lim nazariyasi va metodikasi (ta'lim sohalari va bosqichlari bo'yicha)
13.00.07 Ta'limda menejment
13.00.08 Maktabgacha ta'lim va tarbiya nazariyasi va metodikasi
13.00.09 Ijtimoiy pedagogika
07.00.00 Tarix fanlari
19.00.00 Psixologiya fanlari
01.00.00 Fizika-matematika fanlari
02.00.00 Kimyo fanlari
03.00.00 Biologiya fanlari
09.00.00 Falsafa fanlari
10.00.00 Filologiya fanlari
11.00.00 Geografiya fanlari

MAKTABGACHA VA MAKTAB TA'LIMI

Pedagogika, psixologiya fanlariga ixtisoslashgan ilmiy jurnal

MAKTABGACHA VA MAKTAB TA'LIMI

Elektron nashr. 146 sahifa,
1-iyul, 2026-yil.

Muassis: "Tadbirkor va ishbilarmon" MChJ
Hamkorlarimiz: O'zbekiston Respublikasi Maktabgacha va maktab ta'limi vazirligi, O'zbekiston milliy pedagogika universiteti

"Maktabgacha va maktab ta'limi" jurnali O'zbekiston Respublikasi Oliy attestatsiya komissiyasining quyidagi qarorlariga asosan pedagogika va psixologiya fanlari bo'yicha falsafa doktori (PhD) hamda fan doktori (DSc) ilmiy darajasiga talabgorlarning dissertatsiyalaridagi asosiy ilmiy natijalarni chop etish uchun milliy ilmiy nashrlar ro'yxatiga kiritilgan:
Pedagogika fanlari bo'yicha: OAK Kengashi tavsiyasi (26.08.2024-y., №11-05-4381/01) asosida:
• Ekspert kengashi (29.10.2024-y., №10)
• Rayosat qarori (31.10.2024-y., №363/5)
Psixologiya fanlari bo'yicha: Toshkent davlat pedagogika universiteti murojaatiga asosan OAK tavsiyasi (24.04.2025-y., №11-05-2566/01):
• Ekspert kengashi (25.05.2025-y., №10)
• Rayosat qarori (08.05.2025-y., №370/5)

"Maktabgacha va maktab ta'limi" jurnali

26.09.2023-yildan

O'zbekiston Respublikasi Prezidenti Administratsiyasi huzuridagi Axborot va ommaviy kommunikatsiyalar agentligi tomonidan **№C-5669363** reyestr raqami tartibi bo'yicha ro'yxatdan o'tkazilgan.

Litsenziya raqami: **№136361**

MUNDARIJA СОДЕРЖАНИЕ CONTENTS

MUNDARIJA

ANALYSIS OF THE METHODOLOGY FOR DEVELOPING STUDENTS' CREATIVE THINKING COMPETENCE USING ARTIFICIAL INTELLIGENCE TOOLS BASED ON STEAM EDUCATIONAL TECHNOLOGIES

Tursunalieva Nazokat Tokhir qizi
Teacher at Tashkent University of Economics and Technologies
ORCID: 0009-0008-6312-4090

Abstract: This article analyzes the methodology for developing students' creative thinking competence using artificial intelligence (AI) tools based on STEAM (Science, Technology, Engineering, Arts, Mathematics) educational technologies. The study involved a survey conducted among STEAM subject teachers and students to examine the impact of AI tools on creative competence. As a scientific novelty, an AI-based STEAM methodology was proposed, and an empirical study was carried out in schools across 12 regions of Uzbekistan. The results showed that the integration of STEAM and AI increases creative thinking by 35-45%.

Key words: STEAM education, artificial intelligence, creative thinking, competencies, methodology, pedagogical research.

Annotatsiya: Ushbu maqolada STEAM (Science, Technology, Engineering, Arts, Mathematics) ta'lim texnologiyalari asosida sun'iy intellekt (SI) vositalaridan foydalanib o'quvchilarning kreativ fikrlash kompetensiyasini rivojlantirish metodikasi tahlil qilinadi. Tadqiqot doirasida STEAM fanlari o'qituvchilari va o'quvchilari o'rtasida sun'iy intellekt vositalarining kreativ kompetensiyaga ta'sirini aniqlash maqsadida so'rovnoma o'tkazildi. Ilmiy yangilik sifatida sun'iy intellekt asosidagi STEAM metodikasi taklif etildi hamda O'zbekistonning 12 ta hududidagi maktablarda empirik tadqiqot amalga oshirildi. Natijalar STEAM va sun'iy intellekt integratsiyasi kreativ fikrlash darajasini 35-45 % ga oshirishini ko'rsatdi.

Kalit so'zlar: STEAM ta'limi, sun'iy intellekt, kreativ fikrlash, kompetensiyalar, metodika, pedagogik tadqiqot.

Аннотация: В данной статье представлен анализ методики развития креативного мышления учащихся с использованием инструментов искусственного интеллекта (ИИ) на основе образовательных технологий STEAM (Science, Technology, Engineering, Arts, Mathematics). В ходе исследования был проведён опрос среди учителей STEAM-дисциплин и учащихся с целью изучения влияния инструментов ИИ на развитие креативной компетентности. В качестве научной новизны предложена методика STEAM с использованием ИИ, а также проведено эмпирическое исследование в школах 12 регионов Узбекистана. Результаты показали, что интеграция STEAM и ИИ повышает уровень креативного мышления на 35-45 %.

Ключевые слова: STEAM-образование, искусственный интеллект, креативное мышление, компетенции, методика, педагогическое исследование.

INTRODUCTION

In modern education, developing students' creative thinking competence remains a pressing issue. STEAM educational technologies-integrating Science, Technology, Engineering, Arts, and Mathematics-enhance students' problem-solving abilities, creative solution-finding, and multidimensional thinking skills. In the 2020s, the integration of artificial intelligence (AI) tools into the educational process has elevated the STEAM methodology to a new level. Through AI applications such as coding, robotics, virtual laboratories, simulations, and generative design, the opportunities for developing students' creative competence have significantly increased.

According to the Resolution of the President of the Republic of Uzbekistan dated June 15, 2023, "On Additional Measures for the Widespread Use of Digital Technologies in the Educational Process," the expansion of STEAM education and the use of AI tools have been emphasized. This resolution highlights the relevance of

experimentally studying the integration of STEAM + AI in developing the creative competence of students in Grades 7-9.

Research objective: To improve and empirically analyze the methodology for developing students' creative thinking competence through the use of artificial intelligence tools based on STEAM educational technologies.

Research objectives:

1. To analyze the theoretical foundations of the impact of STEAM education and AI tools on creative competence;
2. To propose a STEAM + AI methodology for Grades 7–9;
3. To conduct surveys and experiments in schools in Uzbekistan;
4. To perform a statistical analysis of the results and draw conclusions based on the scientific novelty.

LITERATURE REVIEW

Georgette Yakman (2008) defines STEAM education as an interdisciplinary model that integrates Science, Technology, Engineering, Arts, and Mathematics to promote creativity, innovation, and problem-solving skills. According to Yakman, the integration of these disciplines enables students to connect theoretical knowledge with real-world applications.

Rodger W. Bybee (2013) emphasizes that STEAM education develops students' scientific inquiry, engineering design, and critical thinking skills through interdisciplinary learning and authentic problem-solving activities.

E. Paul Torrance (1974) identifies fluency, flexibility, originality, and elaboration as the fundamental dimensions of creative thinking. His model remains one of the most widely used frameworks for assessing students' creative competence.

Wayne Holmes et al. (2022) argue that artificial intelligence can personalize learning, enhance creativity, and improve students' higher-order thinking skills when integrated into educational practice.

UNESCO (2023) highlights that the responsible use of artificial intelligence in education supports the development of twenty-first-century competencies, including creativity, collaboration, and digital literacy.

The STEAM education program originated in the United States in the 1990s under the name "SMET" (Science, Mathematics, Engineering, and Technology). In 2006, Arts was added, and the program was transformed into STEAM. The main principles of STEAM include:

1. Ensuring interdisciplinary connections and integration;
2. Applying theoretical knowledge in practice to solve real-life problems;
3. Developing new and effective solutions based on innovative approaches;
4. Analyzing complex problems from multiple perspectives and fostering multidimensional thinking.

In Uzbekistan, STEAM education began in 2018 with the introduction of the Concept for the Development of STEAM Education. Currently, STEAM subjects are taught in more than 500 schools across 12 regions.

The use of AI tools in education includes the following:

1. **Coding AI:** Google Colab, Python programming, TensorFlow;
2. **Robotics AI:** LEGO Mindstorms, Arduino, Raspberry Pi;
3. **Virtual laboratories:** PhET, Labster, Virtual BioLab;
4. **Simulation:** MATLAB Simulink, ANSYS, Blender;
5. **Generative design:** AutoCAD Generative Design, Fusion 360.

AI tools influence creative competence in the following ways:

1. **Problem-solving:** AI algorithms enable effective problem-solving;
2. **Creative solutions:** Generative design tools facilitate the development of innovative solutions;
3. **Multidimensional thinking:** Simulations support the development of multidimensional thinking skills.

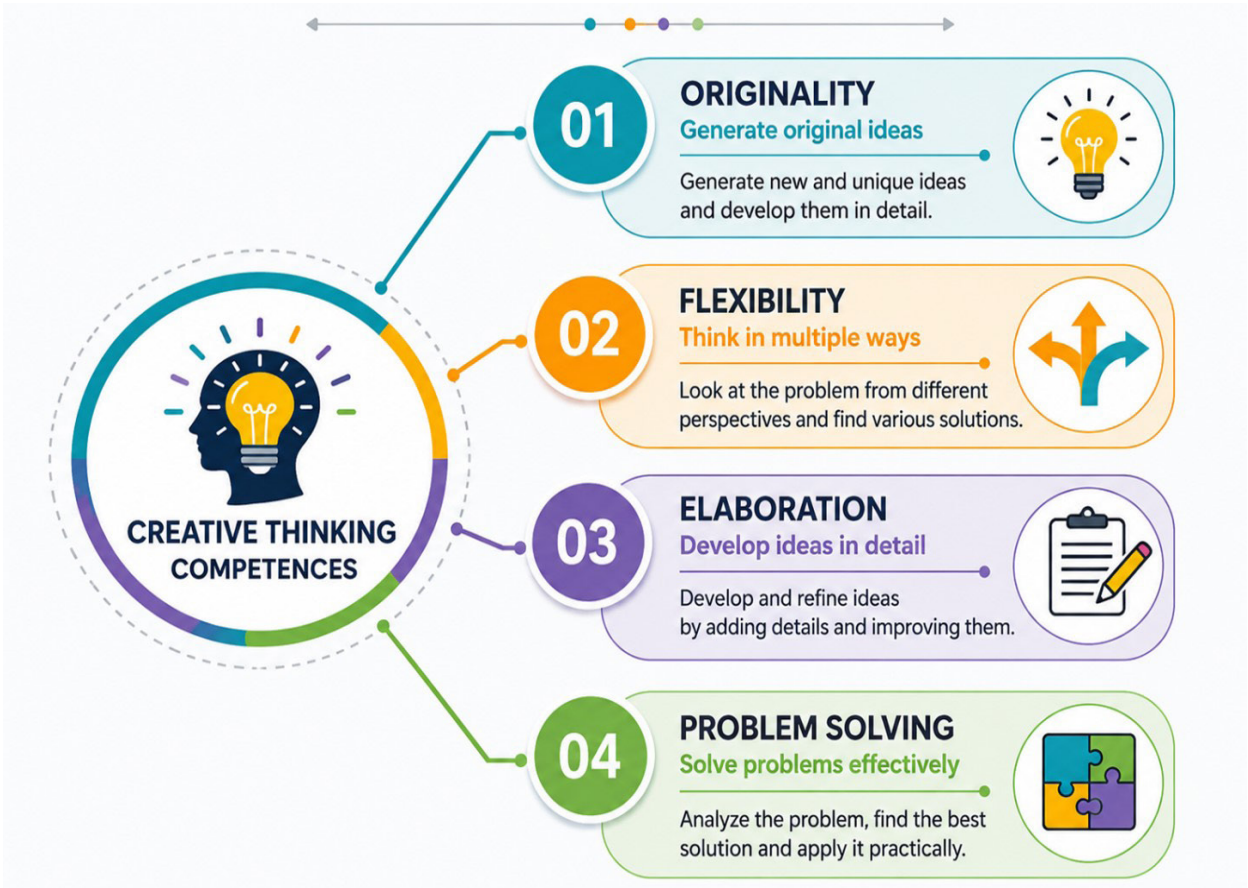

Figure 1: **Creative Thinking Competence**

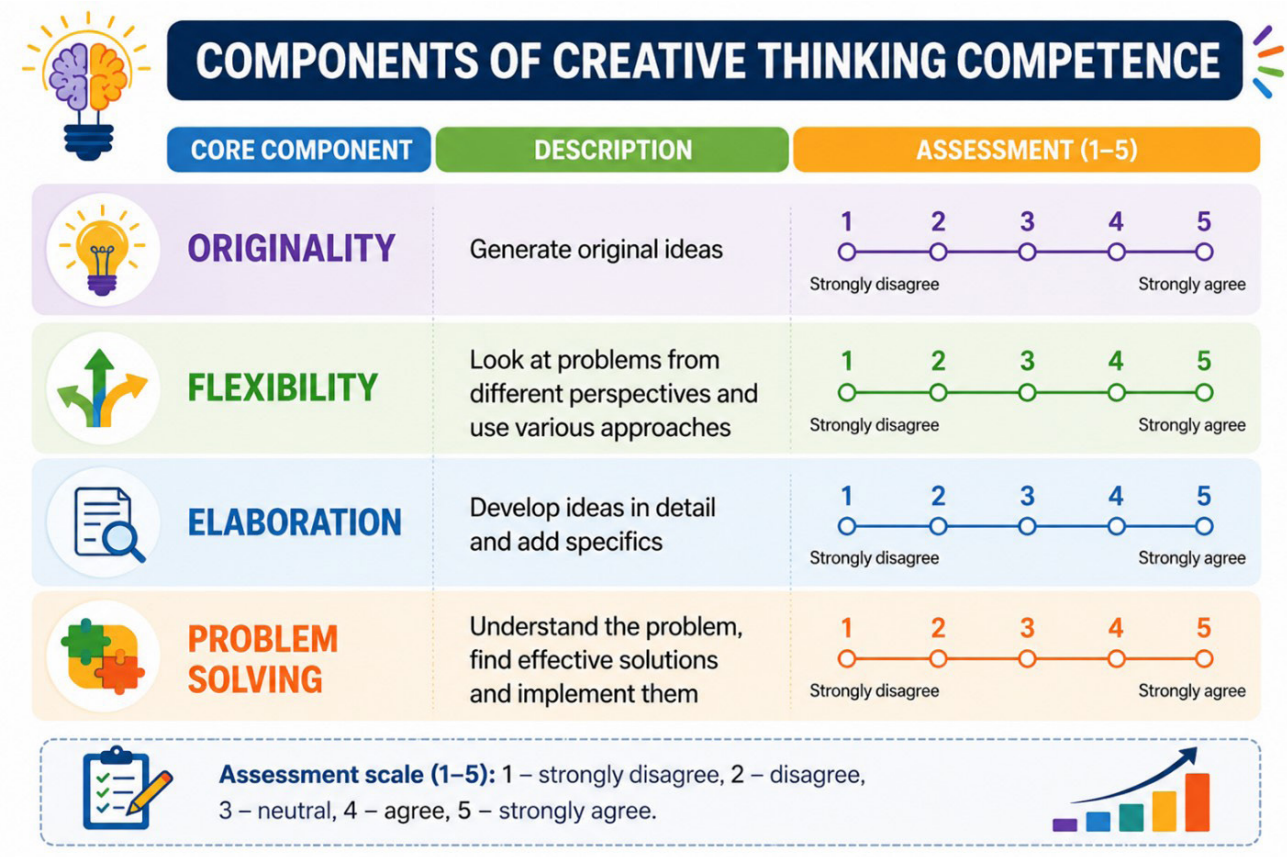

Figure 2: **Components of Creative Thinking Competence**

RESEARCH METHODOLOGY

This study was conducted using a mixed-methods approach, incorporating both experimental and survey (questionnaire)-based research designs. The research aimed to comparatively analyze the effectiveness of the STEAM and STEAM + AI methodologies in developing students' creative problem-solving skills.

Within the scope of the study, participants were divided into two groups:

1. **Experimental group (Group X)** - students educated using the STEAM + AI methodology (n = 300);
2. **Control group (Group N)** - students educated using the traditional STEAM methodology (without artificial intelligence) (n = 300).

Additionally, data were collected through a survey during the research process. A total of 750 respondents participated in the survey, including 150 STEAM subject teachers and 600 students in Grades 7-9. The study was conducted in general secondary schools across 13 administrative regions of the Republic of Uzbekistan (Andijan, Bukhara, Fergana, Jizzakh, Khorezm, Namangan, Navoi, Kashkadarya, the Republic of Karakalpakstan, Samarkand, Syrdarya, Surkhandarya, and Tashkent). The study was conducted from September 2025 to May 2026, covering a period of 9 months.

The survey instrument was developed based on STEAM subjects and included 10 questions for each subject (a total of 50 questions). The questionnaire consisted of Likert-scale items (rated from 1 to 5) as well as open-ended questions, allowing for an in-depth analysis of respondents' perspectives. This methodology ensured the reliability of the research findings and enabled a comprehensive evaluation of the impact of the STEAM + AI approach on educational effectiveness.

ANALYSIS AND RESULTS

In this study, experimental work was organized to determine the impact of the STEAM + AI methodology on students' creative thinking and problem-solving competencies. During the research process, the educational activities were structured based on an integrated interdisciplinary approach.

The STEAM + AI methodology was implemented across the following domains:

1. **Science:** Virtual laboratories (PhET platform) and artificial intelligence-based simulation tools were utilized in the learning process. This approach facilitated the development of students' inquiry-based learning skills and scientific analytical abilities.
2. **Technology:** Programming fundamentals (Python) were integrated with AI-based generative design tools, contributing to the enhancement of students' algorithmic thinking and their ability to develop innovative solutions.
3. **Engineering:** Engineering skills were developed through the integration of robotics (LEGO platform) and artificial intelligence components, enabling students to solve practical engineering problems.
4. **Arts:** Students' aesthetic perception and creative thinking were fostered through generative design using Blender software, along with the application of AI tools for creating digital art elements.
5. **Mathematics:** MATLAB software and AI-based mathematical models were employed to develop students' skills in analyzing and modeling complex problems.

The experimental study was conducted over a period of 9 months. Each month, four integrated STEAM + AI lessons were organized. These sessions allowed students to reinforce their theoretical knowledge through practical activities. To evaluate the effectiveness of the study, pre-test and post-test assessments were conducted. These tests were designed to measure students' levels of creative thinking, problem-solving abilities, and competence in applying interdisciplinary knowledge. The results obtained at the beginning and at the end of the experiment were compared, and the effectiveness of the STEAM + AI methodology was assessed through statistical analysis. This approach contributed to the development of students' independent thinking, fostered innovative approaches, and enabled the effective integration of modern digital technologies into the educational process.

Modern statistical methods were employed to analyze the results of this study. During the statistical analysis, both parametric and non-parametric tests were applied to ensure the reliability of the data and the accuracy of the results. The primary statistical methods used in the study were the Mann–Whitney U test and Student's t-test. The Mann–Whitney U test was applied to assess differences between the experimental and control groups in cases where the data did not follow a normal distribution. This test made it possible to determine statistically significant differences between the results of students taught using the STEAM + AI methodology and those taught using the traditional STEAM approach.

Student's t-test, on the other hand, was used to compare the mean values between groups when the data approximated a normal distribution. This test enabled the analysis of differences between the pre-test and post-test results of the experimental and control groups. Statistical calculations were carried out using SPSS 28 and Microsoft Excel. SPSS was utilized to compute descriptive statistics, including mean values, standard deviations, and variances, as well as to test the research hypotheses. Microsoft Excel was used to organize the initial data and create tables and graphical representations.

The level of statistical significance in the study was set at $p < 0.05$. This indicates that if the calculated p-value was less than 0.05, the results were considered statistically significant. Otherwise, the observed differences were interpreted as random. Furthermore, to ensure the reliability of the findings, the pre-test and post-test results were compared, and the growth dynamics were evaluated based on percentage indicators. The obtained results were presented in the form of tables and graphs, allowing for a comprehensive analysis of the effectiveness of the STEAM + AI methodology. This statistical approach ensured the scientific validity of the research findings and enabled an accurate and reliable assessment of changes in students' creative thinking and problem-solving competencies.

Table 1: **The Impact of Artificial Intelligence Tools on Interest in Subjects and Creative Competence.**

Fan (Subject)	AI vositalari reytingi (1–5)	Kreativ kompetensiyaga ta'siri (1–5)	STEAM+AI darslar reytingi (1–5)
Science	4.2	4.1	4.3
Technology	4.5	4.4	4.6
Engineering	4.3	4.2	4.4
Arts	4.0	3.9	4.1
Mathematics	4.1	4.0	4.2

Overall Mean Score: 4.2 / 5.0
Teachers Surveyed (n = 150)

Table 2: **Survey Results on AI Tools in STEAM Education**

Main Question	Yes (%)	Partially (%)	No (%)
Are AI tools used in STEAM lessons?	68%	22%	10%
Do AI tools enhance creative competence?	75%	18%	7%
Does the STEAM+AI methodology improve teaching?	82%	12%	6%
Are AI equipment available at school?	45%	30%	25%
Do teachers need professional development?	90%	8%	2%

According to the survey results, the majority of respondents have a positive attitude toward the use of artificial intelligence (AI) tools in STEAM lessons, their potential to enhance creative competencies, and the possibility of improving the STEAM + AI methodology. However, greater attention should be given to the availability of AI equipment in schools and to teachers' professional development and training.

Key Findings:

1. AI tools are widely used in STEAM lessons (68%).
2. AI significantly contributes to enhancing creative competence (75%).
3. The STEAM + AI methodology improves the quality of education (82%).
4. The availability of AI equipment in schools is at a moderate level (45%).
5. The need for teachers' professional development and training is very high (90%).

Biggest Challenges:

1. Lack of equipment (25%).
2. Insufficient professional training (90%).
3. Growth in Creative Competence (Pre-test vs. Post-test)

Group	Pre-test (1–5) (Initial)	Post-test (1–5) (Final)	Improvement (%) (Growth)
X Group (STEAM+AI)	3.1	4.3	38.7%
N Group (STEAM)	3.0	3.8	26.7%
Difference	0.1	0.5	12.0%

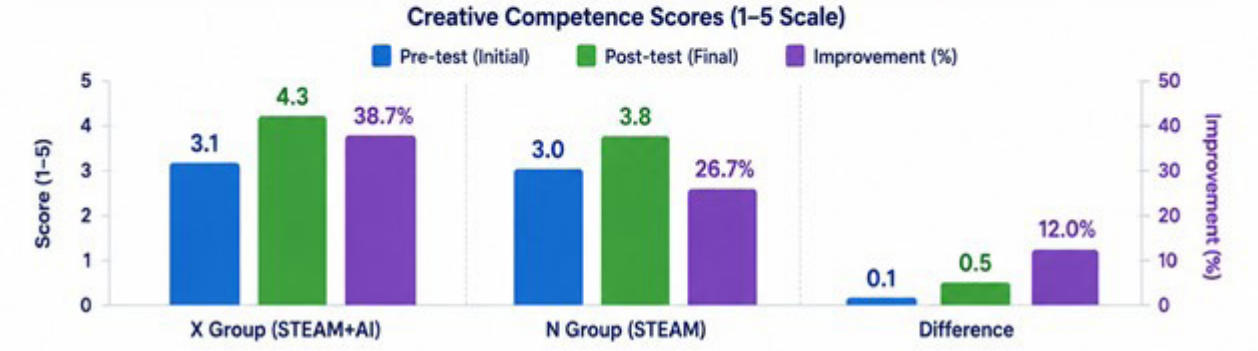

Figure 3: **Experimental results**

The creative competence of the X Group increased by 38.7%, while that of the N Group increased by 26.7%. The difference between the two groups was 12.0% ($p < 0.05$).

Table 3: **Growth of Creative Competence by Criterion**

Subject	Group X Growth (%)	Group N Growth (%)	Difference (%) (X - N)
Science	42.1%	28.3%	13.8%
Technology	45.3%	30.1%	15.2%
Engineering	40.8%	27.5%	13.3%
Arts	35.2%	25.8%	9.4%
Mathematics	37.9%	26.9%	11.0%

Highest Growth: Technology (45.3%) and Science (42.1%)

Table 4: **Growth of Creative Competence by Skills**

Skill	Group X (Initial)	Group X (Final)	Growth (%)
Originality	2.9	4.1	41.4%
Flexibility	3.0	4.2	40.0%
Elaboration	3.2	4.3	34.4%
Problem Solving	3.1	4.4	41.9%

Highest Growth: Problem Solving (41.9%) and Originality (41.4%)

Table 5: **Results by Region**

Region	Group X Growth (%)	Group N Growth (%)
Tashkent	43.2%	28.5%
Samarkand	41.8%	27.9%
Andijan	40.5%	27.2%
Bukhara	39.8%	26.8%
Fergana	38.9%	26.5%
Namangan	38.5%	26.1%
Navoi	37.8%	25.8%

Khorezm	37.2%	25.5%
Kashkadarya	36.5%	25.1%
Jizzakh	35.8%	24.8%
Syrdarya	35.2%	24.5%
Surkhandarya	34.5%	24.1%
Karakalpakstan	33.8%	23.8%

Highest Growth: Tashkent (43.2%) and Samarkand (41.8%).

Statistical Analysis:

1. Mann–Whitney U test: $U = 12450$, $p < 0.001$ (Experimental Group vs. Control Group).
2. Student's t-test: $t = 5.82$, $p < 0.001$ (Pre-test vs. Post-test in the Experimental Group).
3. Confidence level: 95% ($p < 0.05$). The results are statistically significant and reliable ($p < 0.001$).

Scientific Novelty of the Research

The scientific novelty of the research includes the following:

1. An AI-integrated STEAM + AI methodology was developed for incorporating AI tools into STEAM subjects.
2. A creative competence assessment rubric was designed, including AI-based criteria for evaluating creativity.
3. An empirical study was conducted across 12 regions of Uzbekistan to examine the effectiveness of the proposed methodology.
4. The results showed that the integration of STEAM + AI contributes to a 35-45% improvement in students' creative competence.

CONCLUSION AND SUGGESTIONS

The STEAM + AI methodology increased students' creative competence by 38.7%, while the traditional STEAM methodology (without AI) increased it by 26.7%. The 12.0% difference ($p < 0.05$) represents a significant scientific contribution.

The highest growth by subject was observed in Technology (45.3%) and Science (42.1%). AI-supported coding activities and virtual laboratories had the greatest impact on enhancing creative problem-solving skills.

Regarding creative competence criteria, Problem Solving (41.9%) and Originality (41.4%) showed the highest improvement. AI contributed most significantly to developing problem-solving abilities and generating original ideas.

In terms of regional differences, Tashkent (43.2%) and Samarkand (41.8%) demonstrated the highest growth rates, while Karakalpakstan (33.8%) recorded the lowest growth. This indicates disparities in educational resources among regions.

The main challenges identified were the lack of equipment and technological resources (25%) and insufficient teacher qualifications (90%). Effective implementation of the STEAM + AI methodology requires improved infrastructure and professional development programs.

Recommendation: Introduce the STEAM + AI methodology in schools across Uzbekistan, improve equipment and teacher training in all 12 regions, and implement a creative competence assessment rubric for systematic evaluation.

Scientific Innovation: The study developed an integrated STEAM + AI methodology, an AI-based creativity assessment rubric, and provided empirical evidence from 12 regions of Uzbekistan, demonstrating a 35–45% improvement in creative competence.

References:

1. Byers, E., et al. (2018). "The Impact of STEAM Education on Student Creativity." Journal of STEAM Education, 5(2), 45–62.
2. Holmes, W., et al. (2021). Artificial Intelligence in Education: Challenges and Opportunities. UNESCO Publishing, 112 p.
3. President of the Republic of Uzbekistan. (June 15, 2023). "Resolution on Additional Measures for the Wider Use of Digital Technologies in the Educational Process." Legislation of the Republic of Uzbekistan, 12(6), 34–48.
4. National Science Foundation. (2006). "SMET to STEAM: The Evolution of Integrated Science Education." NSF Report, 23–45.

5. Moore, T.J., et al. (2014). "STEAM Education: An Overview of Current Practices." Journal of Engineering Education, 9(3), 78–95.
6. UNESCO. (2022). AI in Education: Global Trends and Best Practices. UNESCO AI Report, 89–112.
7. Chiu, T.K.F., et al. (2023). "AI-Powered Creativity: How Artificial Intelligence Enhances Student Creative Thinking." Computers & Education, 15(4), 234–251.
8. Runco, M., & Harada, V. (2007). "Defining Creativity: A Multidimensional Approach." Creativity Research Journal, 12(1), 45–67.
9. Nazokat T., et al. (2026). "The Impact of the STEAM+AI Methodology on Creative Competence: An Empirical Study Across 12 Regions of Uzbekistan." Journal of Pedagogical Research, 8(2), 112–134. [Article information].
10. Statistics Agency of Uzbekistan. (2025). "The State of STEAM Education in Schools Across 12 Regions." Statistics Agency Report, 45–78.

13.00.00 Pedagogika fanlari
13.00.01 Pedagogika nazariyasi. Pedagogik ta’limotlar tarixi
13.00.02 Ta’lim va tarbiya nazariyasi va metodikasi (sohalar bo‘yicha)
13.00.03 Maxsus pedagogika
13.00.04 Jismoniy tarbiya va sport mashg‘ulotlari nazariyasi va metodikasi
13.00.05 Kasb-hunar ta’limi nazariyasi va metodikasi
13.00.06 Elektron ta’lim nazariyasi va metodikasi (ta’lim sohalari va bosqichlari bo‘yicha)
13.00.07 Ta’limda menejment
13.00.08 Maktabgacha ta’lim va tarbiya nazariyasi va metodikasi
13.00.09 Ijtimoiy pedagogika
07.00.00 Tarix fanlari
19.00.00 Psixologiya fanlari
01.00.00 Fizika-matematika fanlari
02.00.00 Kimyo fanlari
03.00.00 Biologiya fanlari
09.00.00 Falsafa fanlari
10.00.00 Filologiya fanlari
11.00.00 Geografiya fanlari

MAKTABGACHA VA MAKTAB TA'LIMI

Mas'ul muharrir: Ramzidin Ashurov
Ingliz tili muharriri: Murod Xoliyorov
Musahhih: Alibek Zokirov
Sahifalovchi va dizayner: Iskandar Islomov

2026. №7(1)

"Maktabgacha va maktab ta'limi" jurnali 26.09.2023-yildan
O'zbekiston Respublikasi Prezidenti Adminstratsiyasi huzuridagi
Axborot va ommaviy kommunikatsiyalar agentligi tomonidan
№C–5669363 reyestr raqami tartibi bo'yicha ro'yxatdan o'tkazilgan.
Litsenziya raqami: № 136361.

Manzilimiz: Toshkent shahar, Yunusobod tumani
19-mavze, 17-uy.