IJTE International Journal of Technology in Education
www.ijte.net

The Effects of Artificial Intelligence and STEAM Applications on Visual Arts Education

Omer Tayfur Ozturk [1 *], Mevlut Unal [2], Mahmut Sami Ozturk [3], Seyda Misman [4]

[1] Department of Painting, Faculty of Fine Arts and Architecture, Necmettin Erbakan University, Turkiye, 0000-0002-5757-1707
[2] Department of Graphics, Faculty of Fine Arts and Architecture, Necmettin Erbakan University, Turkiye, 0000-0002-8220-7480
[3] Department of Graphics, Faculty of Fine Arts and Architecture, Necmettin Erbakan University, Turkiye, 0000-0002-5519-3909
[4] Depart. of Painting, Faculty of Arts, Design, and Architecture, Karamanoğlu Mehmetbey University, Turkiye, 0000-0003-0540-4971
* Corresponding author: Omer Tayfur Ozturk (tozturk@erbakan.edu.tr)

Article Info

Article History

Received:
22 October 2025

Revised:
30 December 2025

Accepted:
28 January 2026

Published:
20 February 2026

Keywords

Visual arts education
Academic achievement
Artificial intelligence
STEAM
Learning retention

Abstract

This research aims to examine the effects of artificial intelligence and STEAM applications on the academic achievement, attitudes towards the course, and learning retention of ninth-grade high school students in Visual Arts. A pre-test-post-test control group experimental design was used in the study. The research was conducted in a high school located in the Mamak district of Ankara during the second semester of the 2025-2026 academic year. The sample consisted of 60 ninth-grade students selected using a random sampling method. The experimental group included 30 students (16 girls, 14 boys), and the control group included 30 students (15 girls, 15 boys). The application was carried out in six sessions within the scope of the "Art Criticism and Aesthetics" unit. In the experimental group, web-based artificial intelligence and STEAM applications were used for instruction, while traditional teaching methods were applied in the control group. A 25-question achievement test developed by the researcher and the Visual Arts Course Attitude Scale developed by Ayaydın and Özsoy (2011) were used as data collection tools. A retention test was administered two months after the application. The findings initially showed no significant difference in academic achievement and attitude between the experimental and control groups ($p>0.05$). However, post-test results revealed that the experimental group, where artificial intelligence and STEAM applications were implemented, had significantly higher academic achievement scores than the control group ($p<0.05$). Similarly, the attitude scores of the experimental group were found to be significantly higher than those of the control group ($p<0.05$). Retention test results also showed that the experimental group had higher learning retention than the control group ($p<0.05$). In conclusion, it was determined that artificial intelligence and STEAM applications positively affect students' academic achievement, attitudes towards the course, and learning retention in Visual Arts lessons. These findings demonstrate that innovative technology-supported teaching approaches are effective in Visual Arts education compared to traditional teaching methods.

Citation: Ozturk, O. T., Unal, M., Ozturk, M. S., & Misman, S. (2026). The effects of Artificial Intelligence and STEAM applications on visual arts education. *International Journal of Technology in Education (IJTE), 9*(2), 491-511. https://doi.org/10.46328/ijte.7101

Introduction

Today, rapidly developing digital technologies and artificial intelligence applications necessitate radical transformations at all levels of education systems; visual arts education is directly affected by this process. The traditional understanding of art education is increasingly giving way to new pedagogical approaches that center on interdisciplinary interaction, technology integration, and digital literacy. Art education is now considered a multi-dimensional field that is not limited to aesthetic production but encompasses critical thinking, creativity, and technological competencies. Özsoy (2022) draws attention to the importance of visual arts in revealing the creative potential of students. In this context, the integration of technology into art education enables students to become producers who effectively use digital tools instead of passive consumers. It is stated that the digital transformation process has increased the trends towards the use of technology in visual arts education and necessitated the restructuring of curricula (Astaño, J. (2025; Dignam, 2024, 2025; Erol & Erol, 2023; Gış & Topal, 2025; Karampelas, 2025; Morales et al., 2021; Shettar et al., 2021; Wu et al., 2021). When education policies are examined, it is seen that course materials and teaching methods are also transforming in parallel with this digitalization process (Ahrenby et al., 2025; Essuman et al., 2025; Houghton et al., 2022; Ijalo, 2025; Kretzschmar et al., 2024; Mayanti & Widiyatmoko, 2025; Osei-Bonsu, 2024;). Studies on artificial intelligence literacy in higher education highlight the importance of addressing these technologies at the high school level as well (Adamakis & Rachiotis, 2025; Coşkun, 2025). Therefore, visual arts education has become a dynamic structure that cannot be considered independently of technological developments.

Art education is no longer just a workshop-based activity, but is also considered a digital acculturation process. With the increasing importance of interdisciplinary approaches, Science, Technology, Engineering, Art, and Mathematics (STEAM) education stands out as a powerful model supporting the holistic development of students. The STEAM approach combines the creative aspect of art with scientific and technological processes, providing students with a multifaceted perspective. Graham (2021) emphasizes that this integration creates significant synergy in education. The inclusion of artificial intelligence in art education allows students to develop their algorithmic thinking skills and aesthetic perceptions together (Zlateva, 2025). STEAM-based applications encourage students to approach complex problems through artistic design processes and it strengthens their ability to establish interdisciplinary connections (Bertrand & Namukasa, 2023; Dignam et al., 2024, 2025; Kara, 2021). This integrated approach enables students to become individuals who not only use technology but also produce it by blending it with aesthetic values. Therefore, the adoption of STEAM and artificial intelligence-based approaches in visual arts courses at the high school level is considered one of the fundamental requirements of contemporary educational understanding.

Problem Statement

Visual arts education has mostly not been considered in the category of "core knowledge" or "fundamental subject" throughout history; this situation has negatively affected the position and perceived importance of the subject within the academic hierarchy. Traditional educational paradigms often tend to position art as a secondary element of academic success or a leisure activity. In Lilliedahl's (2022) analysis, based on the Bernsteinian

approach, the reasons why art is not accepted as a core knowledge area in secondary education are questioned, and it is emphasized that this situation stems from theoretical and structural limitations in curriculum structures. However, with the inclusion of artificial intelligence technologies in artistic production processes, the concepts of "artwork," "originality," and "creativity" have begun to be debated again; this has created new areas of uncertainty in educational environments. Munoz (2024), by examining how the "aura" and originality of the artwork are transformed at the intersection of artificial intelligence art and visual arts education, draws attention to the philosophical and pedagogical dilemmas in this field. Striking a balance between students' self-efficacy perceptions in the face of AI-generated visuals and excessive reliance on technology constitutes a significant problem area for educators. Bian et al. (2025) examined the effects of AI-assisted visuals on students' classroom participation, self-efficacy perceptions, and cognitive load; they pointed out that the uncontrolled use of these technologies poses various pedagogical risks.

Furthermore, it appears that many art educators lack sufficient technical knowledge and pedagogical skills to integrate AI tools into teaching processes. Heaton (2025) addresses the challenges of the "reconciliation" process with AI in art education, revealing the resistance, uncertainty, and anxiety experienced by teachers during the adaptation process to this new technology. The inability of traditional art education approaches to adapt to the speed and production practices of the digital age can reduce students' motivation towards the lesson; students may perceive a disconnect between school and real life when they cannot experience the technologies they use intensively in their daily lives in the school environment. This situation leads to the underutilization of the potential of visual arts lessons and weakens their functionality. Therefore, the failure to update existing curricula to incorporate contemporary approaches such as artificial intelligence and STEAM is a significant factor deepening the quality problem in education. High school is a critical developmental stage where individuals' identity development intensifies, the need for socio-emotional skills increases, and academic pressure becomes more pronounced. In this process, art education plays an important role in developing students' emotional expression and supporting their psychological well-being. However, the technology-centered transformation process risks overshadowing this human and affective dimension of art education. Kastner et al. (2021) emphasized the importance of visual arts programs aimed at developing adolescents' socio-emotional skills and experimentally examined the effects of digital drawing-based applications in this process.

In this context, it is seen that teachers' cultural identities and pedagogical approaches play a decisive role in the integration of technology into the classroom environment. Garcia-Lazo et al. (2024) highlight the potential of visual arts education to strengthen the cultural identities of prospective teachers, but note that uncertainties remain regarding how this potential can be integrated with technology. Similarly, Chen (2024), addressing the integration of socio-emotional learning into arts education at the middle school level in China, emphasized the importance of mental health-supporting practices; however, they stated that it is not yet sufficiently clear how AI-assisted processes will affect this emotional dimension. Samarescu et al. (2024) examined the attitudes of the new generation of teachers towards artificial intelligence and revealed concerns about the risks of reducing human interaction as well as the opportunities offered by these technologies. Whether AI and STEAM applications limit students to predefined algorithmic patterns instead of supporting their creativity is one of the important debate topics in the field. Furthermore, the possibility that the use of technology may weaken fundamental elements such

as "dexterity" and "tactile experience" in artistic production is another worrying issue for arts educators. In addition, technological infrastructure deficiencies and digital inequalities prevent these applications from reaching all students equally; differences in access among students can undermine the perception of fairness in the classroom and lead to learning losses.

Research Objective and Questions

The aim of this research is to examine the effects of Artificial Intelligence and STEAM applications on the achievement, attitudes, and learning retention of ninth-grade high school students in Visual Arts. To this end, the following research questions were addressed:

- Is there a significant difference in pre-test scores on academic achievement in Visual Arts among students' groups?
- Is there a significant difference in pre-test scores on the attitude scale in Visual Arts among students' groups?
- Is there a significant difference in post-test scores on academic achievement in Visual Arts among students' groups?
- Is there a significant difference in post-test scores on the attitude scale in Visual Arts among students' groups?
- Is there a significant difference in retention scores on the Visual Arts test among students' groups?

Literature Gap and the Importance of Research

When the literature on artificial intelligence and STEAM applications in education is examined, it is seen that research is largely concentrated at the higher education level; studies focusing on the high school level and especially visual arts education are limited. Yim, Su, and Wegerif (2025) and Chen et al. (2022) draw attention to the inadequacy of applied research that centers the interaction between artistic creativity and artificial intelligence, despite the existence of STEAM-based applications in lower education levels. The limited number of concrete examples for classroom applications (Li and Gu, 2023) and the need for approaches that holistically address the cognitive and affective changes experienced by high school students in artistic production processes (Xiao et al., 2024) constitute the main research gap in the field. It is observed that most of the existing studies deal with technology or art in isolation; empirical research that examines these two fields within a pedagogical synthesis in the context of the high school curriculum is quite limited. Accordingly, this research, planned to be conducted at the ninth-grade level, aims to fill the aforementioned gap in the literature by bringing together theoretical approaches with classroom applications.

The research aims to offer teachers a technology-enriched and applicable pedagogical framework by transferring the findings of studies that demonstrate the effectiveness of interdisciplinary approaches in different fields (Oanh and Dang, 2025; Arpaci et al., 2023; Irdalisa et al., 2024; Kibici, 2025a) to visual arts education. While the emphasis on collaboration and digital production by Nurramadhani et al. (2021) and Liao et al. (2025) is adapted to the high school level; the digital transformation indicated by Xu (2024) and Fang and Jiang (2024) is addressed in the context of the art curriculum. It is expected that the findings will guide students in using artificial

intelligence technologies with ethical and aesthetic awareness and at the same time offer policymakers a holistic and universal perspective on the transformation of art education in the digital age.

Theoretical Framework

Artificial Intelligence and the STEAM Approach in Visual Arts Education

Visual arts education is being restructured along the lines of Science, Technology, Engineering, Art, and Mathematics (STEAM), transcending its traditional boundaries in line with the accelerating technological transformation of the 21st century and the increasing need for interdisciplinary interaction. The STEAM approach stands out as a pedagogical model that aims to offer students a multifaceted and holistic learning experience by integrating the creative and aesthetic dimensions of art with scientific processes (Kaşarcı et al., 2025). In his study examining the disciplinary boundaries between art and STEAM, Graham (2021) emphasizes that art is not only a supporting element within this structure; it is a fundamental component that gives meaning to scientific thinking and discovery processes. Art education allows students to concretize and deeply understand abstract scientific concepts by visualizing them. In this context, the effectiveness of the STEAM approach is directly related to the organic integrity that art establishes with other disciplines. The pedagogical model developed by Bertrand and Namukasa (2023) shows that art does not only offer an aesthetic contribution within STEAM; It reveals that it plays a role as a functional mental tool in problem-solving and creative thinking processes. Within this interdisciplinary structure, the visual arts course ceases to be an isolated workshop activity and transforms into an interactive learning environment where technology and engineering concepts are also discussed. Mun's (2022) study of STEAM curricula implemented in art high schools in Korea reveals the decisive role of aesthetic experience within this approach and shows that art-focused schools take on a pioneering function in the integration process. In this respect, STEAM-based visual arts education represents not only the enrichment of the curriculum but also a radical transformation in the understanding of education. The integration of artificial intelligence technologies into visual arts education is considered a significant development that transforms artistic production practices and teaching processes. Artificial intelligence is not only a technical tool but also an actor that necessitates a rethinking of the concepts of creativity, originality, and artwork in educational environments. Zlateva (2025) states that artificial intelligence is increasingly replacing traditional methods in art education with digital and algorithmic processes; This situation emphasizes that it demands digital literacy and critical evaluation skills from students. However, AI-assisted applications also bring about various debates regarding labor, originality, and ethical use in artistic production. Heaton (2025) reveals that resistance and concerns towards AI in art education are shaped around the value and role of human creativity (Kibici, 2025b). Adamakis and Rachiotis (2025), on the other hand, state that AI literacy should be addressed within a pedagogical framework, drawing attention to the importance of placing ethical awareness at the center of curricula. Accordingly, the use of AI in visual arts education should be considered as a learning process that aims to enable students to use these technologies critically and consciously, beyond simply acquiring technical competence. In this process, the teacher's role is evolving from that of a mere transmitter of information to a mentoring approach that guides students in establishing a balance between technology and artistic expression. The new aesthetic understanding and visual culture shaped by the digital age are also transforming the content and teaching materials of art education. Visual arts education encompasses a wide range of applications, including traditional tools as well as

digital media, big data, and next-generation technologies. Ahrenby, Häikiö, and Marklund (2025) demonstrate that teaching materials used in art education are changing in parallel with the digitalization process, and the weight of digital content in the classroom is increasing. Karlsson Häikiö (2022) states that visual communication and visual culture competencies have become central to the contemporary art education curriculum. Concepts such as big data and digital aesthetics create new research and application areas in art education (Christ, Penthin, and Kröner, 2021), while also enabling students to interact with global visual culture. Fang and Jiang (2024) state that the Internet of Things and artificial intelligence technologies are transforming artistic production by bridging the gap between the physical and digital worlds. However, the intensive use of digital tools can also bring with it the risk of neglecting traditional art forms. Therefore, in visual arts education, technology should be the goal, not the end itself. It needs to be positioned as a tool that strengthens artistic expression and is used in a balanced way with the historical-cultural context.

Artificial Intelligence-Supported Visual Arts Applications in Secondary Education

The Effects of STEAM-Based Applications on Student Outcomes

STEAM-based educational applications offer multidimensional outcomes aimed at developing not only students' artistic skills but also their cognitive, scientific, and collaborative work competencies. Studies in the literature show that integrating project-based learning approaches with STEAM education significantly increases students' academic achievement and problem-solving skills. Irdalisa et al. (2024) examined the contribution of STEAM-based worksheets developed with the ecoprint technique to the project-based learning process and revealed that these materials helped students understand the learning content more deeply. Similarly, it has been observed that such applications strengthen group work and collaboration skills. Nurramadhani, Kumala, and Permana (2021), by examining the effect of STEAM-based project learning on the collaboration competencies of middle school students, stated that the process of creating a joint product supports the development of social skills. The integration of mobile learning technologies with STEAM also stands out as an important element that facilitates the learning process. Chen and Huang (2023) addressed the effects of STEAM-based mobile learning on learning success and cognitive load, and found that the balanced use of technology for pedagogical purposes had positive effects on learning outcomes. Experimental studies conducted in the context of science education also reveal that STEAM modules increase interdisciplinary permeability. Arpaci et al. (2023) reported that a STEAM-based learning module applied in science education facilitated students' understanding of scientific concepts through the integration of art with science. These findings show that STEAM applications enable students to gain a holistic perspective and recognize interdisciplinary relationships. The inclusion of artificial intelligence and robotics technologies in educational environments adds a new dimension to students' critical and creative thinking skills. STEAM education aims to transform students from passive consumers of information into active learners who question, transform, and create new products. Chiu and Hwang (2024) showed that mind mapping and robot-based learning approaches significantly improved students' critical and creative thinking skills. Research on interdisciplinary art education practices also shows that this approach makes students' thinking processes more effective. Art education practices conducted in online and digital environments support creative thinking in different ways. Le (2023) states that team-based approaches applied in online learning environments strengthen students' creative thinking skills in the field of digital art. In addition, the psychological and affective dimensions

of STEAM education are also important in terms of student achievements. Xiao et al. (2024), by examining children's emotion recognition processes in the context of STEAM education, emphasized that art plays a decisive role in the development of emotional intelligence. Students' ability to express their emotions through artistic means and understand the emotions of others constitutes an important part of their social and emotional development. Accordingly, STEAM-based applications offer a holistic learning environment that allows students to develop in both cognitive and affective areas. Artificial intelligence and technology-supported art education supports students in solving complex problems by using creative and analytical thinking skills together, and prepares them for the future as well-rounded individuals required by the digital age.

Pedagogical Approaches and Current Research on Artificial Intelligence and STEAM Applications

The effectiveness of artificial intelligence and STEAM applications in education is largely related to the pedagogical approaches and attitudes towards technology adopted by teachers. How teachers integrate digital tools into teaching processes directly affects students' learning experiences and determines the function of technology in education. Samarescu et al. (2024), by examining the perceptions of new generation teachers regarding artificial intelligence, revealed that technology is mostly seen as a pedagogical support element rather than a threat, but that there is a need to strengthen pedagogical competencies in this area. Multimodal teaching approaches used in digital media arts education increase classroom interaction by addressing different learning styles. Shi (2025), by addressing the opportunities and challenges offered by multimodal teaching in digital media arts education from the teacher's perspective, emphasizes that this approach enriches the learning process. However, teachers' cultural identities and perspectives on art are also important factors determining the quality of STEAM applications. Garcia-Lazo et al. (2024) showed that visual arts education strengthens the cultural identities of prospective teachers and that this is reflected in their teaching practices. The impact of interdisciplinary pedagogical models is observed even in specialized fields such as biology drawings. Onuorah et al. (2025) highlighted the importance of pedagogical synthesis by stating that the Technology-Education-Art (TEA) based artificial intelligence model positively influenced students' attitudes towards biological drawing. In this context, updating pedagogical approaches in a way that is compatible with technology and supporting teachers with continuous professional development programs stands out as a critical requirement for the sustainability of artificial intelligence and STEAM applications. Evaluating artificial intelligence and STEAM applications necessitates multidimensional and data-driven approaches that go beyond traditional measurement and evaluation understandings. The subjective nature of evaluation processes in art education has long made this field controversial; However, digital technologies are adding a more systematic and analytical dimension to evaluation. Clark-Fookes (2025) describes the tension between validity and reliability in art evaluation as a "difficult problem to solve," drawing attention to methodological limitations in this field. In contrast, data mining and machine learning-based approaches allow for a more objective analysis of student performance. Wang et al. (2024) argue that the use of these techniques strengthens measurement processes in their hybrid evaluation model developed for art education. Studies in the field of artificial intelligence in education have increased significantly in recent years, both in terms of quantity and subject diversity. Chen et al. (2022) revealed the development trends and research networks of the field through their bibliometric analysis. However, the risk of technology deviating from pedagogical goals should not be ignored. Li and Gu (2023), in their risk analysis developed within the framework

of human-centered artificial intelligence, emphasize that technology should be limited in a way that is compatible with educational purposes. Therefore, artificial intelligence and STEAM applications should be considered not only in terms of implementation processes but also in terms of evaluation approaches and the management of potential risks. Current literature indicates that the role of technology in education needs to be continuously questioned and restructured in line with pedagogical goals.

Method

This research, which aims to evaluate the effect of web-based artificial intelligence and STEAM applications on the academic achievement and attitudes of 9th-grade high school students in visual arts lessons, investigated the effect of these innovative teaching approaches compared to traditional teaching. In this research, the "pre-test-post-test control group design" of the experimental design model was used. Before the application study to be carried out in the study, experimental and control groups were formed in accordance with the experimental design, and the relevant units were taught in the classroom environment with artificial intelligence and STEAM applications in the experimental group, while the lesson was taught in the classroom environment suitable for traditional education methods in the control group. In the research, comparisons were made according to the data obtained from the experimental and control groups before and after the application.

Research Group

The research population consists of 9th-grade students in a high school located in Mamak District, Ankara Province. The research sample was determined using the random sampling method. In the random sampling method, random units are listed and selected from the population (Kılıç, 2013). The sample of this study consists of 60 9th-grade students in a high school affiliated with the Ministry of National Education in Mamak District, Ankara Province, during the second semester of the 2025-2026 academic year. Two classes at the 9th-grade level of the school were determined using the purposive sampling method. There are 60 (30+30) students in the classes determined as the experimental and control groups. The research was conducted with 15 girls and 15 boys in the control group, and 16 girls and 14 boys in the experimental group.

Implementation Process

The achievement test developed for the "Art Criticism and Aesthetics" unit was used as a pre-test and post-test in both the experimental and control groups. The same test was used a third time two months after the completion of the implementation to measure the "retention" level of what was learned. Before starting the implementation, the researcher administered a pre-test to both groups, after which the unit was taught over six sessions. During this process, the traditional teaching method was used in the control group, and the usual course of the class was not interfered with. In the experimental group, the lessons were taught considering the principles of artificial intelligence and STEAM techniques.

The experimental applications carried out in the experimental group are presented below. Artificial Intelligence and STEAM Applications for 9th Grade Visual Arts Class

1. LESSON PLAN: "DIGITAL ART WITH ARTIFICIAL INTELLIGENCE"

• Duration: 2 lesson hours (80 minutes)

• Topic: AI-Supported Digital Art Production

• STEAM Connections: Technology, Art, Engineering

Learning Outcomes:

• Recognizes AI-based art tools

• Compares traditional and digital art techniques

• Analyzes AI-generated visuals using artistic criticism methods

• Produces original artwork using simple AI tools

Lesson Flow:

Introduction (15 minutes):

• Historical development of the relationship between artificial intelligence and art

• Introduction to tools such as DALL-E, Midjourney, and Stable Diffusion

• Ethical discussion: "Can artificial intelligence produce artwork?"

Main Activity (50 minutes):

• Experimental use of online AI art tools

• Visual production based on themes chosen by students

• Artistic analysis of the produced visuals

Evaluation (15 minutes):

• Classroom sharing of student work

• Justification of artistic choices

• Comparison of traditional and digital processes

Example Activity: "AI Portraits"

• Students are asked to choose words that reflect their own emotional states

• Portraits are created using AI tools with the chosen words

• Artistic expression analysis is performed on the resulting portraits

Example Worksheet:

• AI art analysis form

• Visual composition evaluation table

• Ethical questions and student opinions section

2. TEACHING PLAN: "INTERACTIVE ART WITH STEAM"

• Duration: 3 lesson hours (120 minutes)

• Topic: Interactive Art Design with STEAM Approach

• STEAM Connections: Science, Technology, Engineering, Art, Mathematics

Learning Outcomes:

• Understands the integration of art and technology

• Creates artistic works with simple electronic circuits • Combines expression

• Applies problem-solving skills to art projects

• Designs interactive artwork through teamwork

Course Outline:

Day 1: Conceptual Design (40 minutes)

• Examining examples of interactive art

• Forming groups and developing project ideas

• Preparing design sketches

Day 2: Prototype Development (40 minutes)

• Introduction to simple electronic components (LED, battery, switch)

• Using Makey Makey or simple sensors

• Integration of electronic components with physical artwork

Day 3: Presentation and Evaluation (40 minutes)

• Presentation of group projects

• Evaluation of the work process

• Discussion of the art-technology relationship

Activity Example: "Emotional Sculptures"

• Students design touch-sensitive sculptures using aluminum foil, copper wire, and simple electronic components

• LEDs light up or simple sounds are emitted when the sculptures are touched

• Each sculpture represents an emotion

Worksheet Example: • Project design stages form

• Material list and budget planning table

• STEAM disciplines to the project Contribution Analysis Table

3. TEACHING PLAN: "ALGORITHMIC ART AND CODING"

• Duration: 2 lesson hours (80 minutes)

• Subject: Art Production with Algorithmic Thinking

• STEAM Connections: Mathematics, Technology, Art

Learning Outcomes:

• Applies algorithmic thinking to artistic processes

• Creates visual designs with simple code blocks

• Recognizes the place of mathematical concepts in art

• Develops the ability to visualize abstract concepts

Lesson Flow:

Introduction (20 minutes):

• Definition and history of algorithmic art

• Relationship between mathematics and art (golden ratio, fractals, symmetry)

• Introduction to tools such as Processing, P5.js or Scratch

Application (45 minutes):

• Basic use of Scratch or similar block-based programming tools

• Creating compositions with simple geometric shapes

• Creating patterns using variables and loops

Evaluation (15 minutes):

• Sharing student work

• The relationship between algorithms and artistic results Discussion

• The Dilemma of Randomness and Planning in Art
Example Activity: "Coded Mandalas"
• Students create mandala patterns using mathematical rules
• Design personalized mandalas using the concepts of symmetry, cycles, and variation
• Create dynamic visuals with color algorithms
Example Worksheet:
• Algorithm design template
• Glossary of mathematical art concepts
• Self-assessment rubric
ASSESSMENT TOOLS:
1. Portfolio Assessment: Students' work produced throughout the process
2. Peer Assessment: Collaboration and contribution in group work
3. Self-Assessment: Students analyzing their own learning processes
4. Project-Based Assessment: Evaluation of final products according to artistic and technical criteria
MATERIAL LIST:
• Computer and internet connection
• Tablet-based drawing tools (optional)
• Simple electronic components (LED, battery, wire, switch)
• Traditional art materials (paper, paint, aluminum foil)
• Free online AI art tools
• Block-based programming platforms (Scratch, etc.)

The teacher in the experimental group encouraged and guided students to help each other in the use of technology. The plans and activities in the experimental group were prepared taking into account the developmental characteristics of 9th-grade students. Each plan was flexibly adapted and modified according to the school's resources. After the applications were completed in both the experimental and control groups, an achievement test and an attitude scale were administered as post-tests. Approximately two months later, a retention test was administered to determine the retention levels of what the subjects in both the experimental and control groups had learned, thus completing the data collection.

Data Collection Tools

Visual Arts Lesson Achievement Test

In this research, an achievement test covering the topics of the "Art Criticism and Aesthetics" unit of the 9th Grade Visual Arts Lesson was used as a data collection tool. Before preparing the developed achievement test, the literature related to the research was reviewed and studies on the development of similar data collection tools were examined. The achievement test was prepared by the researcher in 2018, taking into account the objectives of the "Art Criticism and Aesthetics" unit in the "Visual Arts Lesson Secondary Education Program and Guide" published by the Ministry of National Education. The achievement test consisted of 30 questions, and each question was calculated as one (1) point. After obtaining the necessary permissions from the relevant institutions,

the discrimination of the items in the test was determined to be above 0.30. The average difficulty of the test was calculated as 0.36. In the validity and reliability studies of the test, it was applied with 60 students before the research. After the application, item analysis was performed on the 30 questions in the test. Five questions with a discrimination index lower than 0.30 were removed from the test to ensure content validity. The KR-20 value was calculated for the reliability of the resulting 25-question achievement test. The KR-20 value of the test was found to be .84, the average difficulty .54, and the average discrimination .43. This test was administered to experimental and control groups to obtain pre-test, post-test, and retention test data.

Visual Arts Course Attitude Scale

The Visual Arts Course Student Attitude Scale (VASTS), developed by Ayaydın & Özsoy (2011), was used to determine students' attitudes towards the Visual Arts course. In addition to consulting expert opinions to ensure the content validity of the attitude scale, factor analysis (Principal Component Analysis) was performed to ensure construct validity. Initially designed with 50 items, the scale was revised by removing 15 items with low factor loadings, resulting in its final form. The attitude scale, designed to determine students' attitudes towards Visual Arts lessons, has a total variance explanation rate of 27%. In this respect, it can be said that the scale is grouped under one factor related to attitudes towards Visual Arts lessons. The Cronbach-Alpha reliability coefficient of the scale was found to be .90.

Data Analysis Techniques

Based on the findings, the normality of the pre-test and pre-test scores of the groups' achievement and attitudes was tested. It was understood that the skewness and kurtosis values of the data obtained from the pre-test and post-test applications of achievement were between +1 and -1, thus normality was achieved. Before making comparisons between groups, analyses were performed after ensuring the assumptions of normal distribution. In the study, dependent samples t-test was used for comparisons between groups.

Findings

The differences in pre-test and post-test scores and retention test scores for academic achievement and attitude in visual arts lessons according to students' groups were analyzed using an Independent Samples t-test, and the findings are presented in Table 1.

Table 1. Comparison of Pretest Scores for Academic Achievement in Visual Arts According to Students' Groups

Pretest	Group	N	Mean	Std. Deviation	t	p
Achievement	Experimental	30	8.77	3.46	-0.249	0.804
	Control	30	8.97	2.71		

The mean pre-test scores for academic achievement in Visual Arts were found to be 8.97 (sd=2.41) in the control group and 8.77 (sd=3.46) in the experimental group. No significant difference was found between the pre-test

academic achievement scores of the students according to their groups (t=-0.249, p=0.804, p>.05).

Table 2. Comparison of Pretest Scores of Students' Attitudes Towards Visual Arts According to Their Groups

Pretest	Group	N	Mean	Std. Deviation	t	p
Attitude	Experimental	30	3.64	0.47	-0.573	0.569
	Control	30	3.73	0.64		

The mean pre-test scores on the Visual Arts course attitude scale were found to be 3.73 (sd=0.64) in the control group and 3.64 (sd=0.46) in the experimental group. No significant difference was found between the pre-test scores of the attitude scale according to the students' groups (t=-0.573, p=0.569, p>.05).

Table 3. Comparison of Posttest Academic Achievement Scores in Visual Arts Course According to Students' Groups

Posttest	Group	N	Mean	Std. Deviation	t	p
Achievement	Experimental	30	17.67	4.86	3.088	0.003
	Control	30	14.43	3.05		

The mean post-test scores for academic achievement in Visual Arts were found to be 14.43 (sd=3.05) in the control group and 17.67 (sd=3.05) in the experimental group. A significant difference was found between the post-test academic achievement scores of the students according to their groups (t=-3.088, p=0.003, p<0.05). According to this finding, the post-test academic achievement scores of the students in the experimental group, where the AI+STEM application was implemented, were found to be higher than those of the students in the control group.

Table 4. Comparison of Posttest Scores of Students' Attitudes Towards Visual Arts According to Their Groups

Posttest	Group	N	Mean	Std. Deviation	t	p
Attitude	Experimental	30	4.47	0.45	3.789	0.000
	Control	30	3.86	0.75		

The mean posttest scores for students' attitudes towards Visual Arts were found to be 3.86 (sd=0.75) in the control group and 4.47 (sd=0.45) in the experimental group. A significant difference was found between the post-test scores of the attitude scale according to the students' groups (t=-3.789, p=0.000, p<0.05). According to this finding, the attitudes of the students in the experimental group, where the AI+STEM application was implemented, towards the Visual Arts lesson were found to be higher than those of the students in the control group.

Table 5. Comparison of Students' Visual Arts Attitude Retention Test Scores According to Their Groups

Posttest	Group	N	Mean	Std. Deviation	t	p
Retention	Experimental	30	16.43	4.45	3.041	0.004
	Control	30	13.30	3.48		

The mean retention scores on the Visual Arts lesson were found to be 13.30 (sd=3.46) in the control group and

16.43 (sd=4.45) in the experimental group. A significant difference was observed in retention test scores between the student groups ($t=-3.041$, $p=0.004$, $p<0.05$). According to this finding, the learning retention of students in the experimental group, where the AI+STEM application was implemented, in the Visual Arts lesson was found to be higher than that of the students in the control group.

Discussion

This research determined the effects of artificial intelligence and STEAM-based applications on academic achievement, attitudes towards the course, and learning retention in Visual Arts lessons for ninth-grade high school students. It is believed that in today's digital transformation process, visual arts education should not be limited to traditional methods but should be blended with technology. The main focus of the study was to scientifically reveal the differences in achievement and attitudes between groups created within an experimental design framework. Accordingly, significant differences between students' pre- and post-application achievement levels and their attitudes towards the course were analyzed. Furthermore, the extent to which the acquired gains are permanent was one of the fundamental questions the research sought to answer.

At the beginning of the research, it was determined that the academic achievement levels of the students in the experimental and control groups regarding the Visual Arts course were quite similar. The lack of a significant difference between the pre-test scores of the groups revealed that the students' cognitive entry characteristics were equivalent before the experiment. It was also determined that the initial attitudes of the experimental and control groups towards the Visual Arts course were similar and at a moderate level. The absence of a significant difference in attitude between the groups revealed that students' interest and approaches to the lesson showed a homogeneous distribution before the intervention.

After the intervention, it was determined that the academic achievement scores of the experimental group, which received artificial intelligence and STEAM-based instruction, increased significantly compared to the control group. This finding shows that interdisciplinary project-based approaches and digital tools strengthen the learning process in art education. AI-supported visual production and analysis activities contributed to students' deeper understanding of art criticism and aesthetic concepts. In parallel with the academic gains reported by Arpaci et al. (2023) in their STEAM-based science education studies, it was observed that learning outcomes were strengthened in this art-centered application. Zlateva's (2025) assessments regarding the effect of artificial intelligence on artistic creativity processes are consistent with this increase in achievement. The traditional method applied in the control group showed more limited improvement. The integration of algorithmic thinking and aesthetic perception by the students in the experimental group was decisive in raising their cognitive levels. Oanh and Dang's (2025) findings regarding the contribution of project-based learning to skill development also support these results. Consequently, the integration of artificial intelligence and STEAM has emerged as an effective teaching approach in enhancing academic achievement.

At the end of the experimental application, it was determined that the attitudes of the students in the experimental group towards the Visual Arts course were significantly more positive than those of the control group. The

integration of artificial intelligence tools into the lesson process increased students' motivation and interest in art. Digital artwork production and interactive design activities supported the active participation of students in the lesson. Xu's (2024) findings regarding the fact that virtual reality and digital media applications encourage creativity explain this increase in attitude. Similarly, it is consistent with Corrales Serrano's (2023) results that gamification and interaction-based methods increase student participation. The integration of technology with aesthetic values strengthened students' sense of belonging to the course. Bian et al.'s (2025) findings regarding the fact that artificial intelligence supports self-efficacy perception are also reflected in the attitude scale results. The lower attitude level in the control group suggests that traditional methods did not adequately align with students' digital life experiences. Consequently, technology-supported art education enabled students to develop a more positive attitude towards the course.

The results of the retention test conducted two months after the application showed that students in the experimental group retained what they learned significantly better than the control group. It was understood that STEAM and AI-supported applications are more effective in transferring information to long-term memory. Active production, project-based work, and collaborative learning processes increased the retention of learned information. Chen and Huang's (2023) findings that technology-supported learning supports permanent learning by balancing cognitive load support these results. Irdalisa et al.'s (2024) findings regarding the effect of using concrete materials and projects on learning retention were also confirmed in this study. The faster forgetting of information in the traditional method can be attributed to the passive learning structure. In conclusion, AI and STEAM-based teaching stands out as an effective approach that supports not only short-term academic success but also sustainable and permanent learning.

Implications

The findings of the research reveal that visual arts education needs to be restructured in line with the requirements of the digital age. The results have empirically supported the views regarding the central position of art within the STEAM approach. The study has shown that artificial intelligence is not only a technical tool; it is also an effective pedagogical component that supports students' cognitive development and academic success. Zlateva's (2025) assessments regarding the transformation experienced in creative processes have been confirmed by concrete successes at the high school level in this research. Application findings have revealed that the use of technology in art lessons positively affects student attitudes and that educators should utilize technology for pedagogical purposes rather than avoiding this process.

Theoretically, the study contributes to the literature on the need to consider visual arts education as an interdisciplinary learning area. Students' ability to solve complex problems artistically through technological tools has strengthened the strategic role of art education in acquiring 21st-century skills. Retention data confirmed that technology-supported instruction supports deeper processing of information and long-term learning. In this context, the findings provide curriculum developers with a strong scientific basis for integrating AI literacy into visual arts education.

Limitations

This research was conducted within specific limitations, and the results should be evaluated within this context. The sample was limited to a single high school in the Mamak district of Ankara. This makes it difficult to generalize the findings to students in different socio-economic backgrounds or different school types. Furthermore, since the study was conducted only on 9th-grade students, the potential effects at different grade levels are outside the scope of this research. The experimental process was limited to a six-session period, making it impossible to observe longer-term effects. The artificial intelligence tools and technological materials used are directly related to the school's existing technical infrastructure and internet access. The fact that not every school has the same technological resources constitutes an obstacle to the widespread adoption of such applications. The achievement test used in the research only covers the topics of the "Art Criticism and Aesthetics" unit and does not represent the entire visual arts curriculum. Students' individual technology use skills and technological resources at home remained uncontrolled variables affecting their learning processes. The status of traditional elements such as "manual dexterity" and "tactile experience" in art education in the face of technology could not be thoroughly examined in this study.

Recommendations

In light of the research findings, several recommendations have been developed for future studies and applications. Comprehensive in-service training programs should be organized for visual arts teachers to integrate artificial intelligence tools and STEAM methodology into their lessons. The art curriculum prepared by the Ministry of National Education should be updated to include digital literacy and artificial intelligence achievements. The technological infrastructure of schools should be improved to enable students to use digital tools in their artistic production. In future research, the effects of artificial intelligence applications at different grade levels and in different branches should be examined through mixed and longitudinal studies. Students' creative processes should be monitored not only through academic achievement but also through more in-depth methods such as qualitative observation and portfolio analysis. Mixed-methods research should be designed to find the ideal balance point between traditional methods and digital tools in art education. Special modules that will increase students' awareness of artificial intelligence ethics should be included in art lessons. Projects should be developed to address digital inequality between schools in different regions, ensuring that technology-supported arts education reaches every student. Finally, students' motivation in this field should be kept alive by organizing interdisciplinary competitions and exhibitions that combine art and technology.

Conclusion

The research has revealed that artificial intelligence and STEAM applications in visual arts education at the high school level are critically important in increasing academic achievement, attitude, and retention. It has been scientifically proven that art education can be transformed from a traditional handicraft course into a technological and scientifically profound one. The results clearly demonstrate the unifying power of art within STEAM and its contribution to students' 21st-century skills. The research provides a concrete and implementable roadmap for the

digital transformation of art lessons for education policymakers. It has been observed that artificial intelligence, when used with the right pedagogical methods, enriches the learning process instead of stifling artistic creativity. This study provides strong data to alleviate the anxieties experienced by art educators in the process of adapting to technological changes. It has contributed to the transformation of students from individuals who consume technology to individuals who produce it by blending it with aesthetic and ethical values. Furthermore, the research supports the idea that technology is an indispensable partner in the future of visual arts education and that this integration improves the quality of education.

References

Adamakis, M., & Rachiotis, T. (2025). Artificial intelligence in higher education: A state-of-the-art overview of pedagogical integrity, artificial intelligence literacy, and policy integration. *Encyclopedia, 5*(4), 180. https://doi.org/10.3390/encyclopedia5040180

Ahrenby, H., Häikiö, T. K., & Marklund, F. (2025). Teaching materials in visual arts education – policy and traditions. *Scandinavian Journal of Educational Research*, 1-13. https://doi.org/10.1080/00313831.2025.2516854

Arpaci, I., Dogru, M. S., Kanj, H., Ali, N., & Bahari, M. (2023). An experimental study on the implementation of a STEAM-based learning module in science education. *Sustainability, 15*(8), 6807. https://doi.org/10.3390/su15086807

Astaño, J. (2025). Trends and Challenges in the Classroom Implementation of Engineering Design Process (EDP): A Systematic Literature Review. *International Journal of Education Science*, *2*(1), 55-74.

Ayaydın, A., & Özsoy, V. (2011). Çoklu Zekâ Kuramı'na Dayalı Öğretimin İlköğretim 6. Sınıf Resim-İş Dersinde Öğrenci Tutumuna Etkisi. *Türk Eğitim Bilimleri Dergisi*, *9*(3), 497-518.

Bertrand, M. G., & Namukasa, I. K. (2023). A pedagogical model for STEAM education. *Journal of Research in Innovative Teaching, 16*(2), 169-191. https://doi.org/10.1108/JRIT-12-2021-0081

Bian, C., Wang, X., Huang, Y., Zhou, S., & Lu, W. (2025). Effects of AI-generated images in visual art education on students' classroom engagement, self-efficacy and cognitive load. *Humanities & Social Sciences Communications, 12*(1), 1548-14. https://doi.org/10.1057/s41599-025-05860-2

Çalışır, S. (2021). *Görsel sanatlar dersi öğretim programı (ortaokul) ve görsel sanatlar öğretmen kılavuz kitabı'nda çevre eğitimi* [Yayınlanmamış Yüksek Lisans Tezi], Anadolu Üniversitesi, Eğitim Bilimleri Enstitüsü, Eskişehir.

Chen, C., & Huang, P. (2023). The effects of STEAM-based mobile learning on learning achievement and cognitive load. *Interactive Learning Environments, 31*(1), 100-116. https://doi.org/10.1080/10494820.2020.1761838

Chen, X., Zou, D., Xie, H., Cheng, G., & Liu, C. (2022). Two decades of artificial intelligence in education: Contributors, collaborations, research topics, challenges, and future directions. *Educational Technology & Society, 25*(1), 28-47. https://doi.org/10.30191/ETS.202201_25(1).0003

Chen, Y. (2024). Integrating social-emotional learning in Chinese junior high school art education to foster mental health. *The Education Review, USA, 8*(2), 211-215. https://doi.org/10.26855/er.2024.02.002

Chiu, M., & Hwang, G. (2024). Enhancing students' critical thinking and creative thinking: An integrated mind

mapping and robot-based learning approach. *Education and Information Technologies, 29*(17), 22779-22812. https://doi.org/10.1007/s10639-024-12752-6

Christ, A., Penthin, M., & Kröner, S. (2021). Big data and digital aesthetic, arts, and cultural education: Hot spots of current quantitative research. *Social Science Computer Review, 39*(5), 1-23. https://doi.org/10.1177/0894439319888455

Clark-Fookes, T. (2025). Arts education's wicked problem: Tensions between reliability and validity in arts assessment. *Arts Education Policy Review*, 1-15. https://doi.org/10.1080/10632913.2025.2515044

Corrales Serrano, M. (2023). Gamification and the history of art in secondary education: A didactic intervention. *Education Sciences, 13*(4), 389. https://doi.org/10.3390/educsci13040389

Coskun, E. (2025). An investigation of the relationship between academic self-efficacy, achievement motivation, and smartphone addiction. *International Journal on Studies in Education, 7*(4), 959-977.

Dignam, C. (2024). Harmonies on the String: Exploring the Synergy of Music and STEM. *International Journal of Technology in Education and Science*, *8*(3), 491-521.

Dignam, C. (2025). Makerspace and the 5 C's of learning: Constructing, collaborating, communicating, critically-thinking, and creatively-thinking. *International Journal of Studies in Education and Science*, *6*(1), 104-127.

Dignam, C., Pennington, L. K., & Daifallah, A. (2024). Beyond the Acronym: Interconnections of STEAM, the Humanities, and Digital Citizenship. *International Journal on Social and Education Sciences*, *6*(3), 452-480.

Dignam, C., Sexton, R., & Muñoz, X. (2025). Beyond the acronym: Interlacing STEAM, special education, and guiding inquiry. *International Journal on Studies in Education*, *7*(2), 304-330.

Erol, M., & Erol, A. (2023). Reflections of STEAM Education on Children According to Early Childhood and Primary School Teachers. *International Journal on Social and Education Sciences*, *5*(3), 493-506.

Essuman, B., Essel, H. B., Steiner, R., Akuteye, A. D., & Essuman, A. B. (2025). Digital literacy, motivation, self-regulation, interest, and task difficulty as predictors of performance in online learning: A path analysis. *International Journal of Current Educational Studies*, *4*(1), 23-46.

Fang, F., & Jiang, X. (2024). The analysis of artificial intelligence digital technology in art education under the internet of things. *IEEE Access, 12*, 1-1. https://doi.org/10.1109/ACCESS.2024.3363655

Garcia-Lazo, V., Donoso, V., Springinzeisz, K., & Jeldres, R. (2024). The potential of visual arts education: Strengthening Pre-Service primary teachers' cultural identity. *The International Journal of Art & Design Education, 43*(2), 221-240. https://doi.org/10.1111/jade.12499

Gış, H., & Topal, A. D. (2025). Sanatta dijital dönüşüm: Görsel sanatlar eğitiminde teknoloji entegrasyonuna yönelik eğilimler ve bulgular. *Academic Journal of Information Technology, 16*(4), 402-421. https://doi.org/10.5824/ajite.2025.04.005.x

Graham, M. A. (2021). The disciplinary borderlands of education: Art and STEAM education (los límites disciplinares de la educación: Arte y educación STEAM). *Infancia y Aprendizaje, 44*(4), 769. https://doi.org/10.1080/02103702.2021.1926163

Heaton, R. (2025). Making peace with artificial intelligence (AI) in art education. *The International Journal of Art & Design Education*. https://doi.org/10.1111/jade.12614

Houghton, T., Lavicza, Z., Rahmadi, I. F., Diego-Mantecón, J.-M., Fenyvesi, K., Weinhandl, R., & Ortiz-Laso,

Z. (2022). STEAMTEACH Austria : Towards a STEAM Professional Development Program. *International Journal of Research In Education and Science, 8*(3), 502-512. https://doi.org/10.46328/ijres.2747

Ijalo, A. I. (2025). VODCast as a Tool for Flipped General Physics. *International Journal of Technology in Education Science*, *2*(2), 168-187.

Irdalisa, I., Zulherman, Z., Elvianasti, M., Widodo, S. A., & Hanum, E. (2024). Effectiveness of project-based learning on STEAM-based student's worksheet analysis with ecoprint technique. *International Journal of Educational Methodology, 10*(1), 923-935. https://doi.org/10.12973/ijem.10.1.923

Kara, S. (2021). An Investigation of Technological Pedagogical and Content Knowledge (TPACK) Competencies of Pre-Service Visual Arts Teachers. *International Journal of Technology in Education, 4*(3), 527-541.

Karampelas, K. (2025). Investigating the Relationship between STEAM and NOS Education Bibliometrically. *International Journal of Education in Mathematics, Science and Technology*, *13*(2), 357-383.

Karlsson Häikiö, T. (2022). Challenges and changes in arts education in Sweden -- visual communication, visual culture and visual competence in the syllabus for visual arts. *Journal of Visual Literacy, 41*(3-4), 201. https://doi.org/10.1080/1051144X.2022.2132621

Kaşarcı, İ., Akın Demircan, Z., Çeliker Ercan, G., & İnci, T. (2025). Managing Artificial Intelligence Ethics in Higher Education: A Systematic Framework for Issues and Policy Recommendations. *International Journal of Current Educational Studies, 4*(2), 112-137. https://doi.org/10.46328/ijces.223

Kastner, L., Umbach, N., Jusyte, A., Cervera-Torres, S., Fernández, S. R., Nommensen, S., & Gerjets, P. (2021). Designing visual-arts education programs for transfer effects: Development and experimental evaluation of (digital) drawing courses in the art museum designed to promote adolescents' socio-emotional skills. *Frontiers in Psychology, 11*, 603984. https://doi.org/10.3389/fpsyg.2020.603984

Kibici, V. B. (2025a). New Trends in Music Education: Technological Approaches from a 21st-Century Perspective. *Studies on Education, Science, and Technology 2025*, 160.

Kibici, V.B. (2025b). Examining the digital literacy and artificial intelligence attitudes of university students studying arts. *International Journal of Education in Mathematics, Science, and Technology (IJEMST)*, 13(5), 1283-1297. https://doi.org/10.46328/ijemst.5839

Kretzschmar, V., Sailer, A., Wertenauer, M., & Seitz, J. (2024). Enhanced educational experiences through personalized and AI-based learning. *International Journal on Studies in Education (IJonSE), 6*(2), 191-209. https://doi.org/10.46328/ijonse.206

Le, S. (2023). Team-based learning in online education: The development of students' creative thinking skills in digital art. *Education and Information Technologies, 28*(11), 14967-14986. https://doi.org/10.1007/s10639-023-11808-3

Li, S., & Gu, X. (2023). A risk framework for human-centered artificial intelligence in education: Based on literature review and delphi-AHP method. *Educational Technology & Society, 26*(1), 187-202. https://doi.org/10.30191/ETS.202301_26(1).0014

Liao, C., Chen, H., Chen, B., Wang, I., Ho, W., & Huang, W. (2025). Exploring the application of text-to-image generation technology in art education at vocational senior high schools in Taiwan. *Information, 16*(5), 341. https://doi.org/10.3390/info16050341

Lilliedahl, J. (2022). Why the arts are not considered core knowledge in secondary education: A Bernsteinian analysis. *Journal of Curriculum Studies, 54*(2), 165-178. https://doi.org/10.1080/00220272.2021.1925971

Mayanti, A. N. R., & Widiyatmoko, A. (2025). The Effect of Canva-Assisted" PjBLSTEAM" to Improve Creative Thinking and Collaboration on Energy Concept. *International Journal of Technology in Education and Science*, *9*(3), 299-321.

Morales, M. P. E., Mercado, F. M., Palisoc, C. P., Palomar, B. C., Avilla, R. A., Sarmiento, C. P., ... & Ayuste, T. O. D. (2021). Teacher Professional Development Program (TPDP) for Teacher Quality in STEAM Education. *International Journal of Research in Education and Science*, *7*(1), 188-206.

Mun, K. (2022). Aesthetics and STEAM education: The case of Korean STEAM curricula at the art high school. *International Journal of Science Education, 44*(5), 854-872. https://doi.org/10.1080/09500693.2021.2011467

Munoz, S. R. (2024). *Original without an aura: How AI art intersects with visual arts education*.

Nurramadhani, A., Kumala, F., & Permana, I. (2021). STEAM-based project learning: The effect to middle school's student's collaboration competences. *Journal of Physics: Conference Series, 2098*(1), 12038. https://doi.org/10.1088/1742-6596/2098/1/012038

Oanh, D. T. K., & Dang, T. D. H. (2025). Effect of STEAM project-based learning on engineering students' 21st century skills. *European Journal of Educational Research, 14*(3), 705-721. https://doi.org/10.12973/eu-jer.14.3.705

Onuorah, B. O., Ekwam, E. O., Okebukola, P., Ahove, M., & Ugwuoke, U. (2025). Effect of technology-education-art (TEA) artificial intelligence model on students' attitude toward biological drawing. *Journal of Applied Research in Higher Education*, 1-11. https://doi.org/10.1108/JARHE-12-2024-0730

Osei-Bonsu, R. (2024). Gender Lens in STEM Education: General Overview of Access, Distribution, and Disparities. *International journal of Technology in Education Science*, *1*(1), 1-28.

Özdemir, S. (2023). *Lise öğrencileri için sanal ortamla desteklenen görsel sanatlar eğitimi*. [Yayınlanmamış Doktora Tezi], Ankara Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.

Özsoy, V. (2022). *Eğitimde görsel sanatlar* (1. baskı). Pegem Akademi Yayıncılık.

Samarescu, N., Bumbac, R., Zamfiroiu, A., & Iorgulescu, M. C. (2024). Artificial intelligence in education: Next-gen teacher perspectives. *Amfiteatru Economic, 26*(65), 145-161. https://doi.org/10.24818/EA/2024/65/145

Shettar, M. R., Lathiwale, Z. S. M., & Kulhalli, M. (2021). The role of ICT in higher education in selected places during COVID-19. *Journal of Research in Social Sciences and Language*, *1*(1), 42-54.

Shi, Y. (2025). Multimodal teaching in digital media arts education: Insights and challenges from teachers' perspectives. *Cogent Education, 12*(1). https://doi.org/10.1080/2331186X.2025.2590849

Tenhovirta, S., Korhonen, T., Seitamaa-Hakkarainen, P., & Hakkarainen, K. (2022). Cross-age peer tutoring in a technology-enhanced STEAM project at a lower secondary school. *International Journal of Technology and Design Education, 32*(3), 1701-1723. https://doi.org/10.1007/s10798-021-09674-6

Wang, S., Wang, H., Lu, Y., & Huang, J. (2024). Toward a comprehensive evaluation of student knowledge assessment for art education: A hybrid approach by data mining and machine learning. *Applied Sciences, 14*(12), 5020. https://doi.org/10.3390/app14125020

Wu, Y., Cheng, J., & Koszalka, T. A. (2021). Transdisciplinary approach in middle school: A case study of co-teaching practices in STEAM teams. *International Journal of Education in Mathematics, Science, and Technology (IJEMST), 9*(1), 138-162. https://doi.org/10.46328/ijemst.1017

Xiao, L., An, X., Chen, N., & Chen, B. (2024). The children's psychological emotion recognition on STEAM education. *Current Psychology, 43*(37), 29738-29749. https://doi.org/10.1007/s12144-024-06618-w

Xu, B. (2024). Practice of digital media art education based on virtual reality technology. *Journal of Electrical Systems, 20*(3s), 1714-1723. https://doi.org/10.52783/jes.1711

Yim, I. H. Y., Su, J., & Wegerif, R. (2025). STEAM in practice and research in primary schools: A systematic literature review. *Research in Science & Technological Education, 43*(4), 1065-1089. https://doi.org/10.1080/02635143.2024.2440424

Zlateva, A. (2025). Artificial intelligence in art education: Transforming visual arts training. *International Journal of Cognitive Research in Science, Engineering and Education, 13*(2), 481-489. https://doi.org/10.23947/2334-8496-2025-13-2-481-489