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

The Impact of STEAM-Based Music Education on Middle School Students' Learning Outcomes and Creative Thinking Skills

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Article Info

Article History

Received:
2 February 2026

Revised:
13 May 2026

Accepted:
12 June 2026

Published:
18 June 2026

Keywords

STEAM
Music teaching
Creative thinking
Art education
Middle school students

Abstract

The aim of this research is to examine the effect of STEAM-based music instruction on the music lesson achievements and creative thinking skills of seventh-grade middle school students. A quasi-experimental design with an unpaired pre-test-post-test control group, a quantitative research method, was used in the study. The study group consisted of a total of 64 seventh-grade students attending a middle school in Mersin province during the 2025-2026 academic year. STEAM-based music activities were implemented in the experimental group, while traditional music instruction continued in the control group. The application process was planned for four weeks, with two lesson hours per week. The Music Lesson Achievement Scale and the Kaufman Creativity Scale, developed by the researcher, were used as data collection tools. The applications carried out in the experimental group consisted of interdisciplinary activities such as sound formation, the mathematical structure of rhythm, coding-based melody production, and audio story design. In this process, students produced products by using science, technology, engineering, art, and mathematics fields in an integrated manner. In the control group, a traditional teaching method based on the curriculum, teacher-centered, note reading, rhythm studies, and singing was applied. The data obtained were analyzed using the SPSS program, and independent samples t-tests were applied for intergroup comparisons. The research findings showed that STEAM-based music teaching had significant and positive effects on students' music lesson outcomes and creative thinking skills. Significant improvements were observed, particularly in the dimensions of fluency, flexibility, originality, and elaboration. In conclusion, it was observed that STEAM-based music teaching significantly improved both students' academic achievements and creative thinking skills. Therefore, it is recommended that more interdisciplinary activities be included in music lessons, that STEAM-based in-service training for teachers be increased, and that curricula be restructured to support this approach.

Citation: Sarikaya, M. & Kibici, V. B. (2026). The impact of STEAM-based music education on middle school students' learning outcomes and creative thinking skills. *International Journal of Technology in Education (IJTE), 9*(3), 897-913. https://doi.org/10.46328/ijte.8186

Introduction

With the acceleration of digitalization, the boundaries between art and technology have become increasingly permeable; this has brought about a transformation in the content and teaching methods of music education. Specifically in music education, Huang (2020) states that music learning supported by technological tools strengthens the capacity to build interdisciplinary conceptual bridges. Similarly, Özer and Demirbatır (2023a) demonstrate that digital applications support student-centered learning experiences. In this context, music education is considered a strong area for the application of the STEAM approach because it encompasses both aesthetic and cognitive dimensions. The STEAM approach stands out as an interdisciplinary learning framework integrating science, technology, engineering, art, and mathematics. As emphasized by Liao (2016) and Perignat and Katz-Buonincontro (2019), this approach not only brings together different disciplines but also transforms learning into a multidimensional and production-based structure. When combined with the design-oriented thinking perspective expressed by Henriksen (2017), STEAM offers a learning environment that holistically develops students' problem-solving, creativity, and critical thinking skills. Aguilera and Ortiz-Revilla (2021) demonstrate that the STEAM approach makes creativity more visible compared to STEM. In this context, Allina (2018) states that STEAM is not only a pedagogical model but also an approach that supports social empowerment. Furthermore, Hughes et al. (2022) state that the inclusion of the art component in learning processes increases conceptual participation and inclusivity.

The middle school period is a critical period in which students' cognitive development accelerates and their creative thinking skills are shaped. It is known that learning experiences during this period directly affect both students' academic achievements and higher-order thinking skills (Demirel et al., 2025). STEAM-based music teaching has the potential to develop not only students' musical knowledge and skills but also their creative production, problem-solving, and interdisciplinary thinking capacities. However, a review of the literature reveals that the conceptual boundaries of STEAM integration in the context of music education are not clear, and practices vary according to different approaches. Boice et al. (2024) state that teachers' understanding of STEAM is heterogeneous and that practices do not converge around a common model; while Perignat and Katz-Buonincontro (2019) indicate that the field exhibits a fragmented appearance in terms of theoretical integrity and evaluation criteria. Amanova et al. (2025), on the other hand, emphasize that variables such as teacher competence, planning, and resources are decisive in the sustainability of practices.

The limited number of studies, particularly in the context of music education, highlights the theoretical and practical gaps in this field (Milosavljević Đukić et al., 2025; Semenikhina et al., 2024). However, it is noteworthy that many existing practices are often tool-centered, with pedagogical integrity taking a backseat. Özer and Demirbatır (2023a) and Leavy et al. (2023) emphasize that while digital tools are becoming widespread in learning environments, this use is not always supported by an explicit instructional design. Furthermore, Phanichraksaphong and Tsai (2021) demonstrate that technology integration offers new possibilities for assessment processes, but these processes must be structured in a way that is consistent with instructional objectives. In this context, the STEAM approach in music education should not only focus on technological innovations but also address the content, process, and assessment dimensions in a holistic manner. This research aims to contribute to filling conceptual and practical gaps in the literature by examining the impact of STEAM-based music instruction on the achievements and creative thinking skills of middle school students.

STEAM and Interdisciplinary Integration

Interdisciplinary integration requires not only the juxtaposition of different course contents but also the establishment of functional relationships between types of knowledge. In this context, art integration creates a continuity extending from interdisciplinarity to transdisciplinary learning (Liao, 2016). STEAM produces learning experiences that strengthen student skills (Bertrand & Namukasa, 2020). However, conceptual flexibility and diversity of representation need to be developed together in order to transfer problem-solving to different areas (Priemer et al., 2020). Indeed, successful integration in school-based STEAM applications is possible through content coordination, teacher collaboration, and flexible pedagogical planning (Amanova et al., 2025). However, the fact that teachers do not interpret STEAM in the same way leads to a high degree of application diversity (Boice et al., 2024). Accordingly, for interdisciplinary integration to be successful, a common theme, production task, and evaluation logic must be simultaneously constructed. Therefore, STEAM integration in the context of music education; STEAM is seen as a planned pedagogical structure that brings together sound, rhythm, design, coding, and problem-solving elements in a common learning architecture (Deák & Kumar, 2024).

In the STEAM approach, how different knowledge fields are integrated around common learning goals is a fundamental topic of discussion. In this regard, the transdisciplinary approach places art integration at the center of learning design, moving it away from a superficial addition logic (Liao, 2016). Furthermore, design thinking functions as a creative interface that structures STEAM integration (Henriksen, 2017). Considering art alongside STEM fields plays a role in strengthening learning equity and participation (Hughes et al., 2022). In addition, problem-solving processes offer deeper learning opportunities when supported by interdisciplinary representational diversity (Priemer et al., 2020). Digital competencies have a transformative function within this integrated structure (Deák & Kumar, 2024). Therefore, the relationship between STEAM and interdisciplinary integration offers a strong explanatory basis, both theoretically and practically, in fields involving multiple modalities such as music education.

STEAM-Based Applications in Music Education and the Development of Creative Thinking Skills

STEAM-based applications in music education have become a subject of increasing research in recent years because they combine aesthetic experience with technological production in the same learning process. In this context, music's position within STEAM is not limited solely to artistic expression, but also fosters pattern, system, and design thinking (Huang, 2020). In addition, digital learning tools create interactive learning environments that concretize the STEAM logic in music education (Özer & Demirbatır, 2023a). The STEAM approach within music education offers a structure that moves the student from a passive recipient to a producer (Milosavljević Đukić et al., 2025). Although music-based STEAM applications are implemented with varying tools in different countries, they commonly prioritize experiential learning (Semenikhina et al., 2024). Similarly, the use of emerging technologies in STEAM environments strengthens creative participation and interdisciplinary interaction (Leavy et al., 2023). Therefore, this approach transforms music lessons from one-dimensional skill instruction into a multi-component learning ecosystem. A significant portion of STEAM-based applications in music education are structured through coding, physical interaction, and digital production tools. In this context, LEGO-based music notation activities offer learning opportunities that support algorithmic thinking at the primary school level (Baratè et al., 2017). Additionally, algorithmic thinking activities established within a musical context make abstract programming concepts more accessible to students (Bell & Bell, 2018). Learning environments that combine music production with coding experiences offer various opportunities, particularly in terms of participation and creativity (Magerko et al., 2016). Scratch and Makey-based activities demonstrate that students can simultaneously use both engineering and musical thinking skills while designing their own instruments (Özer & Demirbatır, 2023b). Furthermore, advanced applications such as automated piano performance evaluation are transforming the assessment dimension in technology integration (Phanichraksaphong & Tsai, 2021). Therefore, STEAM-based applications in music education, along with the diversification of production tools, make learning more experiential, interactive, and enjoyable.

Creative thinking is considered a central skill within the STEAM context due to the originality, flexibility, and expressive dimensions inherent in music education. In this context, Aguilera and Ortiz-Revilla (2021) state that indicators of creativity emerge in STEAM activities and that art integration enhances this visibility. Similarly, Allina (2018) emphasizes that creativity is linked not only to individual production but also to social participation and subjectification processes. Kuo et al. (2019) state that interdisciplinary project-based processes simultaneously support learning motivation and creativity. Accordingly, music education is considered a field where creative thinking can naturally emerge through tasks focused on sonic experimentation, improvisation, composition, and design. Therefore, the STEAM approach offers a theoretical and pedagogical framework that systematically supports the creative potential in music education. The development of creative thinking is not limited solely to producing original work, but also encompasses the skills of generating ideas, developing alternatives, and evaluating them within the process. In this context, Sakon and Petsangsri (2021) state that STEAM-based design processes produce structured but flexible learning environments that enhance creativity. Sun et al. (2021) indicate that STEM applications support creative problem-solving. Wu et al. (2025) state that creativity styles, when considered together with learning participation and motivation, constitute an important variable in explaining the quality of STEAM experiences. Similarly, the research findings of Güney and Sever (2025) show that STEAM-based music activities support critical thinking tendencies, and this can be interpreted together with creative production processes. Therefore, developing creative thinking in music education requires learning designs that go beyond product-oriented outputs and include process-oriented exploration, reflection, and redesign stages. Consequently, this study aims to both highlight the gap in the field and offer a conceptual orientation towards application by addressing the axes of STEAM and interdisciplinary integration, STEAM-based applications in music education, and the development of creative thinking skills.

The main objective of this research is to examine the effect of STEAM-based music instruction on the music lesson outcomes and creative thinking skills of middle school students. In line with this general objective, the following sub-objectives were addressed:

1. Is there a significant difference in music lesson achievement scores between the experimental group, which received STEAM-based music instruction, and the control group, which received traditional instruction?
2. Is there a significant difference in creative thinking skills scores between the experimental group, which received STEAM-based music instruction, and the control group?

Method

Research Model

This study utilized a quantitative research method. The study, which examined the effects of a STEM-based teaching program on the learning outcomes and creativity of students in the experimental group and a traditional teaching method in the control group, employed an unpaired pre-test-post-test control group quasi-experimental design. Since there was no random assignment of subjects in the study, it is quasi-experimental. “In unpaired control group designs, care should be taken to ensure that the participants in the groups have similar characteristics, and the formation of the groups should be as unbiased as possible” (Robson, 2011). Robson (2011) mentioned that quasi-experimental designs should be used when random assignment to groups is not possible. Table 1 shows the design of the research.

Table 1. Research Design

Group	Pre Test	4-Week Application	Post Test
Experimental Group (STEAM)	M1	STEAM-based music events	M3
Control Group	M2	Traditional music teaching	M4

In this study, the dependent variables were identified as students' music lesson achievement scores and creative thinking skills scores. The independent variable was the teaching method, consisting of two different approaches: STEAM-based music education and traditional music teaching.

Research Group

The study group for this research consists of a total of 64 7th-grade students, selected randomly from 7th-grade classes in middle schools affiliated with the Ministry of National Education in Mersin Province during the 2025-2026 academic year. Two 7th-grade classes were chosen (experimental group: 32 students) and two 7th-grade classes were chosen (control group: 32 students). The experimental group comprises 16 girls and 16 boys. The control group comprises 17 boys and 15 girls. The selection of the study group considered the overall student population, class size, and the availability of technological resources.

Experimental Application Process

• Duration: 2 lesson hours per week (total 8 lesson hours + pre-test/post-test).

• Control group: Curriculum-based, teacher-centered, note reading, singing, rhythm exercises. • Experimental group: STEAM-based projects (music + science, technology, engineering, mathematics, visual arts).
Before the experimental applications of the research, the music lesson achievement scale and the Kaufman creativity scale were administered simultaneously to the experimental and control groups as pre-tests.

Procedures Performed in the Experimental Group

Week Composition: The Hidden World of Sound – The Dance of Science and Music
Activity Name: Vibrating Sounds, Playing Boxes
In the first week of the application, we started by asking the most basic question with the students in the experimental group: "How is sound produced?" This question allowed them to examine a phenomenon they hear about in daily life but never question, through a scientific and artistic lens. First, a small experiment was conducted by building a bridge of science. Students were asked to vibrate a ruler by hanging it from the edge of the table at different lengths. We discovered that when the longer part of the ruler hung down, it produced a thicker sound, and when it remained short, it produced a higher-pitched sound. Then, when we dipped a tuning fork into a container of water, the water droplets scattered around created a magical moment where the vibration became visible. The sparkle in the eyes of a student who said, "So sound is actually movement!" showed that we had achieved our goal at that moment. On the technology side, we visualized sound waves with “Chrome Music Lab – Spectrogram.” When a student played the flute, colorful waves danced on the screen. For the mathematical connection, we plotted the relationship between these wavelengths and pitch (high/low) in simple graphs. The most exciting moment of the week was the engineering design: Each student designed their own musical instrument using materials they brought from home, such as boxes, rubber bands, wooden spoons, cardboard, and rubber bands of different sizes. One student made a “box guitar” by stretching five different rubber bands; another created a “water xylophone” by filling plastic bottles with water at different levels. By the end of the week, students answered the question “What is sound?” not just with a memorized definition, but with the vibrations they produced with their own instruments. A significant increase in the fluency of their creative thinking skills was observed: They were able to generate 5-6 different ideas for producing sound with ordinary materials.

Week 2 Composition: The Mathematics of Rhythm – When Fractions Are Beaten
Activity Name: My Body Is a Rhythm Machine
We started the second week by connecting it to fractions, which they were familiar with from math class. We used a complete cake model to explain to the students what 4/4, 3/4, and 2/4 meant in a measure. When the cake was divided into four equal slices, each slice represented a quarter beat. With fun questions like, "If we eat half of a cake, how many beats are left?", rhythm went from being an abstract concept to concrete mathematics. In the music application, students first created a 4/4 rhythm phrase with body percussion (hand clapping, chest beating, finger snapping). Then, with the support of technology, they used a web tool called "Incredibox". In this tool, they created original rhythm patterns by arranging beatbox sounds according to fraction values using a drag-and-drop method. In the engineering design dimension, "Rhythm Stick Design" was created. Students observed that wooden sticks cut to different lengths produced different sounds when struck against the floor.

One group even constructed a small "rhythm ladder" by cutting these sticks in specific proportions (mathematical ratios). This week's creative output: Each student wrote an original four-measure rhythmic phrase and presented it to the class, first using body percussion, then with their own designed rhythm stick. One student's rhythm was so interesting that their classmates said, "You should make this the soundtrack for a video game!" This feedback demonstrated the development of creative thinking in terms of flexibility and originality.

Week 3 Composition: Coding Melodies – Music Production with Scratch
Activity Name: Block by Block Melody
In the third week, students had now understood the nature of sound and the mathematical structure of rhythm. It was time to bring melody together with technology. This week, which began with the question "How do we describe a melody to a computer?", turned into a coding workshop. Science and music integration: First, we talked about the prevalence of the pentatonic (five-note) scale in nature. Students were surprised when I said, "Almost all children's songs in the world are made with these five notes." Then we introduced these five notes (do-re-mi-sol-la) as numerical values in the Scratch program. With Scratch's "Music Extension," each note was converted into a number: 60 = Do, 62 = Re, 64 = Mi, 67 = Sol, 69 = La, etc. Students coded a simple melody with drag-and-drop blocks. "What happens if we play note number 64 for 4 seconds?" Through exploratory questions like these, they obtained different melodies by changing the duration and note. The most creative moment occurred in the integration of visual arts: Each student matched the melody they coded with a color palette. For example, a cheerful melody was represented by yellow-orange lines, and a sad melody by blue-purple waves. The result was a product we called "visual music." At the end of the week, each student both played the 8-second melody they coded in Scratch on the computer and displayed it on the board with the visual abstraction they drew. The detailing aspect of creativity increased significantly this week: Students added subtleties such as tempo changes and echo effects to their melodies.

Week 4 Composition: Audio Story Workshop – A Space Journey
Activity Name: Stories Woven with Sounds
The last week was a final project where all STEAM components came together: designing a 1-minute audio story. We chose "Space Journey" as the theme because it offered rich opportunities in terms of both science (sound doesn't travel in space, so how do you make music?) and engineering (sound effects). Students were divided into teams of 4. Each team first wrote the scenario of the story: a rocket launch, a journey among the stars, landing on an alien planet, and what happens there. Then they moved on to music design. Some teams produced "alien sounds" using simple musical instruments they made in Week 1 (for example, a buzzing sound by putting paper over a comb). Some teams created robotic tapping sounds using a simple electronic circuit (buzzer, battery, resistor) – this was an engineering marvel. In terms of technology, they recorded sounds using Audacity software, layered them, and adjusted their speeds. Mathematically, they made sure the durations did not exceed 60 seconds. As for visual arts, they designed an "album cover" for their stories. In the last lesson of the week, each team presented their audio stories to the class. The lights were turned off; only sounds and imagination remained. One team's rhythmic ascent depicting a rocket launch thrilled the entire class. Another team's metallic sound effects designed for the "talking stones" they encountered on an alien planet were a pinnacle of creativity. This activity combined all sub-dimensions of creative thinking (fluency, flexibility,

originality, detail) in a single product. In addition, the learning outcomes of music lessons (rhythm, melody, timbre, emotional expression) were learned in a natural and lasting way.

Control Group Activities (4 Weeks, Traditional Music Teaching)

In the control group, traditional music teaching based on the existing curriculum, teacher-centered, and note-based was implemented for 4 weeks. In the first week, students were introduced to the definition of sound, note names (do, re, mi, fa, sol, la, si) were shown on the board, and simple rhythm patterns (e.g., “clap your hands – tap your knees”) were repeated with a metronome. In the second week, the concept of time signature (4/4, 3/4) was explained, students practiced the rhythm of a simple song like “Ah Venedik” by clapping, and memorized the lyrics. In the third week, melodic patterns were shown on the staff, students imitated the melody of “İzmir’in Kavakları” in turn with their flutes or voices, and worked on written note values (whole notes, half notes, quarter notes). In the fourth week, students were asked to sing two songs (e.g., “Mutlu Yıllar” and “Küçük Kurbağa”) in turn and accompany them with rhythmic accompaniment, and a listening test and a written achievement test were administered for end-of-term evaluation. Throughout the process, there was no integration of STEAM, coding, science experiments, mathematical modeling, or engineering design; the lessons were entirely structured around music theory, notation reading, singing, and rhythm repetition.

Following the experimental applications of the research, the music lesson achievement scale and the Kaufman creativity scale were administered simultaneously to the experimental and control groups as post-tests.

Data Collection Tools

7th Grade Music Lesson Learning Outcomes Scale

The 7th Grade Music Lesson Achievement Scale was developed to measure the learning outcomes of students at this grade level. While developing the 7th Grade Music Lesson Achievement Scale, the curriculum was examined, and statements representing the learning outcomes were included. In this way, 12 questions were prepared to ensure the content validity of the 7th Grade Music Lesson Achievement Scale. Furthermore, the prepared questions were revised by consulting with music teachers and instructors. A 5-point rating system was used in the scoring of the scale. If a student fully achieved the relevant music learning outcome, they received a score of 5; if they achieved it only partially, they received a score of 1. The lowest possible score for each item on the scale is 1, and the highest is 5. Item-total correlation analyses were conducted during the validity process of the 7th Grade Music Lesson Achievement Scale. The analyses showed that all items in the scale had high and significant correlations with the total scores. The Cronbach's reliability coefficient for the 7th grade music lesson achievement scale was calculated as 0.86.

Kaufman Creativity Test

This study used the Kaufman Creativity Scale, developed by Kaufman (2012), to measure the creativity of seventh-grade middle school students. This scale was adapted into Turkish by Şahin (2016). The Turkish form of the Kaufman Creativity Test consists of 42 items on a 5-point Likert scale. The rating is from "very little-1" to "very much-5". There are no items that can be calculated by reversing the scale. Construct validity studies were conducted using factor analysis, and the reliability of the KCT was calculated using Cronbach's alpha internal consistency coefficient. The Cronbach's alpha internal consistency reliability coefficients ranged from 0.85 for the entire scale and from 0.74 to 0.89 for the subscales. Acceptable reliability coefficients were found for both the subscales and the total scale. Based on the data obtained in this research, the Cronbach's alpha internal consistency reliability coefficients of the creativity perception scale were found to be 0.83 for the entire scale and between .72 and .89 for the subscales.

Data Analysis Techniques

In line with the research objectives, the study examined whether there were significant differences between the experimental and control groups in terms of music lesson achievement and creativity. Data collected during the research period using the Kuafman Creativity Scale (pre-test-post-test) for music lesson achievement (pre-test-post-test) were analyzed using the SPSS program. The data obtained from the measurement instruments used in the research met the assumptions of normal distribution. In this context, an independent samples t-test analysis was conducted to determine whether there was a significant difference between the pre-test/post-test achievement and creativity of the experimental and control groups. The independent samples t-test is used to test whether the difference between the means of two independent samples is significant.

Findings

Table 2 presents the t-test analyses conducted on the pre-test scores of the seventh-grade music lesson achievement scale participants in the experimental and control groups.

Table 2. Comparison of Pre-Test Scores of the Music Lesson Achievement Scale in the Experimental and Control Groups

Pre-Test	Group	N	Mean	Std. Deviation	t	p
Achievement	Experimental	32	3.70	0.64	-0.181	0.857
	Control	32	3.73	0.44		

According to the analyses, a t-value of 0.181 was calculated between the mean pre-test achievement scores of the experimental and control groups in music lessons. Based on this finding, it can be said that the two groups showed a similar distribution of music lesson achievements at the beginning of the study.

As shown in Table 3, the pre-test scores of participants in the experimental and control groups on the sub-dimensions of the Kaufman Creativity Scale were compared. According to the analyses, the t-values were calculated as follows: Academic Creativity subscale: 0.181, Scientific/Mechanical Creativity subscale: 0.177, Artistic Performance Creativity subscale: 0.614, Self/Daily Creativity subscale: 0.583, and Artistic Creativity subscale: 0.412. Based on these t-values, no significant difference was found between the pre-test scores of the children in the experimental and control groups on the Kaufman Creativity Scale (p>0.05). It can be said that the creativity levels of the students in the experimental and control groups were equivalent before the experimental applications of the research.

Table 3. Comparison of Kaufman Creativity Scale Pre-Test Scores of Experimental and Control Groups

Pre-Test	Group	N	Mean	Std. Deviation	t	p
Academic Creativity	Experimental	32	3.04	0.77	0.223	0.825
	Control	32	3.00	0.80		
Scientific/ Mechanical Creativity	Experimental	32	2.82	0.69	-0.177	0.860
	Control	32	2.84	0.57		
Creativity in the Field of Artistic Performance	Experimental	32	3.56	0.98	-0.614	0.542
	Control	32	3.72	1.05		
Self/ Daily Creativity	Experimental	32	3.06	0.98	-0.583	0.562
	Control	32	3.22	1.16		
Artistic Creativity	Experimental	32	3.38	0.75	-0.412	0.682
	Control	32	3.47	1.05		

Table 4 shows the t-test analyses performed on the post-test scores of the seventh-grade music lesson achievement scale participants in the experimental and control groups.

Table 4. Comparison of Post-Test Scores of Experimental and Control Groups on the Music Lesson Achievement Scale

Post-Test	Group	N	Mean	Std. Deviation	t	p
Achievement	Experimental	32	4.22	0.49	2.151	0.035*
	Control	32	3.92	0.62		

*p<0.05

According to the analyses, a t-value of 2.51 was calculated between the mean post-test achievement scores of the experimental and control groups. This value indicates a significant difference in music achievement between the experimental and control groups after the research experimental applications. Based on the group averages, it can be said that the students in the experimental group, where STEM application was carried out, achieved higher music achievements compared to their peers in the control group.

Table 5 compares the post-test scores of participants in the experimental and control groups on the sub-dimensions of the Kaufman Creativity Scale. According to the analyses, the t-values were calculated as follows: Academic Creativity subscale: 2.245, Scientific/Mechanical Creativity subscale: 2.301, Artistic Performance Creativity subscale: 0.576, Self/Daily Creativity subscale: 0.273, and Artistic Creativity subscale: 0.728. Based on these t-values, a significant difference was found between the post-test scores of the children in the experimental and control groups in the academic creativity and scientific/mechanical creativity subscales (p<0.05). According to the means of the groups, the students in the experimental group, where STEM application was carried out, had higher post-test scores in academic creativity and scientific/mechanical creativity compared to those in the control group.

Table 5. Comparison of Kaufman Creativity Scale Post-Test Scores of Experimental and Control Groups

Post-Test	Group	N	Mean	Std. Deviation	t	p
Academic Creativity	Experimental	32	3.51	0.82	2.245	0.028*
	Control	32	3.04	0.85		
Scientific/ Mechanical Creativity	Experimental	32	3.44	0.76	2.301	0.025*
	Control	32	3.00	0.76		
Creativity in the Field of Artistic Performance	Experimental	32	3.94	0.91	0.576	0.567
	Control	32	3.81	0.82		
Self/ Daily Creativity	Experimental	32	3.41	1.04	0.373	0.710
	Control	32	3.31	0.97		
Artistic Creativity	Experimental	32	3.75	0.80	0.728	0.469
	Control	32	3.59	0.91		

*$p<0.05$

Discussion

This study investigated the effect of STEAM-based music instruction on the music lesson outcomes and creative thinking skills of seventh-grade middle school students through a quasi-experimental design. The research findings revealed that the experimental group, which received STEAM-based music instruction, had significantly higher post-test scores on music lesson outcomes than the control group, which learned using traditional teaching methods. The fact that this difference emerged despite no significant difference between the two groups in pre-test measurements strongly suggests that this effect is largely due to the implemented teaching intervention. The findings indicate that integrating music education with science, technology, engineering, and mathematics disciplines has a positive impact on learning outcomes. This suggests that beyond acquiring musical knowledge, more lasting learning occurs at the understanding and application levels within an interdisciplinary context. In the study, students exploring the physical properties of sound through science experiments, relating rhythm to mathematical patterns, and generating melodies using digital tools like Scratch provided high-quality learning experiences that supported the learning outcome. Similarly, Bertrand and Namukasa (2020) state that STEAM experiences strengthen transferable skills in students and that interdisciplinary content supports lasting learning. Huang (2020) states that when music is considered within the STEAM integration not only as artistic expression but also as a field that fosters pattern and systems thinking, learning outcomes are deepened. This finding confirms that placing music education beyond the traditional framework of notation instruction into a multi-component learning ecosystem can significantly increase the level of achievement.

This result indicates that restructuring music education within the STEAM framework supports not only musical but also technological and mechanical thinking capacity. The students in the experimental group designing their own musical instruments with materials they brought from home, producing rhythmic sounds through electronic circuits, and performing sound recording and editing operations with Audacity software provide concrete engineering experiences that foster scientific/mechanical creativity. It can be considered an expected outcome that such activities positively affect students' ability to solve a mechanical problem in original ways. Özer and Demirbatır (2023b) state that Scratch and Makey Makey-based activities simultaneously strengthen both engineering and musical thinking skills in students. Deák and Kumar (2024) indicate that digital competencies have a transformative function within STEAM frameworks and that these competencies are particularly related to mechanical and technical creativity. Leavy et al. (2023) also emphasize that emerging technologies increase creative engagement and strengthen interdisciplinary interaction in STEAM learning environments. When these findings are considered together, it is seen that redesigning music education with STEAM integration offers students opportunities for engineering and technology-oriented thinking, and these opportunities significantly support scientific/mechanical creativity.

Secondly, research findings show that the experimental group, which received STEAM-based music instruction, had significantly higher post-test scores on the academic creativity subscale than the control group. This finding indicates that the STEAM process strengthens academically-oriented creative skills in students, such as problem-solving, analytical thinking, and transferring information to new contexts. It is thought that the activities implemented in the experimental group, which guided students to relate sound vibrations to science, explore the mathematical structure of rhythm, and produce melodies using coding logic, created a favorable environment for the development of academic creativity. In this process, students develop not only musical knowledge but also the capacity to make interdisciplinary connections and think creatively. Kuo et al. (2019) state that interdisciplinary project-based learning processes simultaneously support student creativity and learning motivation. Similarly, Aguilera and Ortiz-Revilla (2021) state that indicators of creativity are visibly prominent in STEAM structures, and this becomes even more pronounced with the contribution of art integration. Güney and Sever (2025) reveal that STEAM-based music activities strengthen critical thinking tendencies and that these tendencies can be observed together with academically-oriented creative production processes. In this context, it is assessed that the STEAM intervention moves students away from rote memorization and engages them in a deeper learning process that encourages exploration, connection, and creation.

The statistically significant difference between the experimental and control groups in the subscales of creativity, self/daily creativity, and artistic creativity in the field of artistic performance indicates that STEAM-based music teaching contributes similarly to these dimensions of creativity for both groups, or that the current intervention is not sufficient to create a significant difference in this area in terms of duration and intensity. It is known that dimensions such as artistic creativity and self/daily creativity require longer-term, repetitive, and reflective learning experiences. Indeed, Harris and De Bruin (2018) state that supporting artistic creativity with teacher practices and open-ended tasks requires time, and that short-term interventions may have a limited impact in this area. Allina (2018) states that creativity in the artistic field is linked not only to the teaching method but also to social empowerment and subjectification processes; therefore, she draws attention to the fact that the effect of short-term experimental interventions on artistic creativity may remain limited. Sakon and Petsangsri (2021) emphasize that STEAM-based design processes offer structured environments that enhance creativity, but that more comprehensive applications are needed for this effect to manifest particularly in aesthetic and artistic dimensions. When these findings are considered together, it becomes clear that supporting artistic creativity in music education is directly related not only to a change in method but also to duration, depth, and contextual richness.

The findings of this research offer various theoretical and practical contributions to the literature on music education and STEAM integration. From a theoretical perspective, the study demonstrates with empirical evidence that incorporating music lessons into an interdisciplinary learning framework supports not only artistic development but also multiple competencies such as academic and scientific creativity. This finding empirically supports Liao's (2016) understanding of transdisciplinary learning and Bertrand and Namukasa's (2020) theoretical framework based on transferable skills, reinforcing the validity of approaches that position music education within a holistic STEAM system. From an applied perspective, the research provides a concrete direction for music teachers to design integrated teaching models that go beyond one-dimensional note instruction and incorporate science experiments, mathematical modeling, digital coding, and engineering design. While the findings support student achievement and specific dimensions of creativity, the lack of significant differences across all sub-dimensions of creativity suggests that the applications need further strengthening in terms of duration and structural depth. Therefore, this study emphasizes the need for more systematic pedagogical frameworks to both clarify the theoretical rationale of STEAM-based music teaching and improve its quality of application. Furthermore, the research strongly supports teaching approaches that redefine music lessons not only in a performance-oriented manner but also in terms of interdisciplinary problem-solving and technology integration.

Limitations and Recommendations

This research should be evaluated within the framework of certain methodological and contextual limitations. First of all, the study was limited to 64 seventh-grade students attending a specific middle school in one province; this restricts the generalization of its findings to different school types, geographic regions, or grade levels. The fact that only a four-week implementation period was planned in the research may have made it difficult to achieve sufficient effect size, especially in skill areas requiring longer-term development, such as artistic creativity. The fact that the study is based on a quasi-experimental design and that participants cannot be randomly assigned to groups constitutes a significant limitation that threatens internal validity. In addition, the fact that creativity was assessed only through a self-report scale eliminates the possibility of directly observing the students' actual creative performance. It should be considered that individual differences such as the teacher's personal competence, experience, and pedagogical understanding of STEAM may affect the quality of implementation, and that these variables are difficult to control. Based on the research findings and limitations, several suggestions are offered for both implementation and future research. Including music teachers in professional development programs related to STEAM-based instructional design can improve the pedagogical quality and consistency of the applications; indeed, the literature emphasizes that teacher competencies are a decisive factor in the success of STEAM applications (Boice et al., 2024). It is recommended that future research cover longer application periods and focus on dimensions needed in broader samples, such as artistic creativity and spontaneous/daily creativity. In future studies, mixed methods designs should be used to integrate qualitative data such as observation, product analysis, and music performance evaluation with quantitative findings; thus, the multidimensional nature of creativity can be understood more comprehensively. Comparative studies conducted across different grade levels, school types, and regions will increase the generalizability of the findings and contribute to understanding in which contexts STEAM-based music teaching is more effective. Finally, developing music-based STEAM designs that can be applied not only with existing educational tools but also in out-of-school contexts can ensure that the educational effect spreads to a wider student audience.

Conclusion

This research demonstrates that STEAM-based music instruction has a significantly positive impact on the learning outcomes and academic/mechanical creativity dimensions of seventh-grade middle school students. These findings empirically show that restructuring music education within an interdisciplinary integrated approach supports not only musical learning but also cognitive and technical creativity. This study fills a gap in the literature where research addressing the relationship between music education and STEAM integration with empirical evidence is limited, and reveals the concrete impact of this integration on student outcomes within the Turkish context. The research supports the idea that integrated teaching models, which enrich traditional music instruction with an interdisciplinary context rather than replacing it, offer a strong alternative from both theoretical and practical perspectives. The findings remind music educators and education policymakers of the importance of developing comprehensive programs for the systematic integration of the STEAM approach into music lessons.

Statements and Declarations

Acknowledgments/Notes: Not applicable.

During the preparation of this article, the authors did not use ChatGPT.

Supplementary Materials: Not applicable.

Author Contributions: All authors contributed equally. All authors have read and agreed to the published version of the manuscript.

Funding: The authors received no funding for the research.

Data Availability: Not applicable.

Ethics Approval: The study was performed in accordance with the study protocol and ethical guidelines and regulations.

Informed Consent: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflicts of interest.

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