http://www.tayjournal.com
https://dergipark.org.tr/en/pub/tayjournal

The Effect of STEAM-Based Music Activities on Students' Critical Thinking Dispositions*

Saniye Güney, Teacher, Corresponding Author
Ministry of National Education, Türkiye
saniieeguney@gmail.com
Orcid ID: 0000-0002-8873-752X

Gülşah Sever, Assoc. Prof. Dr.
Gazi University, Türkiye
gulsah.sever@gmail.com
Orcid ID: 0000-0003-0559-6993

Article Type: Research Article
Received Date: 22.01.2025
Accepted Date: 30.07.2025
Published Date: 31.07.2025
Plagiarism: This article has been reviewed by at least two referees and scanned via a plagiarism software
Doi: 10.29329/tayjournal.2025.1290.05

Citation: Güney, S., & Sever, G. (2025). The effect of STEAM-based music activities on students' critical thinking dispositions. *Türk Akademik Yayınlar Dergisi (TAY Journal)*, *9*(2), 318-346.

* This study obtained from the first author's master's thesis titled "The impact of STEAM-based music class activities on students' 21st century skills"

Abstract

This study aimed to evaluate the effect of the Science, Technology, Engineering, Arts, Mathematics [STEAM] approach in music lesson activities on students' critical thinking dispositions. Qualitative and quantitative data were collected and analyzed using a mixed method with a nested design. The study group consisted of 37 tenth grade students in an Anatolian high school and six STEAM field experts (physics, biology, mathematics, music, visual arts, information technologies) from school teachers. The implementation period lasted eight weeks in total. The study's quantitative data were obtained through the pre-test-post-test comparison of the UF/EMI Critical Thinking Disposition Scale forms. The quantitative findings revealed that students made significant progress in their critical thinking dispositions, as reflected in the positive changes between the pre-test and post-test scores. The qualitative data obtained from the teacher and student interviews of this study support the critical thinking skills of students in the STEAM approach in music lesson activities. In line with the quantitative and qualitative findings, it was suggested to provide better time management in the activities, increase diversity, give more freedom and responsibility to students, encourage group work, increase the richness of materials, and develop new measurement tools. The originality of this research lies in its comprehensive evaluation of the impact of STEAM-integrated music education on critical thinking, contributing valuable insights to the existing literature, particularly regarding the integration of art-based disciplines like music. These findings not only emphasize the effectiveness of the STEAM approach in fostering critical thinking but also highlight the importance of interdisciplinary practices in nurturing 21st-century skills.

Keywords: Music education, STEAM approach, critical thinking tendency.

Introduction

Education has evolved from transferring practical knowledge throughout human history to today's structured and technologically supported complex systems. This transformation in education has created a new ground for interdisciplinary studies and led to the prominence of hybrid teaching methods that include more than one discipline rather than one discipline. In this way, education programs have become more flexible and focused on problem-solving (Newell, 2001; Yavuz, 2016). From another perspective, this transformation in education has been closely associated with societies' economic, social, and cultural development. While societies' welfare and development policies determine which skills individuals should be equipped with, educators have carried out various reforms in this direction.

With the impact of these reforms that took place in parallel with industrialization, four main evolutionary stages of education and the focus of each stage emerged (Diwan, 2017). While Education 1.0 represented traditional teaching methods, Education 2.0 marked a period when technology started to be used more. Education 3.0 encouraged students to become active producers of knowledge rather than passive consumers of information, while Education 4.0 emphasized creative thinking, problem-solving, and the ability to develop innovative projects. This process from Education 1.0 to 4.0 has shown how multidimensional knowledge and interdisciplinary approaches have taken shape in modern education systems. Instead of focusing on a single discipline, ancient scientists developed a broad perspective by having knowledge in many fields (İsababayeva Apaydın & Arslan, 2015). This broad perspective has been replaced by narrower and more specialized knowledge over time. However, in the education 3.0 and 4.0 processes, this narrowed knowledge structure has been expanded by re-establishing interdisciplinary connections (Turhal, 2020).

The 21st century skills aligned with Education 4.0 include solving complex problems, critical thinking, creativity, people management, collaboration, and emotional intelligence (World Economic Forum, 2016). In another perspective, these skills are classified under three general headings: learning and innovation skills, life and career skills, and information media and technology literacy skills (Partnership for 21st Century Learning, 2019).

Critical thinking enables individuals to analyze problems deeply, evaluate different perspectives, and produce effective solutions (Levy, 1997). It paves the way for the emergence of innovative ideas by encouraging creative thinking. It also improves the ability to work in cooperation (Ennis, 1993). Logical evaluation of personal decisions and sensitivity to social problems are among the contributions of critical thinking. Critical thinking skills have been addressed in various aspects by researchers such as Russell (1963), Paul (1990), Siegel (2017), and Lipman (1988). These researchers characterized critical thinking as the art of thinking about our thoughts by associating it with attitude, functional, and judgment factors. They also defined this skill as reason-based validation.

In current approaches, it is discussed that critical thinking skills play an active role in analyzing the problems encountered, producing final solutions and making improvements in the social field. In this context, Science, Technology, Engineering, Arts, Mathematics [STEAM] education has become an effective model that strengthens critical thinking with its interdisciplinary structure. With its interdisciplinary structure and creative problem-solving oriented projects, STEAM enables students to acquire knowledge and use it in a critical and innovative way. Integrating science, technology, engineering, and art disciplines with music education especially deepens critical thinking skills. In addition, it is seen that people who receive STEAM education develop the ability to evaluate in a social context (Campbell, 2004).

In the 2023 Education Vision published by the Ministry of National Education [MoNE] (2018), the instructional design at the secondary education level is closely linked to individuals' acquisition of scientific skills. It is emphasized that the secondary education system needs a structural transformation to provide students with universal skills and make them actors of change. This perspective aligns with the holistic approach adopted in the Century of Türkiye Education Model (Türkiye Yüzyılı Maarif Modeli), which emphasizes the balanced development of cognitive, emotional, and social domains in an integrated manner. Although a specific curriculum for the music course has not yet been released within this model, its comprehensive and interdisciplinary vision underlines the importance of designing music education in a way that supports students' multifaceted growth and active participation in a rapidly changing world. It is also stated that the curriculum should be process-oriented, take into account individual differences, and use technology effectively. Continuous updating of the curriculum and making it suitable for the needs of the 21st century make it necessary to investigate contemporary approaches in music lessons.

The reviewed literature emphasizes the importance of arts education, and deficiencies in areas such as critical thinking and problem-solving are stated (Didin & Köksal, 2017;

Perignat & Buonincontro, 2019). In addition, the inadequacy of students' critical thinking skills and what needs to be done to improve these skills are emphasized (Demir & Aybek, 2014; Korkmaz & Yeşil, 2009). In this context, considering the current educational conditions, it is seen that studies to improve critical thinking skills have gained importance. However, art education supports awareness, self-confidence, and creativity.

STEAM education has received increasing attention in the educational literature, especially as an innovative model that encourages the development of interdisciplinary skills (Bequette & Bequette, 2012; Yakman & Lee, 2012). However, in international literature, it is seen that the STEAM approach remains STEM oriented in general and that the arts are often considered only as an aesthetic complement (Henriksen, 2014). Studies on the impact of arts, especially music education, on cognitive processes such as critical thinking and problem-solving are limited and mostly limited to small-scale projects (Kim & Park, 2012; Perignat & Buonincontro, 2019). For example, Perignat and Buonincontro's (2019) literature review on the effects of STEAM suggests that music is underrepresented in STEAM practices and that a stronger pedagogical framework to support interdisciplinary thinking is needed.

How STEAM integration with music education, which indirectly includes all disciplines, affects students' critical thinking skills emerges as an important research topic. However, it is seen that the research and findings on this issue are limited, and generally, the implementation processes are not analyzed in depth (Liao, 2016). In addition, the number of studies on STEAM education in developing countries such as Türkiye is increasing, but the majority of these studies focus on the science, mathematics, and technology axis, and it is observed that art-based disciplines such as music education are not addressed (Gülhan, 2022).

In this context, the unique contribution of this study to the field is that it fills this gap in the international literature by examining the development of students' critical thinking disposition with both qualitative and quantitative methods in music education with the STEAM approach. The research aimed to demonstrate that music education is not only an aesthetic activity, but can also play a critical role in developing cognitive skills in an interdisciplinary context. The findings of this study bring an innovative perspective to the literature by providing valuable information on how music education can be integrated into STEAM models in an international context.

Therefore, in this study, the following questions were sought to be answered in order to evaluate the effect of STEAM approach in music lesson activities on students' critical thinking dispositions.

1. What is the effect of STEAM approach in music lesson activities on students' critical thinking dispositions?

2. What are the students' views on the application of STEAM approach in music lesson activities?

3. What are teachers' views on the implementation of STEAM approach in music lesson activities?

Method

Research Design

In this study, STEAM approached music lesson activities were developed, and the effects of these activities on students' critical thinking dispositions were examined. Both qualitative and quantitative data were collected and analyzed using a mixed method with a nested design. Quantitative data were applied as pre-tests and post-tests at the beginning and end of the study. Qualitative data were obtained through structured interviews with students and unstructured and semi-structured interviews with teachers.

Participants

The study group of this research consisted of 37 tenth-grade students in an Anatolian high school and six STEAM field experts (physics, biology, mathematics, visual arts, information technologies, music) from school teachers. The sample size was kept small since this study aimed to examine in depth the impact of the STEAM approach on critical thinking skills in the context of music education and to allow for more qualitative and quantitative findings to be evaluated together. Working with a small sample made it possible to analyze the experiences of each participant in more detail and to interpret the findings in more depth (Creswell, 2017). In addition, selecting a homogeneous group of students in the sample, i.e., students of the same age level and with similar educational backgrounds, increased the study's internal validity (Patton, 2002). However, it is also known that this situation limits the generalizability of the findings, and follow up studies with a larger and more diverse sample are needed to generalize the results to different age groups, school types, or cultural contexts. Nevertheless, this study is essential research to understand the potential effects of integrating a STEAM approach into music education.

Data Collection Tools

Qualitative data were obtained from structured, semi-structured, and unstructured interview notes and research journals. The quantitative data of the study were obtained with the "UF/EMI Critical Thinking Disposition Scale" adapted into Turkish by Kılıç and Şen (2014). In order to collect the data, the "UF/EMI Critical Thinking Disposition Scale" was applied at the beginning of the study and thus pre-test data were obtained. Qualitative data were collected during the implementation. At the end of the implementation process, the "UF/EMI Critical Thinking Disposition Scale" was applied again, and post-test data were obtained. The Turkish adaptation and development of the scale was conducted by Kılıç and Şen (2014). The scale has three sub-dimensions: anticipativeness, cognitive maturity, and innovativeness. The internal consistency coefficient of the anticipation sub-dimension was calculated as .88, cognitive maturity as .70, and innovativeness as .91.

Table 1.

Reliability Analysis of UF/EMI Critical Thinking Disposition Scale

Subdimensions	Number of questions	Cronbach's Alpha	General Cronbach's Alpha
Predictability	11	.846	.910
Innovation	7	.914	
Cognitive Maturity	7	.897	

A semi-structured interview form and unstructured observation notes were used as qualitative data collection tools in the study. The interview questions were developed by the researchers in accordance with the purpose of the study. During the question development process, the literature was reviewed, sample questions from previous similar studies were used, and content validity was ensured through expert opinions. Sample questions used in the semi-structured interviews with students are as follows:

1. In this activity, which activities and how did you achieve the interdisciplinary connections inherent in the STEAM approach?

2. Do you think this activity contributed to you? If yes, how did you think it contributed?

3. What are your opinions and suggestions on the topic?

The interviews with the students were conducted personally by the researcher. A voice recorder was used during the interviews, and the recordings were later transcribed and analyzed. The following questions were asked in semi-structured interviews with teachers:

1. Do you see a progression between the beginning and the end of this activity, which was prepared using the STEAM approach?

2. Has the connection between science–technology–engineering–music–mathematics been established with this activity?

3. Do you observe any improvement in students' interdisciplinary connections through the STEAM curriculum designed for this activity?

4. If you observe improvement, in what direction do you think it is?

5. How and in what ways could this activity, prepared using the STEAM approach, be improved through further work by practitioners?

6. If so, what are your opinions and suggestions?

These questions were developed by the researcher, and after expert consultation, necessary adjustments were made and simplified to reflect the teachers' areas of expertise. Interviews were conducted face to face. All data were collected on a voluntary basis, in accordance with ethical principles, and participant confidentiality was maintained.

Throughout the research process, observations were conducted with STEAM field experts before and after the unstructured intervention to facilitate exchanges of ideas. These observations were used to support the interview data.

Analysis

In the study, the researcher processed and analyzed the data collected through questionnaire forms using the SPSS 26.0 package program. "Wilcoxon Signed Ranks Test" was applied to evaluate the statistical differences between the participants' pre-test and post-test results. The significance (p) value was accepted as 0.05 in all analyses. When $p<.05$ in the test results, the difference was considered statistically significant, and when $p>.05$, the difference was considered statistically insignificant. The "UF/EMI Critical Thinking Disposition Scale" was developed to measure individuals' tendencies towards critical thinking accurately. The

UF/EMI Critical Thinking Disposition Scale used as a quantitative data tool, was used with frequency, percentage, t-tests, or one-factor analysis of variance [ANOVA] according to whether the data showed normal distribution in the SPSS statistical program.

Qualitative data were obtained through interviews with students and teachers and their responses to the questions. In the first stage, these data were processed. These interviews, which were audio recorded, were transcribed on a computer without any changes. The transcribed interview records were reviewed by the researcher and made suitable for analysis (Coolican, 2009; Kvale, 1996). MAXQDA 21 program was used to analyze the transcribed interviews. The data were analyzed using the inductive analysis method. The data coded by the researcher were organized by coding, which is defined as the process of naming meaningful parts of the data (Yıldırım & Şimşek, 2013). The codes created individually were reviewed with the mentor teacher until a consensus was reached. In this study, student opinions were coded with the letter 'T'. Teacher opinions were coded with different letters according to their fields: 'F' (Physics), 'B' (Biology), 'G' (Visual Arts), and 'M' (Music). After the coding process was completed, it was submitted to expert opinion. With the expert opinion, the content analysis was completed by defining and interpreting the findings. This study analyzed semi-structured and unstructured teacher interviews and structured student interviews using descriptive analysis.

Research Process

In this study, in which the STEAM approach was applied to music lesson activities, the researcher first organized a meeting with STEAM field experts. This meeting sought solutions to ensure that students were motivated towards music lessons. With the joint decision of STEAM field experts and the researcher, a plan was made to ensure the connection between STEAM disciplines under the leadership of the music lesson. The engineering design process using the STEAM approach formed the framework for the general objectives planned in this direction. The planning objectives were selected together with STEAM field teachers. These objectives were selected from the annual plans prepared within the framework of the secondary education program of the courses included in STEAM. However, since there is no engineering course in the secondary education program, the design process plan was created separately.

The implementation process lasted a total of eight weeks, including the process of collecting quantitative and qualitative data. The implementation was carried out in 2 weekly music class hours. The "UF/EMI Critical Thinking Disposition Test" was administered in the first week. In the second week, biology-music; in the third week, physics-music; in the fourth week, mathematics-music; in the fifth, sixth, and seventh weeks, the STEAM connection was established between biology-physics-mathematics-music-technology-engineering. A post-test was administered in the eighth week of the implementation, and a structured interview was conducted with the students. The researcher recorded her observations about the implementation in the form of notebooks, video, and audio recordings. In the second week of the implementation, dialogues were developed to establish a connection between biology and music lessons. The students were divided into homogeneous groups with equal numbers. These groups were asked to come up with group names related to the topic of the elements of the cell in the biology lesson. Then, they were tasked with writing song lyrics appropriate to their chosen group names. In the third week of the implementation, dialogues were developed to establish a connection between physics and music lessons. Sound sensitive LEDs were emphasized based on the answers received, and sample material was shown. In the fourth week of the application, dialogues were developed to establish a connection between mathematics and music lessons. In the connection between function and music, frequencies were given to the definition set, and note names were given to the value set. The keyboard to be used in the prototype was assigned sounds with the software program, and the sounds that come when the keys are pressed were determined as the definition set, and the sounds that come when the keys are pressed were determined as the value set. This situation played a role in associating the function, which is a mathematics subject, with the music lesson. Then, model cartons were given to the students. The students drew vectors of the instruments on these cards. At this point, support was received from the visual arts teacher. In the fifth week of the implementation, dialogues were developed on connecting music, physics, biology, mathematics, technology, and engineering. Students were asked to create a music prototype with instrument cartons, a computer, a computer keyboard, a sound-sensitive LED, a speaker, cables, and silicone materials. One student who could assign a sound to the keyboard keys with the software program was given additional time outside the application. This student created the software program under the supervision of the researcher. In the sixth week of the implementation, the students removed the keypad on the mechanical keyboard. The electronic circuit was cleaned with solder paste when the keypads were removed. Between the copper circuit on the electronic board and the electronic circuit on the keypad, 1.5 meters of special spiral copper cable was used to transfer the sound of the keys. Support was received from an IT specialist during keyboard operations. In the seventh week of the implementation, the students were asked to place the keyboard keys assigned sound on the instrument cartons. Each group carried out this process individually. After all groups had completed this process, the resulting prototype was practically tested. In the eighth week of the implementation, a post-test was administered to the students, and structured interviews were conducted. Unstructured interviews were conducted with STEAM field experts throughout the process to keep them informed about the students' situations. When necessary, ideas were exchanged with STEAM field experts, and the results were shared with them. STEAM field experts' opinions about the activity's implementation were recorded.

Ethical Permits of Research:

In this study, all the rules specified to be followed within the scope of "Higher Education Institutions Scientific Research and Publication Ethics Directive" were complied with. None of the actions specified under the heading "Actions Contrary to Scientific Research and Publication Ethics", which is the second part of the directive, have been taken.

Ethics Committee Permission Information:

Name of the committee that made the ethical evaluation = Gazi University Ethics Commission

Date of ethical review decision = 10.05.2023

Ethics assessment document issue number = E-652780

Findings

The aim of this study is to examine the effect of the STEAM approach applied with music lesson activities on students' critical thinking dispositions. In this direction, quantitative data were obtained by analyzing the students' critical thinking dispositions through pre-test and post-test results. Qualitative data were obtained through structured student interviews and semi-structured and unstructured teacher interviews.

1. The Effect of STEAM Approach in Music Lesson Activities on Students' Critical Thinking Tendencies

The critical thinking disposition test was structured into three sub-dimensions: anticipativeness, innovativeness, and cognitive maturity. The findings obtained are presented in tables.

Table 2.

Post-test-Pre-test Comparison of UF/EMI Critical Thinking Disposition Scale

		n	*M*	*SD*	Min	Max
Pre-test		37	3.53	.59	1.48	4.72
Post-test		37	3.87	.52	1.92	4.84
Wilcoxon signed ranks test						
		n	Rank mean	Rank sum	*Z*	*p*
Pre-test–post-test	Negative sorting	8	13.25	106.00	-3.424	.001
	Positive sorting	27	19.41	524.00		
	Equality	2				
	Total	37				

Looking at the general results of the UF/EMI Critical Thinking Disposition Scale in Table 2, it is seen that the post-test averages of the students increased significantly compared to the pre-test averages (Z=-3.424; p<.05). It was observed that the STEAM approach applied with music lesson activities contributed to the critical thinking disposition of 27 students, while the critical thinking disposition of 8 students decreased. The remaining two students did not show a developmental difference in achieving equality. It is thought that the students who did not show development were due to individual differences, difficulties in adapting to the content of the activities, or the inability of the scales to measure the abilities of this student group fully.

Table 3.

Post-Test-Pre-Test Comparison of Anticipativeness *Subdimension*

		n	*M*	*SD*	Min	Max
Pre-test		37	3.56	.67	1.36	4.82
Post-test		37	3.88	.59	1.82	5.00
Wilcoxon signed ranks test						
		n	Rank Mean	Rank Sum	*Z*	*p*
Post-test–pre-test	Negative sorting	9	15.56	140.00	-2.869	.004
	Positive sorting	26	18.85	490.00		
	Equality	2				
	Total	37				

As seen in Table 3, the increase in students' scores in the anticipativeness sub-dimension is statistically significant (Z=-2.869; p<.05). These findings show that the student's ability to predict future possibilities and think according to these possibilities has improved. The decrease in 9 students' scores suggests that students may have difficulty integrating their existing knowledge and skills into their predictive abilities or may need more guidance in this process.

Table 4.

Post-Test-Pre-Test Comparison of Innovativeness Subdimension

		n	*M*	*SD*	Min	Max
Pre-test		37	3.52	.74	1.86	4.71
Post-test		37	3.87	.54	2.43	4.71
Wilcoxon signed ranks test						
		n	Rank Mean	Rank Sum	*Z*	*p*
Post-test–pre-test	Negative sorting	11	14.91	164.00	-2.287	.022
	Positive sorting	23	18.74	431.00		
	Equality	3				
	Total	37				

As seen in Table 4, in the innovativeness sub-dimension, students' innovativeness skills increased significantly in the post-test ($Z=-2.287$; $p<.05$). These findings show that the STEAM approach applied with music lesson activities supported students' creative thinking and innovative solution development skills. However, the decrease in the skills of 11 students indicates that these students could not fully participate in innovative thinking processes or that the existing methods were not effective enough for these students.

Table 5.

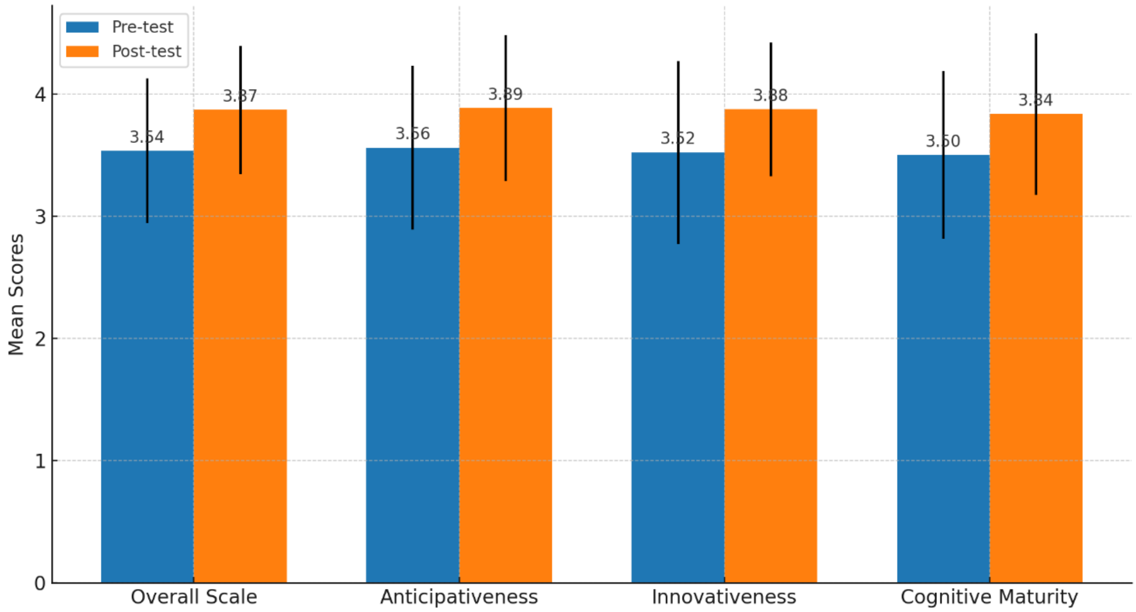
Post-Test-Pre-Test Comparison of Cognitive Maturity Subdimension

		n	*M*	*SD*	Min	Max
Pre-test		37	3.50	.68	1.29	4.86
Post-test		37	3.83	.66	1.57	5.00
Wilcoxon signed rans test						
		n	Rank Mean	Rank Sum	*Z*	*p*
Post-test–pre-pest	Negative sorting	12	13.00	156.00	-2.612	.009
	Positive sorting	23	20.61	474.00		
	Equality	2				
	Total	37				

In Table 5, a significant increase was observed in the cognitive maturity sub-dimension ($Z=-2.612$; $p<.05$). These findings indicate that the students developed a more mature and structured thought process and improved their ability to evaluate and analyze complex situations. However, the fact that 12 students experienced a decrease in this dimension may indicate that they experienced different difficulties in their cognitive development processes. This suggests that these students' cognitive maturity skills should be further supported.

Figure 1.

Comparison of Pre-test and Post-test Mean Scores on the Critical Thinking Disposition Scale and Its Sub-dimensions (n = 37)



Note. Post-test mean scores for the overall scale and all three sub-dimensions were significantly higher than pre-test mean scores ($p<.05$). Error bars represent standard deviations.

2. Student Opinions on the Application of the STEAM Approach in Music Lesson Activities

When the post-application opinions of the students who participated in the research are analyzed, it is seen that there are statements belonging to the critical thinking code. These findings show how music education can be associated with other disciplines and how these relationships can be established. Critical thinking includes analyzing information, evaluating different perspectives, and using information in new contexts. Students made connections between music courses and numeracy and science courses (T1, T14, T36). This shows the ability to use knowledge in one context and between different disciplines. Recognizing such relationships is seen as an important part of critical thinking. The statement "At first, we said, 'What is the connection?' and then we learned that connection" (T1) shows that the student questioned the information that initially seemed disconnected and then re-evaluated this information and established meaningful connections. "Concretizing the waves of the vocal cords" (S10) reflects the student's effort to make an abstract concept more concrete. Critical thinking deepens understanding by supporting abstract concepts with concrete examples. The connections established between different subjects, such as biology, mathematics, and music, show that students develop interdisciplinary thinking skills (T14, T37). This is important in developing critical thinking because it brings together different perspectives to reach a richer understanding. The statement "We talked and discussed the relationship between music and mathematics" (T37) shows that students strengthen critical thinking by sharing and discussing their ideas with others. Discussion develops the skills of evaluating different perspectives and defending their ideas. These statements show that students are developing their critical thinking skills and have started to make sense of knowledge in a broader context by making connections between different disciplines. Such statements indicate that students memorize information and develop the ability to analyze and revaluate it in different contexts.

3. Teachers' Views on the Application of STEAM Approach in Music Lesson Activities

The findings from this study reveal that the application had a significant impact on students' creative thinking skills. By assigning instrument sounds to computer keys and connecting them through wires, students were encouraged to think creatively (F). This process allowed them to combine technology and original ideas in unique ways, enhancing their ability to use technology in a creative manner (B). Additionally, the task of producing products from the materials provided fostered an environment that nurtured students' creativity (G).

In terms of communication, the application provided opportunities for students to move beyond their comfort zones and interact with peers they might not have otherwise engaged with. By randomly grouping students based on numbers they called out, they were able to communicate with others outside their typical social circles (G). This process not only improved communication but also allowed students to develop teamwork, leadership, and interpersonal skills (B), demonstrating that the application contributed to both social and technical growth.

The application also had a clear impact on students' collaboration skills. Students exhibited significant changes in their ability to collaborate both within and across disciplines (G). By engaging in STEAM based music activities, students had the chance to work together, sharing their unique skill sets and learning from one another (B). This suggests that the application fostered an environment conducive to collaborative learning, which is a crucial aspect of modern education.

The novelty of the project was also noteworthy. Students found it to be a "unique and thought-provoking" experience (M). This non-traditional approach to learning allowed students to gain new perspectives on how they could use the knowledge and skills they had acquired in different, innovative ways. In a digital age where information is easily accessible, the application encouraged students to reflect on how to apply this knowledge creatively, transforming their approach to learning.

One of the most important findings is that the application helped students shift their perspective on how they access and use information (M). Given today's easy access to knowledge, students learned not only how to acquire information but also how to apply it effectively, developing a more analytical and practical approach to problem-solving. This shift in perspective is an essential skill for future educational and professional settings.

Suggestions for enhancing the impact of the application emerged from the findings as well. It was recommended that the project be expanded to involve more students, creating interactive sessions with visual backgrounds and incorporating artificial intelligence technologies (M). This would allow for more dynamic and engaging activities, providing students with an even more immersive and participatory learning experience.

In terms of application skills, students were able to integrate both creative and technical skills throughout the project. Using vector images of instruments helped students more easily draw their designs on cardboard (G), while the incorporation of technological elements, such as assigning sounds to computer keys and connecting instruments with wires, allowed them to practice and develop their technical abilities (F). These skills directly contributed to students' understanding of how to apply theoretical knowledge to practical tasks.

The application also provided ample opportunities for students to engage in critical thinking. Throughout the process, students evaluated the pros and cons of their work, aiming to reach the best possible outcome (G). The STEAM approach played a key role in fostering critical thinking, as students were encouraged to review their performances and those of their peers, refining both musical and technical skills in the process (B). This ongoing evaluation allowed students to improve not only their technical abilities but also their capacity for reflection and improvement.

Regarding satisfaction, students were observed to work with high levels of motivation, which directly influenced the outcomes of the project (M). The research findings indicated that students were highly motivated by this unconventional and thought-provoking activity, resulting in improved performance (B). This underscores the importance of motivation in achieving successful learning outcomes, demonstrating that when students are engaged and excited, their work quality improves significantly.

Lastly, the interdisciplinary connections made through the application were crucial. Students developed skills across multiple disciplines, including music, physics, and technology, as they integrated various aspects of knowledge to complete the project (F). The process of drawing and cutting out instrument shapes also involved elements of visual arts (G), while the creation of software and the technical work of soldering and wiring enhanced the connection between music and technology (B). These activities provided students with a holistic understanding of how different fields intersect and work together, strengthening their ability to make interdisciplinary connections.

The qualitative findings obtained from student and teacher interviews aligned with the quantitative results of the UF/EMI Critical Thinking Disposition Scale. Specifically, in the sub-dimensions where post-test scores increased such as innovativeness and cognitive maturity students reported observable developments in related skills, including creativity, interdisciplinary thinking, and problem-solving. For instance, students indicated that they were able to reinterpret information that initially seemed unrelated, thereby concretizing abstract concepts, which reflects cognitive maturity. Moreover, their engagement in designing musical prototypes using technology and developing original ideas within group work settings supported the observed improvement in innovative thinking skills. This consistency between data types suggests that the STEAM based music activities contributed to students' critical thinking development not only through measurable outcomes but also through self-reflective and experiential learning processes expressed in their own words. Therefore, the qualitative and quantitative data complement each other and together demonstrate that interdisciplinary and arts-integrated approaches can be effective tools for enhancing critical thinking skills in a holistic manner.

Discussion and Conclusion

In this study, the effect of STEAM based activities implemented in music lessons on students' critical thinking dispositions was examined, and the findings revealed a significant improvement in this disposition. The pre-test and post-test analyses of the study showed that STEAM based music lesson activities improved students' critical thinking dispositions. Baek et al. (2011) stated that STEAM activities strengthen analytical skills and understanding of complex problems. Kim and Park (2012), who emphasized the contribution of art to creative and critical thinking skills, and Kolodner et al. (2003), who stated that problem-based learning supports these processes, also support these findings. In addition, Yakman and Lee (2012) stated that STEAM education improves critical thinking skills by creating long-term effects. Similarly, Kömürcü (2022) stated that STEAM based music education improves creativity, critical thinking, and musical communication. In this context, the role of the art-oriented structure of STEAM activities and problem-based learning processes in positive change is emphasized.

The study's quantitative findings revealed that students significantly improved in critical thinking, innovativeness, and cognitive maturity. These results are in line with international studies in the field of STEAM education. Wilson et al. (2021) found that transdisciplinary STEAM courses improve students' critical and creative thinking skills. Significant improvements were observed, especially in problem-solving, generating ideas, and evaluating from different perspectives. Henriksen (2014) and Kim and Park (2012), while emphasizing the effects of STEAM on creative and critical thinking skills, drew attention to the critical role of interdisciplinary approaches in this development. Perignat and Buonincontro (2019) state that STEAM practices enable students to view knowledge from different perspectives and develop creative problem-solving skills. However, most of these studies are STEM-oriented, and the contribution of arts, especially music, to critical thinking processes has been addressed to a limited extent.

However, while these studies highlight the positive impact of STEAM on critical thinking, creativity, and problem-solving, it is important to note that the role of the arts, particularly music, in developing these skills has not been thoroughly explored. In the current study, the findings indicate that music-based STEAM activities have had some effect on students' 21st century skills. Specifically, the data show that students experienced improvements in areas such as innovation and cognitive maturity, though these changes were not statistically significant. The lack of significant improvement in critical thinking and problem-solving skills may reflect the complexity of these cognitive processes, which require more in-depth and sustained engagement than what was provided through the music activities.

Additionally, the results suggest that certain dimensions, like entrepreneurial and career awareness skills, showed some growth in students, but again, these changes were not statistically significant. This raises questions about the extent to which music-centered STEAM initiatives can truly foster deeper cognitive development in these areas. It is possible that music activities may need to be complemented with other, more targeted pedagogical approaches to yield more noticeable improvements in critical thinking and problem-solving.

While the study's findings align with previous research regarding the overall benefits of STEAM education, it is important to acknowledge the current study's limitations. These include the relatively small sample size and the failure to consider other influential factors, such as teaching methods, student motivation, and the specific content of the music activities. These factors may have limited the observed changes in specific skill areas.

Therefore, future research should explore how integrating the arts, particularly music, within a STEAM framework can be further optimized to address critical thinking and problem-solving skills. Such studies could incorporate a larger and more diverse sample, consider additional pedagogical strategies, and evaluate the long-term effects of these types of educational interventions. By doing so, it may be possible to better understand the potential of music-based STEAM education in enhancing students' cognitive and creative abilities, as well as their overall 21st-century skill development.

Qualitative findings show that students gain the ability to analyze and apply knowledge in different contexts by making connections between different disciplines, such as biology, mathematics, and engineering, through music education. These findings are in line with Liao's (2016) finding that STEAM education promotes critical thinking in an interdisciplinary context. However, some students had difficulty in this process and did not show sufficient development in critical thinking skills. This situation reveals that STEAM activities should be designed by better considering individual differences.

Structured interviews revealed that STEAM activities improved students' skills such as creative thinking, communication, and collaboration. However, some students did not make enough progress in this process, making it necessary to reorganize the activities to take into account individual differences. Adapting the measurement tools to fully reflect the students' progress may enable more precise evaluations in future research.

The structured interviews with both students and teachers revealed that STEAM activities had a positive impact on students' skills, such as creative thinking, communication, and collaboration. However, it was also noted that some students did not make sufficient progress in these areas. For instance, while many students showed improvements in creative thinking, others struggled to engage with the activities in a way that fostered significant skill development. This suggests that individual differences, such as prior knowledge, motivation, and learning styles, may play a crucial role in the success of the activities. Moreover, the interviews with teachers highlighted the importance of adjusting the teaching methods and activity structures to accommodate these differences. Teachers noted that while group collaboration fostered communication and teamwork, some students felt less confident when working in larger groups. This indicates that a more personalized approach, potentially offering opportunities for both group and individual tasks, could lead to better outcomes. As for the evaluation of students' progress, both students and teachers mentioned that the measurement tools used during the study did not fully capture the nuances of their development. For example, some students demonstrated progress in non-cognitive skills, such as confidence and problem-solving, which were not adequately reflected in the traditional assessment methods. Adapting the measurement tools to encompass a broader range of skills and more effectively account for individual growth could provide more precise and comprehensive evaluations in future research. This approach could also help identify areas where students need additional support and guide the refinement of the STEAM activities to better suit diverse learning needs.

The study's findings reveal that the STEAM approach significantly improves critical thinking skills by encouraging interdisciplinary learning processes. Kim and Auh (2024) stated that STEAM-based music activities, in addition to increasing student engagement, allow students to gain a deeper understanding of musical principles and use this knowledge in different contexts. This finding aligns with what was observed in the study sample, where students developed skills to apply knowledge by connecting to disciplines such as biology, mathematics, and engineering. This is important in showing how STEAM activities support creative and analytical thinking processes.

This study's contribution to the international literature is to examine the role of creative disciplines in critical thinking processes more comprehensively by considering music as a central component in STEAM education. Campbell (2004) emphasized the importance of music in cultural and cognitive development; in this study, music was shown to be a critical tool within STEAM pedagogy. In particular, the connections established with different disciplines reveal that music plays an important role in interdisciplinary thinking processes beyond a purely aesthetic activity.

In conclusion, the STEAM approach offers a rich learning environment that can support 21st-century skills such as creativity, communication, collaboration, and critical thinking. However, further consideration of individual differences, examination of long-term effects, and development of measurement tools will enable this potential to be fully realized.

Recommendations

More longitudinal research is needed as the long-term effects of the STEAM approach have not yet been fully addressed. The same need also applies in the context of music education. In addition, although the STEAM approach has the potential to improve student's critical thinking skills, it has been pointed out that individual differences need to be considered more. In this context, educators:

-Adjust curriculum integration to students' learning styles,

-Increase access to STEAM materials.

Researchers are recommended to:

-Develop more sensitive tools to measure critical thinking dispositions,

-Develop modeling designs for how to connect STEM disciplines to music lessons,

-Develop digital tools for STEAM activities and train users,

-Extend the duration and improve time management to increase the effectiveness of the STEAM approach in music lesson activities,

-Consider the relationship between STEAM and music education more comprehensively.

To expand STEAM-based music lessons, the Ministry of National Education should:

-Provide financial support,

-Organize practical teacher training,

-Invest in STEAM infrastructure,

-Prioritize the development of measurement tools appropriate for STEAM focused curriculum practices.

References

Baek, Y., Park, H., Kim, Y., Noh, S., Park, J. Y., Lee, J., & Han, H. (2011). STEAM education in Korea. *Journal of Learner-Centered Curriculum and Instruction, 11*(4), 149-171.

Bequette, J. W., & Bequette, M. B. (2012). A place for art and design education in the STEM conversation. *Art Education*, *65*(2), 40-47. https://doi.org/10/10.1080/00043125.2012

Campbell, P. S. (2004). *Teaching music globally: Experiencing music, expressing culture*. Oxford University.

Coolican, H. (2009). *Research methods and statistics in psychology*. Hodder.

Creswell, J. W. (2017). *Araştırma deseni* [Research design]. (S. B. Demir, Trans.). Eğiten.

Demir, R., & Aybek, B. (2014). Lise öğrencilerinin eleştirel düşünme eğilimlerinin çeşitli değişkenler açısından incelemesi [An analysis of the critical thinking dispositions of high school students through various parameters]. *Journal of Social Sciences and Humanities Research*, *32,* 122-140.

Didin, E., & Köksal-Akyol, A. (2017). The relationship of art and music education with adolescents' humor styles and interpersonal problem solving skills. *Eurasian Journal of Educational Research*, *17*(72), 43-62.

Diwan, P. (2017). *Is Education 4.0 an imperative for success of 4th industrial revolution? Medium*. Retrived November 15, 2024 from https://pdiwan.medium.com/is-education-4-0-an-imperative-for-success-of-4th-industrial-revolution-50c31451e8a4

Ennis, R. H. (1993). Critical thinking assessment. *Theory into Practice, 32*(3), 179-186.

Ertaş Kılıç, H., & Şen, A. İ. (2014). UF/EMI eleştirel düşünme eğilimi ölçeğini Türkçeye uyarlama çalışması [Turkish adaptation study of UF/EMI critical thinking disposition instrument]. *Education and Science*, *39*(176), 1-12.

Gülhan, F. (2022). Türkiye'de yapılmış STEAM/[STEM+A (sanat)] araştırmalarındaki eğilimlerin analizi [Analysis of trends in researches on STEAM (STEM+art) made in Turkey]. *Turkish Journal of Educational Studies*, *9*(1), 23-46. https://doi.org/10.33907/turkjes.737496

Henriksen, D. (2014). Full STEAM ahead: Creativity in excellent STEM teaching practices. *The STEAM Journal*, *1*(2),15. https://doi.org/10/buhar.20140102.15

İsababayeva Apaydın, A., & Arslan, F. (2015). Antik Yunan felsefesinde ahlaki eğitim aracı olarak "müzik" ["Music" as means of moral education in ancient Greek philosophy]. *Journal of Values Education, 13*(29), 323-342.

Kim, C., & Auh, Y. (2024). The effect of STEAM integration on middle school music education. *International Journal on Integrated Education, 7*(2), 17-28.

Kim, Y., & Park, N. (2012). The effect of STEAM education on elementary school student's creativity improvement. In Kim, Th., et al. (Eds.), *Computer applications for security, control and system engineering 2012*. (pp. 115-121). Springer.

Kolodner, J. L., Crismond, D., Fasse, B. B., Gray, J. T., Holbrook, J., Ryan, M., & Puntambekar, S. (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting a learning-by-design curriculum into practice. *Journal of Learning Sciences, 12*(4), 495-547.

Kömürcü, M. H. (2022). STEAM eğitim modeli'nin müzik eğitimi bakımından değerlendirilmesi [Evaluation of the STEAM education model in terms of music education]. In A. Doğanay, O. Kutlu, & S. Erol, (Eds.), *Güncel eğitim bilimleri araştırmaları* V [Current educational science research V]. (pp. 151-161). Akademisyen.

Korkmaz, Ö., & Yeşil, R. (2009). Öğretim kademelerine göre öğrencilerin eleştirel düşünme düzeyleri [Students' critical thinking level as to educational degrees]. *Kırşehir Ahi Evran University Faculty of Education Journal, 10*(2), 19-28.

Kvale, S. (1996). *Interviews an introduction to qualitative research interviewing*. Sage.

Levy, M. (1997). *Computer-assisted language learning: Context and conceptualization*. Oxford University.

Liao, C. (2016). From interdisciplinary to transdisciplinary: An arts-integrated approach to STEAM education. *Journal Art Education*, *69*(6), 44-49. https://doi.org/10.1080/00043125.2016.1224873

Lipman, M. (1988). Critical thinking-what can it be? *Educational Leadership, 46*(1), 38-43.

Ministry of National Education (MoNE) (2018). *2023 eğitim vizyonu felsefesi.* Retrived November 17, 2024 from https://l24.im/gs97xyl

Newell, W. H. (2001). A theory of interdisiplinary studies. *Issues in Inteactive Studies, 19,* 1-25.

Partnership for 21st Century Learning. (2019). *P21 framework definitions*. Retrived November 15, 2024 from https://www.battelleforkids.org/networks/p21

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Sage.

Paul, R. (1990). Critical thinking handbook: K-3rd grades. A guide for remodelling lesson plans in language arts (ED325803). ERIC. https://eric.ed.gov/?id=ED325803

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

Russell, D. H. (1963). The prerequisite: Knowing how to read critically. *Elem English*, *40*(6), 579–97.

Siegel, H. (2017). *Education's epistemology: Rationality, diversity, and critical thinking*. Oxford University.

Turhal, E. (2020). From art and music education to STEAM. In S. Idin (Ed.), *Research highlights in education and science 2020* (pp. 171-183). ISRES.

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

World Economic Forum. (2016). *World Economic Forum Annual Meeting*. Retrived November 17, 2024 from https://www.weforum.org/events/world-economic-forum-annual-meeting2016/

Yakman, G., & Lee, H. (2012). Exploring the exemplary STEAM education in the U.S. as a practical educational framework for Korea. *Journal of the Korean Association for Science Education, 32*(6), 1072–1086.

Yavuz, M. (2016). *Yeni nesil okul: Araştıran okul* [The next generation school: The research school]. Eğitim.

Yıldırım, A., & Şimşek, H. (2013). *Sosyal bilimlerde nitel araştırma yöntemleri* [Qualitative research methods in social sciences]. Seçkin.

BIOGRAPHICAL NOTES

Contribution Rate of Researchers

Author 1: %60

Author 2: %40

Support and Thanks

No support was received from other individuals or institutions.

Conflict Statement

There was no conflict situation.

Notice of Use of Artificial Intelligence

There is no section written by artificial intelligence in the article.

Müzik Dersi Etkinliklerinde STEAM Yaklaşımının Öğrencilerin Eleştirel Düşünme Eğilimlerine Etkisi

Özet

Bu çalışmada müzik dersi etkinliklerinde Bilim, Teknoloji, Mühendislik, Sanat ve Matematik [STEAM] yaklaşımının öğrencilerin eleştirel düşünme eğilimleri üzerindeki etkisinin değerlendirilmesi amaçlanmıştır. İç içe desenli karma yöntem kullanılarak nitel ve nicel veriler toplanmış, analiz edilmiştir. Araştırmanın çalışma grubunu bir anadolu lisesinde onuncu sınıfta öğrenim gören 37 öğrenci ve okul öğretmenlerinden altı STEAM alan uzmanı (fizik, biyoloji, matematik, müzik, görsel sanatlar, bilişim teknolojileri) oluşturmuştur. Uygulama süresi toplamda sekiz hafta sürmüştür. Araştırmanın nicel verileri UF/EMI Eleştirel Düşünme Eğilimi Ölçeği formlarının ön test–son test karşılaştırması ile elde edilmiştir. Araştırmanın nitel verileri ise yapılandırılmış öğrenci görüşmeleri, yarı yapılandırılmış ve yapılandırılmamış öğretmen görüşmeleri ile elde edilmiştir. UF/EMI Eleştirel Düşünme Eğilimi ölçeği ön test–son testinden elde edilen nicel bulgular öğrencilerin belirli bir süreçte ilerleme kaydettiğini ve eleştirel düşünme eğilimlerinin gelişimine olumlu yönde katkıda bulunduğunu göstermiştir. Bu çalışmanın öğretmen ve öğrenci görüşmelerinden elde edilen nitel verileri müzik dersi etkinliklerinde STEAM yaklaşımının öğrencilerin eleştirel düşünme eğilimlerini geliştirdiğini göstermiştir. Elde edilen nicel ve nitel bulguların sonuçları doğrultusunda; etkinliklerde daha iyi zaman yönetimi sağlanması, çeşitliliğin artırılması, öğrencilere daha fazla özgürlük ve sorumluluk verilmesi, grup çalışmalarının teşvik edilmesi, materyal zenginliğinin artırılması ve yeni ölçme araçlarının geliştirilmesi önerilmiştir.

Anahtar Kelimeler: Müzik eğitimi, STEAM yaklaşımı, eleştirel düşünme eğilimi.

Giriş

Eğitim, tarih boyunca pratik bilgi aktarımından başlayarak teknolojik destekli sistemlere dönüşmüştür. Bu dönüşüm, disiplinler arası öğretim yöntemlerini ön plana çıkarmış, eğitim programlarını esnek ve problem çözmeye odaklı hale getirmiştir (Newell, 2001; Yavuz, 2016). Toplumların kalkınma politikaları, bireylerin donatılması gereken becerileri belirlerken eğitimciler de bu doğrultuda reformlar gerçekleştirmiştir.

Sanayileşmeyle birlikte eğitimde dört ana evrimsel aşama ortaya çıkmıştır (Diwan, 2017). Eğitim 1.0 geleneksel yöntemleri, Eğitim 2.0 teknolojinin kullanımını, Eğitim 3.0 aktif bilgi üretimini, Eğitim 4.0 ise yaratıcı düşünme ve problem çözme becerilerini desteklemiştir (İsababayeva Apaydın & Arslan, 2015; Turhal, 2020).

Eğitim 4.0 doğrultusunda belirlenen 21. yüzyıl becerilerinde karmaşık problemleri çözebilme, eleştirel düşünme, yaratıcılık, insan yönetimi, iş birliği ve duygusal zekâ önemli bir yer tutmaktadır (World Economic Forum, 2016). Başka bir açıdan bu beceriler; öğrenme ve yenilik becerileri, yaşam ve kariyer becerileri, bilgi-medya ve teknoloji okuryazarlığı becerileri şeklinde üç genel başlıkta sınıflandırılmaktadır (Partnership for 21st Century Learning, 2019).

Eleştirel düşünme, bireylerin sorunları analiz etme, farklı bakış açılarını değerlendirme ve etkili çözümler üretme becerisini geliştirmektedir (Ennis, 1993; Levy, 1997). Ayrıca, yaratıcı düşünmeyi teşvik ederek yenilikçi fikirlerin ortaya çıkmasını sağlamakta ve iş birliği becerilerini güçlendirmektedir. Russell (1963), Paul (1990), Siegel (2017) ve Lipman (1988) eleştirel düşünmeyi düşünceler üzerinde derinlemesine değerlendirme ve nedenlere dayalı onaylama sanatı olarak tanımlamışlardır.

Eleştirel düşünme, sorunları analiz etme, çözüm üretme ve toplumsal iyileştirme süreçlerinde önemli bir rol oynamaktadır. Bilim, Teknoloji, Mühendislik, Sanat ve Matematik [STEAM] eğitimi, disiplinler arası yapısıyla bu beceriyi güçlendiren etkili bir modeldir. Yaratıcı problem çözme odaklı projeleri sayesinde, öğrencilerin bilgiyi eleştirel ve yenilikçi bir şekilde kullanmalarını sağlamaktadır. Özellikle bilim, teknoloji, mühendislik ve sanatın müzik eğitimi ile entegrasyonu, eleştirel düşünme becerilerini derinleştirmektedir (Campbell, 2004).

Millî Eğitim Bakanlığı'nın [MEB] (2018), 2023 Eğitim Vizyonunda, ortaöğretimde öğretim tasarımının bireylerin bilimsel beceriler edinmesiyle bağlantılı olduğu belirtilmiştir. Değişen evrensel becerilere uyum sağlamak ve öğrencileri dönüşümün aktörleri haline getirmek için yapısal değişikliklere ihtiyaç duyulduğu vurgulanmaktadır. Müfredatın süreç odaklı, bireysel farklılıkları gözeten ve teknolojiyi etkin kullanan bir yapıya sahip olması gerektiği ifade edilmektedir. Bu doğrultuda, müzik dersinde çağdaş yaklaşımların araştırılması önem kazanmaktadır.

Alanyazında sanat eğitiminin eleştirel düşünme, problem çözme ve yaratıcılık gibi becerileri desteklediği vurgulanmaktadır (Didin & Köksal, 2017; Perignat & Buonincontro, 2019). Bununla birlikte, öğrencilerin eleştirel düşünme becerilerindeki yetersizlikler ve bu becerilerin geliştirilmesi için yapılması gereken çalışmaların önemi belirtilmektedir (Demir & Aybek, 2014; Korkmaz & Yeşil, 2009). Mevcut eğitim koşulları incelendiğinde, eleştirel düşünme becerilerini geliştirme yönünde adımlar atılmasının gerekliliği ön plana çıkmaktadır.

İçinde dolaylı olarak tüm disiplinleri barındıran müzik eğitimi ile STEAM entegrasyonunun, öğrencilerin eleştirel düşünme becerilerini nasıl etkilediği önemli bir araştırma konusu olarak ortaya çıkmaktadır. Ancak bu konuya dair araştırmaların ve bulguların sınırlı kaldığı ve genellikle uygulama süreçlerinin derinlemesine analiz edilmediği görülmektedir (Liao, 2016). Bunun yanı sıra, Türkiye gibi gelişmekte olan ülkelerde STEAM eğitimi üzerine yapılan çalışmaların sayısı artmakta ancak bu çalışmaların büyük çoğunluğu fen, matematik ve teknoloji eksenine odaklanmış olup müzik eğitimi gibi sanat temelli disiplinlerin ele alınmadığı gözlemlenmektedir (Gülhan, 2022).

Bu kapsamda, bu çalışmanın alana özgün katkısı, STEAM yaklaşımlı müzik eğitimi özelinde öğrencilerin eleştirel düşünme eğiliminin gelişimini hem nitel hem de nicel yöntemlerle inceleyerek uluslararası literatürdeki bu boşluğu doldurmasıdır. Araştırma, müzik eğitiminin yalnızca estetik bir etkinlik olmadığını, aynı zamanda disiplinler arası bir bağlamda bilişsel becerilerin gelişiminde kritik bir rol oynayabileceğini göstermeyi amaçlamıştır. Bu çalışmanın bulguları, uluslararası bağlamda müzik eğitiminin STEAM modellerine nasıl entegre edilebileceğine dair değerli bilgiler sunarak literatüre yenilikçi bir bakış açısı kazandırmaktadır.

Bu nedenle bu çalışmada müzik dersi etkinliklerinde STEAM yaklaşımının öğrencilerin eleştirel düşünme eğilimleri üzerindeki etkisinin değerlendirilmesi amacıyla aşağıdaki sorulara yanıt aranmıştır.

1. Müzik dersi etkinliklerinde STEAM yaklaşımının öğrencilerin eleştirel düşünme eğilimleri üzerindeki etkisi nasıldır?

2. Müzik dersi etkinliklerinde STEAM yaklaşımının uygulanmasına dair öğrenci görüşleri nasıldır?

3. Müzik dersi etkinliklerinde STEAM yaklaşımının uygulanmasına dair öğretmen görüşleri nasıldır?

Yöntem

Araştırmanın Modeli

Bu çalışmada, STEAM temelli müzik ders etkinliklerinin öğrencilerin eleştirel düşünme eğilimlerine etkisi incelenmiştir. Araştırma, iç içe desenli karma yöntem kullanılarak hem nitel hem de nicel verilerle yapılmıştır. Nicel veriler, ön test ve son test olarak toplanmış; nitel veriler ise öğrencilerle yapılandırılmış, öğretmenlerle ise yapılandırılmamış ve yarı yapılandırılmış görüşmelerle elde edilmiştir.

Çalışma Grubu

Bu araştırmanın çalışma grubunu, bir anadolu lisesinin onuncu sınıfında öğrenim gören 37 öğrenci ve altı STEAM alan uzmanı (fizik, biyoloji, matematik, görsel sanatlar, bilişim teknolojileri, müzik) oluşturmuştur. Araştırma, STEAM yaklaşımının müzik eğitimi bağlamındaki eleştirel düşünme becerileri üzerindeki etkisini derinlemesine incelemeyi amaçlamaktadır. Örneklem büyüklüğü küçük tutulmuş, bu da katılımcıların deneyimlerinin detaylı bir şekilde analiz edilmesine olanak sağlamıştır (Creswell, 2017). Ayrıca, öğrencilerin homojen bir grup olarak seçilmesi, araştırmanın içsel geçerliliğini artırmıştır (Patton, 2002). Ancak, küçük örneklem bulguların genelleştirilebilirliğini sınırlamaktadır ve farklı yaş gruplarına, okul türlerine ya da kültürel bağlamlara yönelik daha geniş çalışmalara ihtiyaç vardır. Bu çalışma, müzik eğitimine STEAM yaklaşımını entegre etmenin potansiyel etkilerini anlamak için temel bir araştırma olarak görülmektedir.

Veri Toplama Araçları

Araştırmada nitel veriler; yapılandırılmış, yarı yapılandırılmış ve yapılandırılmamış görüşmeler ile araştırmacı günlüğü notlarından elde edilmiştir. Nicel veriler ise Kılıç ve Şen (2014) tarafından Türkçe 'ye uyarlanan "UF/EMI Eleştirel Düşünme Eğilimi Ölçeği" ile toplanmıştır. Veriler, çalışmanın başlangıcında uygulanan ön test ile toplanmış, ardından uygulama sürecinde nitel veriler elde edilmiştir. Uygulama sona erdiğinde, aynı ölçek ile yapılan son testle veriler tekrar toplanmıştır.

Verilerin Analizi

Araştırmada, anketlerle toplanan veriler SPSS 26.0 programı ile işlenmiş ve analiz edilmiştir. Katılımcıların ön test ve son test sonuçları arasındaki istatistiksel farklılıkları değerlendirmek için "Wilcoxon İşaretli Sıralar Testi" uygulanmıştır. Anlamlılık değeri .05

olarak kabul edilmiştir; $p<.05$ olduğunda farklılık anlamlı, $p>.05$ olduğunda ise önemsiz kabul edilmiştir. "UF/EMI Eleştirel Düşünme Eğilimi Ölçeği", bireylerin eleştirel düşünme eğilimlerini ölçmek için geliştirilmiş ve Kılıç ve Şen (2014) tarafından Türkçeye uyarlanmıştır. Ölçek; öngörüsellik, bilişsel olgunluk ve yenilikçilik olmak üzere üç alt boyuta sahiptir. Alt boyutların iç tutarlılık katsayıları sırasıyla .88, .70 ve .91 olarak hesaplanmıştır. Verilerin analizi, SPSS programında normal dağılım gösterip göstermediğine bağlı olarak frekans, yüzde, t testleri veya tek faktörlü varyans analizi [ANOVA] ile yapılmıştır. Elde edilen veriler tablolar halinde sunulmuştur.

Tablo 1.

UF/EMI Eleştirel Düşünme Eğilimi Ölçeğine Ait Güvenirlik Analizi

Alt boyutlar	Soru sayısı	Cronbach's Alpha	Genel Cronbach's Alpha
Öngörüsellik	11	.846	
Yenilikçilik	7	.914	.910
Bilişsel olgunluk	7	.897	

Nitel veriler, öğrenci ve öğretmenlerle yapılan röportajlardan elde edilmiştir. Görüşmeler, ses kaydıyla alınmış ve bilgisayar ortamında yazıya dökülmüştür. Deşifre edilen görüşme kayıtları, araştırmacı tarafından gözden geçirilmiş ve analize uygun hale getirilmiştir (Coolican, 2009; Kvale, 1996). MAXQDA 21 programı kullanılarak tümevarım analizi yöntemiyle çözümlenen veriler, kodlama işlemiyle düzenlenmiştir (Yıldırım & Şimşek, 2013). Kodlar, danışman öğretmenle gözden geçirilmiş ve uzman görüşü ile içerik analizi tamamlanmıştır. Yarı yapılandırılmış ve yapılandırılmamış öğretmen görüşmeleri ile yapılandırılmış öğrenci görüşmeleri, betimsel analiz yöntemiyle incelenmiştir.

Araştırma Süreci

Bu çalışmada, STEAM yaklaşımının müzik dersi etkinliklerinde uygulanması süreci toplamda sekiz hafta sürmüştür. İlk hafta ön test olarak, "UF/EMI Eleştirel Düşünme Eğilimi Testi" uygulanmıştır. Ardından planlanan STEAM ders programı doğrultusunda sırasıyla biyoloji, fizik, matematik, görsel sanatlar ve bilişim teknolojileri dersleri ile müzik dersi arasında bağlantılar kurulmuştur. Uygulama sürecinde, öğrenciler çeşitli disiplinler arasındaki ilişkileri keşfetmiş ve çeşitli projeler üzerinde çalışmıştır. Öğrenciler biyoloji dersinde hücre ögeleriyle şarkı sözü yazmış, fizik dersinde sese duyarlı ledler kullanmış, matematik dersinde fonksiyonlarla müzik arasındaki ilişkiyi kurmuş, görsel sanatlarda çalgı maketi yapmış, bilişim teknolojilerinde farklı materyallerle müzik prototipi oluşturmuş, mekanik klavye ve elektronik devrelerle müzik prodüksiyonu yapmıştır. Uygulama süresince araştırmacı, süreci verimli yönetebilmek için STEAM alan uzmanlarıyla yapılandırılmamış görüşmeler yapmıştır. Altı hafta süren uygulama sürecinden sonra son test uygulanmış, ardından öğrencilerle yapılandırılmış görüşmeler, öğretmenlerle ise yarı yapılandırılmış görüşmeler gerçekleştirilmiştir. Böylece nitel ve nicel veriler toplanmış, kayıt altına alınmıştır. Bu süreç, öğrencilerin farklı disiplinler arası düşünme ve yaratıcı çözüm üretme becerilerini geliştirmeyi amaçlamıştır.

Araştırmanın Etik İzinleri:

Bu çalışmada "Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi" kapsamında uyulması gerektiği belirtilen tüm kurallara uyulmuştur. Yönergenin ikinci bölümü olan "Bilimsel Araştırma ve Yayın Etiğine Aykırı Eylemler" başlığı altında belirtilen eylemlerin hiçbiri gerçekleştirilmemiştir.

Etik Kurul İzin Bilgileri:

Etik değerlendirmeyi yapan kurulun adı = Gazi Üniversitesi Etik Komisyonu

Etik Kurul Etik inceleme karar tarihi = 10.05.2023

Etik değerlendirme belgesi konu numarası = E-652780

Bulgular

Bu araştırma, müzik dersi etkinliklerinde uygulanan STEAM yaklaşımının öğrencilerin eleştirel düşünme eğilimleri üzerindeki etkisini incelemektedir. Eleştirel düşünme eğilimi, ön test ve son test sonuçlarıyla analiz edilerek nicel verilere ulaşılmıştır. Nitel veriler ise yapılandırılmış öğrenci görüşmeleri ile yarı yapılandırılmış ve yapılandırılmamış öğretmen görüşmelerinden elde edilmiştir.

1. Müzik Dersi Etkinliklerinde STEAM Yaklaşımının Öğrencilerin Eleştirel Düşünme Eğilimleri Üzerindeki Etkisi Nasıldır?

Eleştirel düşünme eğilimi testi öngörüsellik, yenilikçilik ve bilişsel olgunluk şeklinde üç alt boyutta yapılandırılmıştır. Elde edilen bulgular tablolar halinde sunulmuştur.

Tablo 2.

UF/EMI Eleştirel Düşünme Eğilimi Ölçeğinin Son Test-Ön Test Karşılaştırılması

		n	*M*	*SD*	Min	Max
Ön test		37	3.5358	.59	1.48	4.72
Son test		37	3.8707	.52	1.92	4.84
Wilcoxon işaretli sıralar testi						
		n	Sıra Ortalaması	Sıra Toplamı	*Z*	*p*
Son test–ön test	Negatif sıralama	8	13.25	106.00	-3.424	.001
	Pozitif sıralama	27	19.41	524.00		
	Eşitlik	2				
	Toplam	37				

Tablo 2'de UF/EMI Eleştirel Düşünme Eğilimi Ölçeğinin genel sonuçlarına bakıldığında öğrencilerin son test ortalamalarının ön test ortalamalarına kıyasla anlamlı bir şekilde arttığı görülmektedir ($Z=-3.424$; $p<.05$). Müzik dersi etkinlikleriyle uygulanan STEAM yaklaşımının 27 öğrencinin eleştirel düşünme eğilimine katkı sağladığı, 8 öğrencinin eleştirel düşünme eğiliminde ise azalma durumu gözlemlenmiştir. Kalan 2 öğrenci eşitliği sağlayarak gelişimsel olarak bir farklılık göstermemiştir. Gelişim göstermeyen öğrencilerin bireysel farklılıklardan, etkinliklerin içeriğine uyum sağlamada yaşadıkları zorluklardan veya ölçeklerin bu öğrenci grubunun yeteneklerini tam olarak ölçememesinden kaynaklandığı düşünülmektedir.

Tablo 3.

Öngörüsellik Alt Boyutunun Son Test-Ön Test Karşılaştırılması

		n	*M*	*SD*	Min	Max
Ön test		37	3.56	.67	1.36	4.82
Son test		37	3.88	.59	1.82	5.00
Wilcoxon işaretli sıralar testi						
		n	Sıra ortalaması	Sıra toplamı	*Z*	*p*
Son test–ön test	Negatif sıralama	9	15.56	140.00	-2.869	.004
	Pozitif sıralama	26	18.85	490.00		
	Eşitlik	2				
	Toplam	37				

Tablo 3'te görüldüğü gibi öngörüsellik alt boyutunda öğrencilerin puanlarındaki artış istatistiksel olarak anlamlıdır (Z=-2.869; p<.05). Bu bulgular öğrencilerin gelecekteki olasılıkları öngörme ve bu olasılıklara göre düşünme yeteneklerinin geliştiğini göstermektedir. 9 öğrencinin puanlarında görülen azalma, öğrencilerin mevcut bilgi ve becerilerini öngörü yeteneklerine entegre etmekte zorlanabileceklerini veya bu süreçte daha fazla rehberliğe ihtiyaç duyabileceklerini düşündürmektedir.

Tablo 4.

Yenilikçilik Alt Boyutunun Son Test-Ön Test Karşılaştırılması

		n	*M*	*SD*	Min	Max
Ön test		37	3.5238	.74890	1.86	4.71
Son test		37	3.8764	.54727	2.43	4.71
Wilcoxon işaretli sıralar testi						
		n	Sıra ortalaması	Sıra toplamı	*Z*	*p*
Son test–ön test	Negatif sıralama	11	14.91	164.00	-2.287	.022
	Pozitif sıralama	23	18.74	431.00		
	Eşitlik	3				
	Toplam	37				

Tablo 4'te görüldüğü gibi yenilikçilik alt boyutunda öğrencilerin yenilikçilik becerileri son testte anlamlı bir şekilde artmıştır (Z=-2.287; p<.05). Bu bulgular müzik dersi etkinlikleriyle uygulanan STEAM yaklaşımının öğrencilerin yaratıcı düşünme ve yenilikçi çözümler geliştirme becerilerini desteklediğini göstermektedir. Ancak 11 öğrencinin becerilerinde azalma görülmesi, bu öğrencilerin yenilikçi düşünce süreçlerine tam anlamıyla katılamadığını veya mevcut yöntemlerin bu öğrenciler için yeterince etkili olmadığını göstermektedir.

Tablo 5.

Bilişsel Olgunluk Alt Boyutunun Son Test-Ön Test Karşılaştırılması

		n	*M*	*SD*	Min	Max
Ön test		37	3.5019	.68728	1.29	4.86
Son test		37	3.8378	.66083	1.57	5.00
Wilcoxon işaretli sıralar testi						
		n	Sıra ortalaması	Sıra toplamı	*Z*	*p*
Son test–ön test	Negatif sıralama	12	13.00	156.00	-2.612	.009
	Pozitif sıralama	23	20.61	474.00		
	Eşitlik	2				
	Toplam	37				

Tablo 5'te bilişsel olgunluk alt boyutunda anlamlı bir artış gözlemlenmiştir (Z=-2.612; p<.05). Bu bulgular öğrencilerin daha olgun ve yapısal bir düşünce süreci geliştirdiklerini, karmaşık durumları değerlendirme ve analiz etme becerilerinde ilerleme kaydettiklerini göstermektedir. Ancak 12 öğrencinin bu boyutta azalma yaşaması, bilişsel gelişim süreçlerinde farklı zorluklar yaşadıklarına işaret edebilmektedir. Bu durum, bu öğrencilerin bilişsel olgunluk becerilerinin daha fazla desteklenmesi gerektiğini düşündürmektedir.

2. Müzik Dersi Etkinliklerinde STEAM Yaklaşımının Uygulanmasına Dair Öğrenci Görüşleri

Araştırma bulguları, öğrencilerin müzik dersi ile diğer disiplinler arasında kurdukları bağlantıları ve bu süreçte eleştirel düşünme becerilerini geliştirdiklerini göstermektedir. Öğrenciler, başlangıçta bağlantısız görünen bilgileri sorgulayarak ve somut örneklerle soyut kavramları daha iyi anlayarak eleştirel düşünme becerilerini güçlendirmişlerdir. Müzik, biyoloji, matematik gibi dersler arasındaki bağlantılar, öğrencilerin disiplinlerarası düşünme yeteneğini geliştirmiştir. Öğrenciler, fikirlerini başkalarıyla paylaşarak ve tartışarak farklı bakış açılarını değerlendirme becerilerini artırmışlardır. Bu süreç, öğrencilerin bilgiyi analiz etme ve yeni bağlamlarda kullanma yeteneklerini geliştirdiğini göstermektedir.

3. Müzik Dersi Etkinliklerinde STEAM Yaklaşımının Uygulanmasına Dair Öğretmen Görüşleri

Araştırmaya katkı sağlayan öğretmenlerin görüşleri:

-Öğrencilerin çalışmalarında karşılaştıkları süreçlerin artılarını ve eksilerini değerlendirerek en iyi sonuca ulaşmaya teşvik edilmesi, eleştirel düşünme becerisini harekete geçirmiştir.

-STEAM yaklaşımı, öğrencilere disiplinler arası düşünme fırsatı sunarak, eleştirel bakış açılarını geliştirmelerine olanak tanımıştır. Özellikle, müzik etkinlikleri sırasında öğrencilerin kendi performanslarını ve diğerlerinin çalışmalarını değerlendirmesi, eleştirel düşünme sürecini derinleştirmiştir.

-Teknolojik unsurların entegrasyonu, öğrencilerin yaratıcı düşünmelerini sağlarken, aynı zamanda bu süreçte eleştirel bir şekilde düşünmelerine olanak tanımıştır.

-İletişim ve iş birliği gibi sosyal becerilerin gelişimi de, eleştirel düşünmenin sosyal boyutunu desteklemiş, öğrencilerin farklı bakış açılarını değerlendirme yeteneklerini artırmıştır.

-Disiplinler arası bağlantılar kurarak, soyut kavramları somut ürünlere dönüştürme süreçleri de öğrencilerin eleştirel düşünme becerilerini pekiştirmiştir.

Bu bağlamda müzik dersi etkinliklerinde STEAM yaklaşımının uygulanmasına dair öğretmen görüşlerinden, öğrencilerin sadece teknik becerileri değil, aynı zamanda eleştirel düşünme yetilerini geliştiren bir öğrenme deneyimi yaşadıkları anlaşılmaktadır.

Tartışma ve Sonuç

Bu çalışmada, müzik dersinde uygulanan STEAM temelli etkinliklerin öğrencilerin eleştirel düşünme eğilimleri üzerindeki etkisi incelenmiştir. Araştırmanın ön test-son test analizleri, STEAM yaklaşımının öğrencilerin eleştirel düşünme eğilimlerini geliştirdiğini ortaya koymuştur. Baek vd. (2011), STEAM etkinliklerinin analitik becerileri ve karmaşık problemleri anlamlandırma yeteneğini güçlendirdiğini belirtirken, Kim ve Park (2012) sanatın yaratıcı ve eleştirel düşünme becerilerine katkısını vurgulamaktadır. Kolodner vd. (2003), problem temelli öğrenmenin bu süreçleri desteklediğini ifade etmiştir. Ayrıca, Yakman ve Lee (2012) STEAM eğitiminin uzun vadeli etkiler yaratarak eleştirel düşünme becerilerini geliştirdiğini belirtmiştir. Benzer şekilde, Kömürcü (2022), STEAM temelli müzik eğitiminin yaratıcılığı, eleştirel düşünmeyi ve müzikal iletişimi geliştirdiğini ifade etmiştir. Bu bulgular, STEAM etkinliklerinin sanat odaklı yapısı ve problem temelli öğrenme süreçlerinin öğrencilerin eleştirel düşünme becerilerini geliştirmedeki rolünü vurgulamaktadır.

Araştırmanın nicel bulguları, öğrencilerin eleştirel düşünme, yenilikçilik ve bilişsel olgunluk gibi boyutlarda anlamlı bir gelişim gösterdiğini ortaya koymuştur. Bu sonuçlar, uluslararası STEAM eğitim araştırmalarıyla paralellik göstermektedir. Wilson vd. (2021), transdisipliner STEAM derslerinin öğrencilerin eleştirel ve yaratıcı düşünme becerilerini geliştirdiğini vurgulamaktadır. Özellikle problem çözme, fikir üretme ve farklı bakış açılarıyla değerlendirme becerilerinde anlamlı iyileşmeler gözlemlenmiştir. Henriksen (2014) ile Kim ve Park (2012), STEAM'in yaratıcı ve eleştirel düşünme becerilerine etkisini belirtirken disiplinler arası yaklaşımların bu gelişimdeki rolünü vurgulamaktadır. Perignat ve Buonincontro (2019), STEAM uygulamalarının öğrencilere bilgiye farklı perspektiflerden bakma ve yaratıcı problem çözme becerisi kazandırdığını ifade etmektedir. Ancak, bu çalışmaların çoğu STEM odaklı olup, sanatın özellikle müziğin eleştirel düşünme süreçlerine katkısı sınırlı olarak ele alınmıştır.

Nitel bulgular, öğrencilerin müzik eğitimi aracılığıyla biyoloji, matematik ve mühendislik gibi farklı disiplinler arasında bağlantılar kurarak bilgiyi analiz etme ve farklı bağlamlarda uygulama yetenekleri kazandığını göstermektedir. Bu bulgular, Liao (2016) tarafından dile getirilen STEAM eğitiminin disiplinler arası bağlamda eleştirel düşünmeyi teşvik ettiği görüşüyle uyumludur. Ancak, bazı öğrencilerin bu süreçte zorlandığı ve eleştirel düşünme becerilerinde yeterli gelişim göstermediği gözlemlenmiştir. Bu durum, STEAM etkinliklerinin bireysel farklılıkları daha iyi dikkate alacak şekilde tasarlanması gerektiğini ortaya koymaktadır.

Yapılandırılmış görüşmeler, STEAM etkinliklerinin öğrencilerin yaratıcı düşünme, iletişim ve iş birliği gibi becerilerini geliştirdiğini ortaya koymuştur. Ancak, bazı öğrencilerin bu süreçte yeterince ilerleme kaydedememesi, etkinliklerin bireysel farklılıkları göz önünde bulunduracak şekilde yeniden düzenlenmesini gerekli kılmaktadır. Ölçme araçlarının öğrencilerin gelişimlerini tam olarak yansıtacak şekilde uyarlanması, gelecekteki araştırmalarda daha kesin değerlendirmeler yapılmasını sağlayabilir.

Araştırma bulguları, STEAM yaklaşımının disiplinler arası öğrenme süreçlerini teşvik ederek eleştirel düşünme becerilerinde anlamlı bir gelişim sağladığını ortaya koymaktadır. Kim ve Auh (2024) tarafından yapılan bir çalışmada, STEAM tabanlı müzik etkinliklerinin öğrenci katılımını artırdığı ve öğrencilerin müzik prensiplerini derinlemesine anlamalarına olanak tanıdığı belirtilmiştir. Bu bulgu, biyoloji, matematik ve mühendislik gibi disiplinlerle bağlantılar kurarak bilgiyi uygulama becerisi kazanan öğrencilerle örtüşmektedir. Sonuç olarak, STEAM etkinliklerinin yaratıcı ve analitik düşünme süreçlerini desteklediği vurgulanmaktadır.

Bu çalışmanın uluslararası literatüre katkısı, müziği STEAM eğitimi içinde merkezi bir bileşen olarak ele alarak, yaratıcı disiplinlerin eleştirel düşünme süreçlerindeki rolünü daha kapsamlı bir şekilde incelemesidir. Campbell (2004) müziğin kültürel ve bilişsel gelişimdeki önemini vurgulamışken bu çalışmada müziğin STEAM pedagojisi içinde eleştirel bir araç olarak kullanıldığı gösterilmiştir. Özellikle farklı disiplinlerle kurulan bağlantılar, müziğin sadece estetik bir etkinlik olmanın ötesinde, disiplinler arası düşünme süreçlerinde önemli bir rol oynadığını ortaya koymaktadır.

STEAM yaklaşımı, eleştirel düşünme becerileri, yaratıcılık, iletişim ve iş birliği gibi 21. yüzyıl becerilerini destekleyen zengin bir öğrenme ortamı sunmaktadır. Ancak, bireysel farklılıkların daha iyi gözetilmesi, uzun vadeli etkilerin incelenmesi ve ölçme araçlarının geliştirilmesi, bu potansiyelin tam anlamıyla ortaya çıkmasını sağlayacaktır.

Öneriler

STEAM yaklaşımının uzun vadeli etkileri ve müzik eğitimi bağlamındaki uygulamaları üzerine daha fazla araştırmaya ihtiyaç vardır. Ayrıca, bireysel farklılıklar dikkate alınarak müfredat entegrasyonu ve STEAM materyallerine erişim olanakları artırılmalıdır. Müzik eğitimcilerine, eleştirel düşünme becerilerini ölçen hassas araçlar geliştirme, STEM disiplinleriyle müzik arasındaki bağları modelleme, dijital araçların geliştirilmesi ve etkinlik sürelerinin iyileştirilmesi önerilmektedir. Millî Eğitim Bakanlığı, STEAM temelli müzik derslerini yaygınlaştırmak için mali destek sağlamalı, öğretmen eğitimleri düzenlemeli, altyapı yatırımlarına öncelik vermeli ve uygun ölçme araçları geliştirmelidir.