Research on Pathways for Integrating Music and STEAM Education: A Case Study of the Affiliated Primary School of Anhui Normal University

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ABSTRACT

Against the backdrop of the continuous deepening of comprehensive education reform, the STEAM education concept is increasingly becoming an important way to cultivate students' core literacy and comprehensive abilities. As an important component of art education, the music discipline not only undertakes the function of aesthetic education in the STEAM system, but also serves as an effective carrier to stimulate students' innovative thinking and interdisciplinary abilities. This paper takes the Affiliated Primary School of Anhui Normal University as the research sample to conduct a systematic analysis of the integration of music and STEAM education, and explore an integrated education model suitable for the background of basic education in China. Research has found that the deep integration of music and STEAM can enhance students' aesthetic literacy, scientific literacy and problem-solving abilities. However, its implementation still faces problems such as scattered courses and a single teaching staff structure. To this end, this paper proposes to optimize the integration path from multiple aspects such as curriculum reconstruction, teacher training, technological empowerment, and institutional support, with the aim of providing references for future basic education reform.

Keywords: STEAM education, interdisciplinary teaching, primary education, innovative practice

INTRODUCTION

The rapid development of science and technology in the 21st century has brought about profound changes in the ways individuals acquire knowledge, interact with information, and participate in society (Roco & Bainbridge, 2013). As knowledge is updated at an unprecedented speed, traditional education models that focus solely on subject-based knowledge transmission are increasingly unable to meet the needs of future-oriented talent cultivation. Many countries have thus shifted toward ability-centered education, emphasizing interdisciplinary thinking, creativity, collaboration, and real-world problem-solving. Within this global trend, STEAM education—integrating Science, Technology, Engineering, Arts, and Mathematics—has emerged as a key approach for promoting holistic and innovative development among students (Belbase et al., 2022). STEAM education not only encourages students to apply knowledge across disciplinary boundaries, but also advocates project-based learning, inquiry-based exploration, and integrated skill development, which align well with the goals of contemporary educational reform (Leavy et al., 2023).

Among the five STEAM elements, Art, particularly music education, has increasingly been recognized as an essential catalyst in cultivating creativity and divergent thinking. Prior research has demonstrated that music learning enhances cognitive flexibility, auditory perception, spatial-temporal reasoning, and emotional expression (Artıktay, 2024). Scholars have also argued that the inclusion of artistic components in STEM-related activities promotes higher engagement, stronger motivation, and improved learning outcomes (Murphy et al., 2019). Moreover, interdisciplinary studies reveal that music can support logical reasoning, computational thinking, and engineering design by fostering pattern recognition, structural analysis, and abstract representation (Weng et al., 2022). From the perspective of multimodal cognition, music integrates auditory, kinesthetic, and

symbolic representations, thereby facilitating deeper conceptual understanding and cognitive transfer across disciplines. These findings highlight the potential of music as a powerful medium to connect humanistic sensibilities with scientific and technological thinking, enriching the educational value of STEAM frameworks.

Despite these promising perspectives, the integration of music and STEAM education remains insufficiently developed, particularly in the context of Chinese primary education. Although STEAM has been promoted in China for more than a decade, its implementation is still largely concentrated in science and technology subjects. Music education often remains at the periphery, limited to basic singing, appreciation, and rhythmic training, with few attempts at interdisciplinary curriculum development.

International research also presents similar challenges. For instance, many STEAM programs worldwide tend to treat "Art" as an add-on or decorative element rather than integrating it meaningfully with scientific and engineering concepts. Scholars note that existing models often lack systematic curriculum structures and theoretical foundations that clarify how music learning can substantively support STEAM objectives (Vennix et al., 2023). Therefore, both globally and locally, there is a pressing need to examine effective pathways that embed music education deeply and coherently into STEAM practice.

Against this backdrop, this study focuses on the Affiliated Primary School of Anhui Normal University, a representative institution with rich educational resources and sustained experience in curriculum innovation. Using a qualitative case-study design, this research examines how music is integrated into STEAM teaching through selected interdisciplinary projects, drawing on classroom observations, teacher interviews, and student learning artefacts. The school has implemented exploratory projects combining music with technology, engineering design, and mathematical thinking, providing valuable examples of interdisciplinary teaching in Chinese basic education. However, systematic analysis of its integration mechanisms, learning outcomes, and pedagogical implications remains limited.

Therefore, this paper aims to fill this gap by conducting an in-depth investigation into the integration of music and STEAM education within this primary school. The contributions of this study are threefold. First, it expands the theoretical discussion on the role of music within STEAM frameworks, linking classroom practices to constructs such as multimodal cognition, embodied learning, and interdisciplinary transfer. Second, it offers a detailed empirical analysis grounded in a real primary school setting, enriching the limited body of case-based research on music–STEAM integration in China. Third, it proposes a localized and scalable integration model that can serve as a reference for policymakers, educators, and researchers seeking to promote innovative STEAM practices in the broader context of basic education reform.

LITERATURE REVIEW

STEAM Education

The concept of STEAM education originated from STEM education, which emerged in the United States in the late 20th century when global technological competition intensified and countries began prioritizing the cultivation of scientific and technological talent (Perignat & Katz-Buonincontro, 2019). STEM—Science, Technology, Engineering, and Mathematics—was initially introduced to strengthen students' competencies in scientific reasoning, engineering design, and mathematical problem-solving. Early STEM programs emphasized real-world applications and hands-on engagement, aiming to bridge the gap between academic knowledge and technological innovation (Ozkan & Umdu Topsakal, 2021). However, as STEM education developed, scholars began to notice its limitations: although it strengthened rational thinking and technical proficiency, it often overlooked emotional development, creativity, and aesthetic sensibility, which are essential components of innovation.

Against this backdrop, the Rhode Island School of Design (RISD) proposed incorporating "Art" into the STEM framework around 2006, leading to the formation of STEAM education. The inclusion of Art was not intended merely as an aesthetic embellishment; rather, it aimed to promote creativity, imagination, and human-centered design thinking. Art—especially visual arts, performing arts, and music—was recognized as a catalyst for divergent thinking, enabling learners to approach scientific and engineering problems from diverse perspectives.

Since then, STEAM education has evolved into a holistic framework emphasizing interdisciplinary integration, project-based learning, and inquiry-oriented exploration (Aguilera & Ortiz-Revilla, 2021). It encourages students not only to acquire knowledge from different fields, but also to synthesize ideas and solutions creatively. International organizations have provided strong policy support for STEAM development. The OECD's "Education 2030" framework (2018) highlights the necessity of integrating disciplines to cultivate innovative, adaptable, and socially responsible learners. It stresses that future education should break rigid disciplinary boundaries and promote learning that connects science, culture, engineering, art, and society. Likewise, UNESCO advocates for interdisciplinary pedagogies to equip students with problem-solving skills relevant to real-world challenges such as sustainability, digital transformation, and global citizenship.

The Position and Value of Music Education in the STEAM System

Within the STEAM education framework, music holds a unique and irreplaceable position (Aróstegui & Castillo-Ferreira, 2025). As a central component of the arts, music contributes not only to aesthetic appreciation and emotional expression but also to cognitive development, interdisciplinary integration, and creative innovation. Traditional views often regard music as peripheral to the "core" STEM fields; however, contemporary educational research increasingly recognizes that music shares deep structural and conceptual connections with science, mathematics, engineering, and technology. These connections make music an important driver for developing well-rounded, creative, and analytically capable learners within the STEAM system.

From a cognitive perspective, elements such as rhythm, pitch, interval patterns, melodic structure, and harmony correspond to mathematical concepts including proportionality, sequences, symmetry, and ratios. Studies have shown that musical training enhances spatial-temporal reasoning, pattern recognition, auditory discrimination, and memory—skills directly relevant to mathematics and scientific inquiry (Graziano et al., 1999). In physics, music connects naturally with acoustics, resonance, sound waves, and frequency analysis. Engineering disciplines also intersect with music through instrument design, sound amplification systems, and digital signal processing. Thus, music is not merely "artistic decoration" but an intellectually rigorous domain that facilitates conceptual understanding across STEM fields.

In addition to cognitive benefits, music plays a significant role in fostering creativity and emotional engagement—two elements essential for successful STEAM learning. Creativity is widely recognized as the core of innovation, and music encourages learners to experiment, improvise, and express ideas in open-ended ways. Music activities, such as composition, performance, and ensemble collaboration, help cultivate imagination, communication, and teamwork. These abilities become especially valuable in interdisciplinary STEAM projects that require brainstorming, problem-solving, and collaborative design processes.

With the growth of digital technology, music's value within STEAM has expanded further. Modern technological tools—including digital audio workstations (DAWs), sound simulation software, programmable instruments, and music-related coding platforms—integrate artistic creativity with computational and engineering thinking. For example, platforms such as Chrome Music Lab, Scratch Music, and Makey Makey enable students to compose melodies, visualize sound waves, code musical patterns, and design interactive sound devices (Özer & Demirbatir, 2023). These activities merge artistic expression with problem-based technological tasks, making learning both engaging and intellectually challenging. Moreover, music supports social-emotional learning (SEL), which contributes to the holistic development emphasized in STEAM education. Music activities promote emotional intelligence, empathy, cultural awareness, and confidence—qualities essential for collaborative STEAM environments. Group performance and project-based music tasks encourage students to communicate ideas, negotiate roles, and support one another in achieving shared goals.

The Integration Practice of Music with Other STEAM Disciplines

Research on the interdisciplinary integration of music within the STEAM framework has expanded significantly in recent years, especially as global education systems increasingly adopt inquiry-based and project-oriented pedagogies. Comparative studies from the United States, Japan, Finland, and other countries reveal that music serves as an effective entry point for interdisciplinary learning due to its structural, mathematical, and perceptual

attributes (Zhang et al., 2023). In science education, for example, students explore acoustics by examining sound wave propagation, vibration frequency, amplitude, and resonance. Many schools guide learners to design simple instruments—such as string devices, shakers, or wind instruments—to observe how material properties influence timbre and pitch. Similarly, in mathematics, rhythm and meter provide intuitive representations of fractions, ratios, sequences, and patterns. Teaching tools such as "Rhythm Pizza," number grids, or tempo-matching tasks help students visualize mathematical relationships through musical structures, making abstract concepts more concrete and engaging. The integration of music with technology has also gained traction as digital platforms such as GarageBand, Soundtrap, and Chrome Music Lab enable students to engage in composition, sound design, and waveform editing (Li, 2025). These tools not only cultivate creativity but also develop computational thinking, as students manipulate digital patterns, automate tracks, and explore algorithmic sound generation.

Engineering-based integration offers another productive pathway for STEAM practice. Many schools encourage students to construct simple sound installations, design amplification systems, or engage in tinkering activities involving circuits and sensors. Through these projects, learners apply engineering design principles—such as prototyping, testing, and iterative improvement—while deepening their understanding of acoustical engineering. Visual and performing arts further enrich interdisciplinary experiences, as seen in projects that combine music with painting, dance, or multimedia storytelling. Such integrated art activities promote multisensory learning and help students appreciate connections between auditory, visual, and kinesthetic forms of expression. Beyond STEAM subjects, interdisciplinary research has also documented successful combinations of music with humanities and physical education. Homone (2021), for instance, reported how teachers across primary and secondary schools designed "Music + History," "Music + Language Arts," and "Music + Physical Education" units during the COVID-19 pandemic to sustain student engagement. These cases highlight the importance of collaborative curriculum design, cross-disciplinary teacher partnerships, and the strategic use of digital tools.

The Integration of Music and STEAM in China

In recent years, research on STEAM education in China has developed rapidly, but research on music as the leading discipline is still relatively weak. Most STEAM courses still mainly focus on science and mathematics, with art subjects, especially music, participating more as auxiliary elements, lacking true equal integration (Belbase et al., 2022). The course forms mostly exist in the form of "special topic activities" and "project expansion", and have not been incorporated into the systematic curriculum system, lacking an effective evaluation mechanism. In addition, music teachers in domestic primary and secondary schools generally face the problem of "isolated subject islands", that is, the teaching goals of music are significantly different from those of STEM subjects, making it difficult to achieve organic collaboration. Insufficient digital literacy and cross-disciplinary teaching ability of teachers are also the main obstacles to implementing integrated teaching.

Research Gaps

It can be seen from the existing research that the integration of music and STEAM education has theoretical support and practical possibility, and can effectively promote the development of students' comprehensive abilities and innovative thinking. However, current research on integration mainly focuses on macro policies and foreign experiences, lacking practical cases and path explorations rooted in local schools, especially in the primary education stage, which is a complete blank. Therefore, it is necessary to carry out school-based practical research at the local level and explore comprehensive strategies that are in line with the Chinese education ecosystem, the actual situation of schools and the ability foundation of teachers. In the comprehensive curriculum experiments of the past two years, Anhui Normal University Affiliated Primary School has accumulated valuable experience, which is worthy of being used as a research sample for in-depth analysis.

Case Analysis

Methodological Overview

This study adopts a qualitative multiple-case study approach. Three representative music–STEAM integration projects implemented in 2024 were purposively selected based on their disciplinary diversity (music–mathematics, music–science, music–technology) and grade coverage. Data sources included: (1) non-participant

classroom observations (6 class sessions in total), (2) semi-structured interviews with six teachers (music, mathematics, science, and information technology), and (3) student artefacts such as rhythm worksheets, handmade instruments, and digital compositions. Data were analyzed through thematic coding, focusing on learning outcomes, instructional strategies, and theoretical alignment.

Case One: "Rhythmic Pizza" — Integrated Teaching of Music and Mathematics

The “Rhythmic Pizza” project targeted fourth-grade students and was designed to connect musical rhythm values with mathematical fractions. The primary objective was to help students grasp abstract fractional concepts through hands-on musical activities while simultaneously deepening their understanding of rhythm. By using playful, experiential methods, the activity promoted a two-way transfer of knowledge between mathematics and music, aligning with STEAM principles of interdisciplinary learning and creativity. In the teaching process, the teacher prepared a round cardstock to represent a “pizza,” with the whole pizza corresponding to a whole note.

The pizza was cut into segments representing different note values, such as half notes and quarter notes. Students worked in small groups to “order” and assemble the musical pizza according to specified rhythm patterns. This approach involved multiple learning dimensions: students engaged in mathematical calculations by building “pizza recipes” using fractional addition, while also arranging combined note values into rhythm sequences and performing them through clapping or percussion. Multimedia tools such as rhythm cards, scorecards, and video demonstrations were used to facilitate interactive learning and provide immediate feedback. Observations and assessments indicated that students gained a concrete, vivid understanding of rhythm values, which enhanced their interest and comprehension of fractions. The activity also fostered teamwork, creativity, and problem-solving skills, as students collaborated to design novel rhythm sequences. Teachers reported high levels of engagement, noting that some students continued experimenting with “Pizza Variations” after class, demonstrating sustained motivation and initiative in learning.

Case Two: "The Secret of Sound" — Integrating Music and Science

The “Secret of Sound” project was implemented with fifth-grade students to integrate scientific concepts of sound generation and propagation with musical elements such as timbre and resonance. The lesson aimed to cultivate students’ scientific inquiry skills while enabling them to explore the acoustical properties of musical instruments. The teaching began with videos of diverse instruments, including guitars, bamboo flutes, and cup drums, prompting students to question how different materials affect sound production. Students then participated in experimental activities, constructing simple instruments using rubber bands, paper cups, and plastic bottles to investigate the impact of material, tension, and structure on timbre and pitch. Following experimentation, students performed rhythms or melodies with their self-made instruments, presenting their results to peers and reflecting on their discoveries. This integrated approach enhanced students’ understanding of key acoustic principles, such as vibration-induced sound and resonant amplification, while promoting creativity and hands-on problem-solving. The classroom atmosphere was lively and interactive, with students actively shifting roles from instrument makers to performers, fostering both scientific reasoning and artistic expression. Teachers observed increased student initiative, engagement, and confidence, noting that the interdisciplinary activity provided a meaningful context for applying theoretical knowledge in a practical, creative setting.

Case Three: "Digital Music Workshop" — Integrating Music and Information Technology

The “Digital Music Workshop” was a collaborative project between music and information technology teachers, aimed at students in grade three and above. The objective was to develop digital literacy and creative musical skills simultaneously through a STEAM-oriented maker approach. Students were guided to use Song Maker in Chrome Music Lab to compose eight-bar melodies incorporating specified pitch and rhythm patterns. The activity encouraged experimentation with tempo, speed, and percussion accompaniment, promoting both technical and artistic creativity. The project culminated in a multimedia “Work Exhibition,” where students displayed and explained their digital compositions. Feedback indicated that students found this approach more engaging and accessible than traditional piano practice. Notably, students who struggled with conventional music performance demonstrated strong abilities in digital creation, reflecting the project’s capacity to lower

barriers to participation and foster inclusive learning. Teachers emphasized that such integrated projects allow students to express creativity confidently, develop computational thinking, and engage in interdisciplinary problem-solving, highlighting the pedagogical potential of combining music with technology within STEAM education.

Comprehensive Analysis

The three integration cases demonstrate that combining music with mathematics, science, and information technology can effectively promote students' interdisciplinary learning, creativity, and core competencies. "Rhythmic Pizza" enables students to grasp abstract fractions through tangible rhythm activities, enhancing both mathematical logic and rhythmic sense. "The Secret of Sound" fosters hands-on scientific inquiry and deepens understanding of acoustics, allowing students to connect theory with practice. The "Digital Music Workshop" lowers barriers to music creation, integrating digital tools to cultivate creativity and technological literacy. Across all cases, student engagement, collaboration, and initiative were significantly enhanced, illustrating the pedagogical value of music as a medium for STEAM learning. These findings suggest that thoughtfully designed interdisciplinary projects can provide meaningful contexts for knowledge transfer, skill development, and holistic competence cultivation (Table 1).

Table 1: Summary of cases

Case	Objectives	Activities and Methods	Achievements
Case 1	For 4grade students, the concept of rhythm duration and fractions is combined to cultivate a sense of rhythm and mathematical logic	"Pizza" is an overall sound value model. Students assemble and combine them to complete rhythm creation and mathematical operations	Enhance your sense of rhythm, number sense and cooperative ability
Case 2	5grade students should understand the relationship between acoustics and music in combination with the content of "Sound Propagation" in the science class	Students made their own Musical Instruments and observed the influence of different materials and tightness on the sound	Understand vibration and pitch, and enhance scientific literacy and hands-on ability
Case 3	Students above Grade 3 create melodies with the help of Chrome Music Lab	Graphically drag and drop notes to create an 8-bar melody and display it	Stimulate creativity and cultivate digital music and information technology literacy

FINDING AND DISCUSSION

Main existing problems

Despite increasing attention to the integration of music and STEAM disciplines, several challenges hinder its systematic implementation. First, most "Music + STEAM" courses are conducted as short-term projects, school-based activities, or interest classes and have not been formally incorporated into national curriculum frameworks or the staged objectives of primary education. The lack of systematic course design and gradual progression, both vertically across grades and horizontally across subjects, results in fragmented learning experiences. This fragmentation undermines the coherence and depth of students' knowledge development, making it difficult to achieve sustained skill accumulation or comprehensive quality transfer. Second, the interdisciplinary competence of teachers is often insufficient, and collaborative teaching faces practical difficulties. Music teachers generally lack professional training in scientific or technological fields, while STEM teachers are unfamiliar with artistic expression and aesthetic education. Consequently, cross-disciplinary cooperation relies heavily on individual teachers' interests and self-study ability, resulting in inconsistent teaching quality and low efficiency. Without structured training programs or collaborative mechanisms at the institutional level, the sustainability of these integrated courses remains uncertain.

Third, disparities in resource allocation and technical support further constrain implementation. Music-STEAM courses typically require digital music platforms, multimedia classrooms, and supporting hardware such as sound systems and microphones. Many schools, particularly in small or rural cities, face insufficient equipment and unstable networks, reflecting a clear "digital divide." Additionally, the absence of diversified evaluation mechanisms limits the capacity to quantitatively assess learning outcomes. Traditional score-based assessments fail to capture the multidimensional goals of STEAM learning, such as creativity, collaboration, and aesthetic development, while qualitative assessments based on presentations or classroom performance cannot fully reflect students' growth. Finally, institutional support is weak. The planning, coordination, and incentive structures for integrated courses are underdeveloped, with course development largely dependent on individual teacher initiative. The lack of a formalized management or project coordination system makes it difficult to sustain comprehensive teaching programs over the long term.

Suggestions for Optimizing the Integration Path

To address these challenges, building a structured and progressive curriculum system is essential. Schools should develop a three-level framework comprising basic courses, interdisciplinary projects, and personalized expansion modules. By aligning "Music + STEAM" projects with national curriculum standards, modules such as "Rhythm and Score," "The Secret of Sound," and "Digital Music Laboratory" can be integrated in a grade-specific sequence, forming a gradual and coherent learning path. This approach ensures vertical progression across grades and horizontal coherence across disciplines, providing students with continuous and structured opportunities for knowledge and skill development. Equally important is the cultivation of a "cross-border" teaching staff and collaborative mechanisms. Establishing a STEAM teaching community that brings together music, information technology, science, and mathematics teachers to co-design lessons, review teaching outcomes, and share expertise can significantly enhance interdisciplinary instruction. Supporting music teachers with training in basic programming, audio editing, and technological tools, while simultaneously enhancing STEM teachers' artistic and aesthetic literacy, promotes mutual professional growth and improves the quality and sustainability of integrated teaching.

Finally, strengthening material, technical, and institutional support is crucial. Governments and schools should increase investments in equipment and digital platforms, provide accessible instruments and experimental props, and upgrade network and multimedia facilities to reduce resource disparities between urban and rural areas. Developing a multidimensional, formative evaluation system that includes peer review, project presentations, and process-oriented assessment can capture students' creativity, collaboration, and technical application more effectively. Moreover, integrating STEAM course implementation into school development plans, establishing interdisciplinary coordinator roles, and linking teacher participation to performance evaluations and professional promotion can institutionalize and sustain the regular operation of integrated courses.

Challenges and Opportunities

While the integration of music and STEAM education has achieved promising results in pilot programs, several challenges remain that may affect its widespread adoption. One major challenge is maintaining the sustainability and scalability of interdisciplinary projects. Many initiatives currently rely on individual teacher enthusiasm, small-scale pilot funding, or short-term school projects. Without institutionalized support, stable curricula, and long-term planning, it is difficult to ensure that such integration consistently benefits all students across grades and schools. Additionally, variations in teacher competence, resource availability, and technical infrastructure create disparities in implementation quality, which may limit the overall effectiveness of the STEAM approach. These challenges highlight the need for systematic teacher training, infrastructure investment, and policy guidance to support equitable access to integrated learning.

At the same time, the growing emphasis on STEAM provides significant opportunities for innovation in music education. The rapid development of digital technologies, including virtual instruments, music production software, and interactive multimedia platforms, allows students to engage in creative, collaborative, and experiential learning that transcends traditional classroom boundaries. Interdisciplinary projects also create opportunities for students to develop essential 21st-century skills, such as critical thinking, problem-solving, teamwork, and computational literacy, in meaningful contexts. Furthermore, integrating music with STEM

disciplines can enhance student motivation, broaden perspectives, and cultivate holistic abilities that align with national educational goals and global competencies.

CONCLUSION

This study reveals that the integration of music education within STEAM frameworks has significant potential to enhance primary students' interdisciplinary learning, creativity, and core competencies. Case analyses from the Affiliated Primary School of Anhui Normal University demonstrate that thoughtfully designed projects—such as "Rhythmic Pizza," "The Secret of Sound," and the "Digital Music Workshop"—effectively combine musical, scientific, mathematical, and technological knowledge. These activities enable students to concretely understand abstract concepts, engage in hands-on experimentation, and develop problem-solving, collaboration, and digital literacy skills. The findings indicate that music serves not merely as an artistic supplement but as a core driver of learning in STEAM education, providing cognitive, emotional, and creative benefits. Students exhibit higher motivation, active participation, and confidence in interdisciplinary tasks, confirming that integrating music with STEM disciplines can create meaningful learning experiences and facilitate holistic development. At the same time, the study highlights key challenges, including fragmented curriculum design, insufficient cross-disciplinary teacher competence, uneven resource allocation, lack of formative evaluation mechanisms, and weak institutional support. These constraints, if unaddressed, hinder the sustainability and scalability of integrated STEAM practices.

To optimize the integration of music and STEAM education, this study proposes several strategies. First, schools should construct a structured and progressive curriculum system that incorporates basic courses, interdisciplinary projects, and personalized expansion modules aligned with national curriculum standards. Such a framework ensures vertical and horizontal coherence, facilitating continuous skill development and knowledge transfer. Second, cultivating a "cross-border" teaching staff and establishing collaborative mechanisms are critical. By forming STEAM teaching communities and providing mutual training in artistic and STEM domains, teachers can enhance interdisciplinary competence and deliver higher-quality, sustainable instruction. Third, strengthening resource and technical support is essential. Schools should invest in digital music platforms, multimedia classrooms, and hands-on experimental tools while addressing disparities between urban and rural areas. Fourth, establishing multidimensional, formative evaluation mechanisms—including peer review, project presentations, and process-oriented assessment—can better capture students' creativity, collaboration, and technical application. Finally, integrating STEAM course implementation into school development plans and institutionalizing coordinator roles ensures the regular and scalable operation of integrated programs.

Despite providing valuable insights, this study has limitations. Its scope is limited to a single primary school, which may restrict the generalizability of findings to other educational contexts or regions. Additionally, long-term impacts on students' academic performance, creative thinking, and career trajectories were not tracked due to time constraints. Future research should expand to multiple schools, incorporate longitudinal studies, and explore the integration of music with other STEAM disciplines, such as engineering or coding, in diverse socio-economic and cultural settings. Furthermore, comparative studies between traditional music teaching and music-integrated STEAM curricula could provide deeper evidence of effectiveness. As digital technology continues to advance, future research should also examine the potential of emerging tools—such as artificial intelligence in music creation, virtual reality for immersive learning, and coding-music hybrid platforms—to enrich interdisciplinary education. By addressing these gaps, scholars and educators can develop more comprehensive, scalable, and sustainable models for embedding music within STEAM education, ultimately fostering creative, innovative, and versatile learners prepared for the demands of the 21st century.

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