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Investigating The Effect of Using Steam-Based Teaching in Music Education in China

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ABSTRACT

Objectives: This study investigates the integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) into music education with three main aims: (1) to assess teachers' and students' self-perceived creativity in music, (2) to explore their perceptions of music learning, and (3) to evaluate the effectiveness of instructional plans within the STEAM framework. **Methods:** A mixed-methods design combined qualitative and quantitative data. Two STEAM-based lesson plans were developed and reviewed by subject experts. Classroom observations captured instructional practice, while surveys administered to 265 teachers and 453 students gathered data on creativity, attitudes, and perceived instructional quality. **Results:** The results indicated marked improvement in students' creativity and attitudes towards music after engaging with STEAM-based instruction. Key factors included collaborative learning, personalised teaching, and experiential activities. Both groups reported higher engagement and greater appreciation of music as a creative, interdisciplinary subject. **Conclusion:** STEAM integration represents a shift from traditional STEM models to a broader educational approach. The findings offer empirical support for adopting STEAM in music education, underlining its capacity to enhance creativity, critical thinking, and learner-centred pedagogy.

Introduction

Background

STEAM education adopts a cross-disciplinary methodology that nurtures innovation and creative problem-solving. Within the Chinese context, although national policies increasingly prioritise innovation, conventional music instruction continues to concentrate

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on technical proficiency, with limited engagement across STEM-related domains. This section explores the evolving integration of STEAM principles into music education and examines its alignment with broader national educational objectives. As highlighted by Olena et al. (2024), applying STEAM within music education introduces a contemporary pedagogical framework, contributing to developing innovative solutions in education. Hughes et al. (2022) emphasised that this model promotes the synergy between diverse disciplines, thereby cultivating critical thinking, creativity, analytical skills, and a more profound appreciation of both scientific and artistic knowledge. Yang (2023) pointed out that STEAM-inspired music instruction departs from traditional paradigms, which are largely centred on mastering instrumental techniques, musical notation, and theoretical understanding. Instead, it interweaves scientific and technical competencies with artistic learning. Aguilera and Ortiz-Revilla (2021) asserted that the purpose of STEAM is to counteract the marginalisation of creativity typically seen in STEM-focused environments. As noted by them, the integration of arts within this framework supports a more balanced and holistic educational experience, effectively uniting artistic and scientific domains through STEAM-based music instruction.

Problem Statement

Although China continues to prioritise innovation, empirical investigations focusing on the application of STEAM in music education remain limited. Prior research (Lee, 2021; Zhang et al., 2023) identifies significant deficiencies in areas such as teacher preparedness, the establishment of effective implementation models, and the assessment of tangible learning outcomes, including creativity and student perceptions. This study seeks to address these issues by assessing how STEAM-based lesson designs influence learning experiences in Chinese music classrooms. Li (2025) argue that the development of STEM education in China is in a period of rapid growth. With further policy support and continuous innovation of education models, greater progress is expected to be made in the future. Kong (2021) similarly contends that Chinese educational policy increasingly supports technological advancement and innovation, with STEAM offering a means of nurturing students equipped not only with technical knowledge but also with creative problem-solving abilities. In this regard, Yang (2020) noted that, as China aspires to develop a workforce with creativity and adaptability, STEAM represents a strategic approach for cultivating these essential competencies in response to global demands.

Nonetheless, Sanz-Camarero et al. (2023) highlighted that, despite the pedagogical benefits STEAM may offer music education, the volume of related academic literature remains sparse. Aguilera and Ortiz-Revilla (2021) suggest this gap stems from limited academic and public engagement with the potential of integrating arts into STEM disciplines, particularly within music education. As a result, this domain receives inadequate funding and institutional support. Lee (2021) pointed out that such neglect limits students' ability to foster creativity and diminishes opportunities to apply critical thinking and problem-solving in meaningful, real-world contexts. Özer and Demirbatır (2023) observed that, although theoretical reviews acknowledge the potential of STEAM in music instruction, there remains a shortage of comprehensive pedagogical resources for educators. This shortfall constrains effective implementation, leaving teachers without

sufficient guidance to embed STEAM within their instructional practices. Consequently, educators often experience pressure and uncertainty, hindering the quality of delivery. Yang (2020) further emphasised that this lack of structural clarity may lead to inconsistent teaching methods, undermining the intended educational benefits of STEAM in music learning.

Research Objectives

1. To assess the influence of STEAM-oriented instructional plans in music education on students' musical creativity and their attitudes towards the subject.
2. To explore teachers' perspectives regarding the fundamental components of STEAM-based music instruction, including intended learning outcomes, curricular content, pedagogical strategies, perceived effectiveness, and the overall applicability and feasibility of the implemented instructional plans.
3. To evaluate students' self-reported views on their creative abilities in music and their attitudes towards the subject following their engagement in STEAM-based music lessons.

Research Questions

1. In what ways do STEAM-oriented instructional plans influence students' creative development and their attitudes towards music?
2. What are teachers' views regarding the usability and practicality of STEAM-based lesson plans?
3. How do students perceive changes in their musical creativity and attitudes following participation in STEAM-integrated music instruction?

Literature Review

Aguilera and Ortiz-Revilla (2021) describe STEAM-based music education as an integrated model that combines science, technology, engineering, the arts, mathematics, and music to create a cohesive learning experience aimed at enriching music instruction. König et al. (2020) emphasise that structured instructional plans serve as comprehensive frameworks that support the effective implementation and delivery of STEAM-based music teaching. In a similar vein, Polanin et al. (2024) regard pedagogical principles as the foundational guidelines that inform teaching strategies and methodological approaches within the STEAM music education setting.

This review of existing literature examines the efforts of various theoretical perspectives to incorporate STEAM into music education at the university level. As noted by Haag et al. (2023), higher education music programmes are often less standardised than those found in schools, making them more complex to define. However, this complexity allows for greater scope in examining teaching principles, curricular design, lesson planning, delivery methods, and their subsequent influence on students' creative capacity and problem-solving abilities. Additionally, Apoki et al. (2022) observed that students entering university often possess diverse levels of prior knowledge across music and STEAM-related disciplines. Analysing the impact of STEAM interventions on university students'

musical creativity, interest, and problem-solving skills may yield valuable insights into the potential of STEAM-based approaches in preparing future professionals across multiple fields. As Zer and Demirbatir underscore, the STEAM framework is inherently multidisciplinary, encouraging learners to apply creative, analytical, and critical thinking to resolve authentic, real-world challenges.

Empirical Studies on STEAM in Music Education

A comprehensive review of recent empirical investigations indicates increasing scholarly interest in applying STEAM methodologies to music education, though considerable research gaps persist. For example, Chao et al. (2020) conducted a quantitative study in Taiwan which showed that integrating STEAM into music instruction significantly enhanced students' problem-solving abilities ($p < 0.01$). Nevertheless, the study maintained a narrow emphasis on technological tools, offering limited insight into the role of interdisciplinary creativity. Similarly, Zhang et al. (2023) evaluated university-level initiatives in China and reported that 68% of participating students experienced improvements in musical creativity as a result of engaging in STEAM-related projects. Despite these encouraging outcomes, the absence of longitudinal data restricted the evaluation of long-term educational impact. Yang (2023) further identified systemic obstacles in teacher preparedness, revealing that only 22% of surveyed educators felt adequately equipped to apply STEAM-oriented strategies in their teaching practice.

Theoretical Underpinnings of Music Education

The development, implementation, and evaluation of STEAM-based music education are intricately linked to a diverse array of theoretical frameworks. As noted by Hödl et al. (2022), Haag et al. (2023), and Quigley and Herro (2016), these frameworks encompass multiple learning theories and pedagogical models that support the effectiveness of instructional design while addressing the varied needs of learners. Drawing upon these theoretical foundations, educators intentionally align the integration of STEM and STEAM principles with established teaching and learning practices to enhance educational outcomes.

Self-Determination Theory (SDT)

The integration of technology within music education is grounded in Self-Determination Theory (SDT), which, as highlighted by Haag et al. (2023) and Lopez (2023), centres on learners' intrinsic motivation and capacity for self-regulation. According to Özer and Demirbatır (2023), SDT presents a comprehensive framework that fosters an environment in which students are intrinsically encouraged to engage meaningfully with musical learning. This is achieved by addressing three core dimensions: autonomy, competence, and relatedness. Haag et al. (2023) emphasised that fostering autonomy contributes significantly to the creation of enriched learning experiences, enabling students to define their own learning goals, musical skills, and attitudes in alignment with their individual educational journeys. In a similar vein, Lopez (2023) observed that the development of competence reinforces students' sense of mastery in music, particularly through the deliberate and strategic use of technological tools.

Technology Acceptance Model (TAM)

As noted by Momani (2020) and Ammenwerth (2019), the Technology Acceptance Model (TAM) provides a valuable framework for understanding the nuanced attitudes and behaviours of both students and educators towards the use of technology in music education. TAM is anchored in two primary constructs: perceived ease of use and perceived usefulness. Deslonde and Becerra (2018) argued that technological tools must be intuitive and straightforward in order to encourage adoption by teachers and learners alike. Perceived usefulness, in this context, relates to the degree to which users believe that the technology will enhance their learning outcomes or instructional effectiveness. According to Momani (2020) and Ammenwerth (2019), successful integration of technology into educational environments is contingent upon users recognising its capacity to improve educational processes and contribute meaningfully to academic achievement.

Constructivism

According to Hödl et al. (2022) and Haag et al. (2023), constructivism asserts that learning is inherently a social and experiential process, wherein individuals actively build knowledge through engagement with their environment. This theoretical stance underpins educational practices that involve learners directly in content exploration, media interaction, and technological engagement—particularly relevant in the interdisciplinary setting of STEAM-based music instruction. When applied to music education, constructivism encourages learners to develop their creativity, analytical thinking, and problem-solving skills by engaging with musical ideas through a STEAM framework. Quigley and Herro (2016) illustrated that such an approach allows students to investigate concepts like mathematical ratios within musical scales or the scientific principles behind sound production by experimenting with digital music tools, thereby supporting an inquiry-driven, experiential mode of learning.

Problem-Based Learning (PBL)

Haag et al. (2023) and Quigley and Herro (2016) characterise Problem-Based Learning (PBL) as a pedagogical approach centred on acquiring knowledge through the resolution of real-world problems. Within music education, PBL becomes particularly effective when integrated with technology, enabling students to undertake meaningful, inquiry-based tasks that require them to apply both subject knowledge and technological tools to formulate innovative solutions. By incorporating technology into PBL, learners are exposed to various digital tools that enhance their musical creativity and problem-solving capabilities. As noted by Hödl et al. (2022), when students engage with software for composing music or analysing sound waves, they are encouraged to explore musical concepts with greater critical and creative depth. This process supports a more profound understanding of musical structure and the scientific foundations of acoustics.

Historical Evolution of Technology in Music Education

According to Gül (2023), the use of technology in music education extends beyond the application of basic playback devices; it functions as a dynamic instrument that facilitates

interaction among learners, instructional content, and educators. The integration of technology into music instruction began in the 20th century with tools such as phonographs and radios, which provided students with access to a variety of musical experiences beyond live performances. Subsequent technological progress led to the incorporation of television and digital media into instructional practices, enabling educators to enrich lessons with multimedia elements. The emergence of the internet and advancements in digital audio technologies further transformed the landscape of music education, offering new possibilities for content delivery, engagement, and learner interaction.

Digital Audio Workstations in Education

Javier Félix et al. (2024) noted that Digital Audio Workstations (DAWs) have become integral to contemporary music education. Widely utilised applications such as GarageBand, Ableton Live, and FL Studio are employed in educational settings to familiarise students with the sequential processes involved in music production. These platforms enable learners to engage in sound design, audio sequencing, and editing, offering hands-on experience with real audio content. The use of DAWs not only enhances technical proficiency but also fosters creativity, thereby deepening students' appreciation of music as both an artistic expression and a technological practice. Integrating DAWs into instructional practices allows educators to provide comprehensive exposure to the multifaceted nature of modern music production.

Interactive and Adaptive Learning Technologies

Qureshi et al. (2021) highlighted the diverse applications of interactive and adaptive learning technologies within music education, particularly in tailoring the learning experience to individual student progress. These technologies personalise both instructional content and pacing by responding dynamically to learners' development. Adaptive platforms are capable of monitoring student progress, identifying specific areas of proficiency and difficulty, and subsequently adjusting the instructional material to better align with the learner's needs. For example, some online platforms offer music theory tutorials that modify their exercises based on students' responses, thereby creating a customised learning trajectory. Similar technologies are employed in instrumental instruction, where software tools track student performance and provide targeted feedback to support ongoing improvement.

Social Media and Collaborative Learning

Al-Rahmi and Zeki (2017) observed that social networking platforms and collaborative digital tools have opened new avenues for music education by enabling students to share their performances and receive audience feedback in real time. Online platforms such as YouTube offer extensive resources for learning instrumental techniques, exploring music theory, and accessing performances across various genres. Through social media groups and discussion forums, students are able to exchange ideas, share learning materials, and participate in collaborative projects. These digital spaces facilitate cooperative tasks such as composing original music, discussing recording techniques, and organising virtual performances. Such real-world applications of music-making not only enrich the learning experience but also cultivate essential collaborative and creative skills.

Augmented and Virtual Reality in Music Education

Carmigniani and Furht (2011) asserted that Augmented Reality (AR) and Virtual Reality (VR) offer transformative potential in the context of music education by reshaping traditional teaching methods. AR tools can project digital overlays onto physical instruments, enhancing real-time interaction and learning. In parallel, VR enables immersive educational experiences, such as exploring the historical evolution of music, conducting a simulated orchestra, or virtually participating as a performer within an ensemble setting.

Accessibility and Inclusion through Technology

Javier Félix et al. (2024) highlighted the pivotal role of technological innovation in promoting inclusive music education for students with disabilities. Through gesture recognition, eye tracking and other adaptive technologies, AI ensures that students with disabilities can participate in music education in a meaningful way.

Ethical Concerns

Hu et al. (2022) emphasised the importance of addressing ethical considerations in research and practice related to STEAM-based music education. Safeguarding participants' rights to privacy and confidentiality is paramount, and informed consent must be obtained from all involved. However, the use of technology in education may also pose risks to students' well-being, including excessive screen time and potential exposure to various digital hazards. According to Yang (2020), as STEAM-based music instruction gains prominence, it is essential to ensure equitable access for students across diverse learning needs and socio-economic backgrounds. This entails critically evaluating the technological resources available to different learner groups and ensuring that the adoption of STEAM methodologies does not inadvertently reinforce existing educational disparities.

The integration of STEAM into music education also necessitates heightened attention to data protection. Wang et al. (2018) stressed that while incorporating technology into teaching practices is commendable, educators must also uphold students' data privacy and maintain appropriate boundaries within digital learning spaces. Additional ethical considerations include issues surrounding intellectual property, such as material ownership, copyright, and patent rights. Li and Chiang (2019) argued that music educators have a responsibility to cultivate students' ethical understanding of creative rights. This includes teaching proper citation practices for digital music content and fostering awareness of the implications of modifying or sharing musical works online. In summary, the successful implementation of STEAM-based music education depends not only on pedagogical innovation but also on the responsible handling of ethical challenges. Addressing these concerns fosters a supportive and inclusive learning environment that respects students' rights while embracing technological advancement.

Methodology

This section outlines the research methodology adopted in the study, with particular emphasis on how the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) was employed to respond to the stated research questions. It also provides an overview of the procedures used for data collection and analysis, highlighting the

distinctions between qualitative and quantitative research approaches. Moreover, it outlines the sampling strategies employed, the instruments utilised for data collection, and the methods of measurement applied in relation to each research question.

Research Design

The research design adopted in this study establishes a coherent framework that informs the selection of an appropriate methodological approach. As noted by Davis (2013) and Allen (2006), a mixed-methods design has been employed, combining both qualitative and quantitative techniques to examine the impact of STEAM-based music instruction. The study is structured using the ADDIE model, which provides a systematic process for designing effective learning experiences and curricula. According to Wiphasith et al. (2016), the initial phase of the ADDIE model, the Analysis phase, involves identifying educational needs and objectives, as well as evaluating the context in which the intervention is to be implemented. During this stage, relevant data sources will be reviewed to define specific learning goals and constraints. The subsequent Design phase builds upon this analysis by shaping the structure and content of the instructional programme, encompassing curriculum outlines, lesson plans, and instructional materials.

The objective of utilizing the ADDIE model for STEAM-based music instruction in Figure 1 is to adhere to the ADDIE phases: Analysis, Design, Development, Implementation, and Evaluation, in the research design. The Analysis phase will involve the assessment of instructors' requirements and the existing condition of STEAM-based music education using surveys and interviews. The Design phase will entail developing comprehensive educational plans that seamlessly incorporate music with STEAM principles. Throughout the development process, these plans will undergo further refinement and be prepared for implementation in the classroom. The implementation phase will involve the execution of these plans in music courses, with improvements being made based on feedback from both teachers and students. The Evaluation phase will analyze the influence on students' music creativity and attitudes towards music using both quantitative and qualitative measurements. The teaching plans will be modified depending on the findings to improve effectiveness and engagement. This systematic approach guarantees a concentrated technique with the goal of enhancing music education based on STEAM principles.

Figure 1: ADDIE Model. source: (Branch, 2009)

Participants

The participants in this study will be drawn from students currently enrolled in middle and high school music classes. A purposive sampling technique will be employed to select individuals from this specific population. The sample will include both male and female students, representing a range of socio-economic backgrounds and differing levels of prior musical experience. These demographic and experiential factors will be central to the sampling strategy. Moreover, the selection of participants will also take into account the research objectives, the requirements for sampling and generalisability, and the practical constraints related to available resources, all of which will influence the final sample size.

Validity and Reliability

To reduce potential threats to validity, a verification checklist will be utilised to ensure that only the pre-identified participants are included in the study. Furthermore, all participating students will be asked to review and consent to the reported findings to independently verify that the outcomes accurately represent their experiences and genuinely reflect the integrity of the research process.

Table 1 presents the results of a reliability test conducted during a pilot study to assess the consistency and dependability of data collection instruments. Two aspects of reliability were evaluated. These comprised internal consistency and inter-rater reliability. Internal consistency, represented by Cronbach's Alpha values, was assessed for Survey A and Survey B, both of which are self-administered survey instruments. Survey A exhibited a Cronbach's Alpha of 0.85, suggesting a reasonably good internal consistency, implying that the questions within this survey are correlated with each other in a coherent manner. Similarly, Survey B showed a slightly higher internal consistency with Cronbach's Alpha of 0.88. On the other hand, inter-rater reliability, indicated by the Intraclass Correlation Coefficient (ICC), was assessed for an Interview Protocol, a tool typically administered by multiple raters. The Interview Protocol demonstrated strong inter-rater reliability with an ICC of 0.9, implying that different raters consistently interpret and evaluate the data collected through interviews. These reliability assessments are essential in ensuring that the instruments used in the study provide consistent and dependable data, which is crucial for the accuracy and validity of the research findings.

Table 1

The reliability test for a pilot study

	Internal Consistency (Cronbach's Alpha)	**Inter-Rater Reliability (ICC)**
Survey A	0.85	-
Survey B	0.88	-
Interview Protocol	-	0.9

Scope and Limitations

Several limitations of this study must be acknowledged. Firstly, the generalisability of the findings is constrained by the specific context and characteristics of the participant group. The insights derived from student responses may have limited applicability beyond formal educational environments. Additionally, the relatively short duration of the

research limited the capacity to observe long-term developments in musical growth, creative expression, or emotional engagement. Although efforts were made to reduce confounding influences, internal validity may still have been affected by external variables, including individual student traits, activity preferences, and broader social influences. Moreover, the study did not aim to explore the complex interrelationships between independent and dependent variables, which remain outside its defined scope. Nonetheless, the findings contribute foundational knowledge, offering a basis for future research to explore these dynamics in greater depth.

Sampling Technique

As noted by Campbell et al. (2020) and Tongco (2007), purposive sampling is particularly valuable in specialised areas of research where participants are expected to possess specific knowledge or experience, thereby contributing more relevant and insightful data. In this study, the proportion of students engaged in STEAM-based music education is estimated at 50% (0.5), with the sampling calculated using a 95% confidence level and a 5% margin of error.

Variables

This study incorporates both dependent and independent variables. The primary dependent variables include students' musical creativity and their attitudes towards music education. Musical creativity will be assessed through a combination of quantitative and qualitative measures, including evaluations of students' written reflections, improvisational skills, and innovative application of musical elements such as rhythm, melody, harmony, and instrumentation. Additional dependent variables encompass students' perceptions of usability, collaborative learning environments, personalised and self-regulated learning contexts, experiential learning settings, and other interactive dimensions of the educational experience. Control variables include prior musical experience (PME), duration of engagement with the STEAM-based programme (ED), teachers' perceptions of usability (TPU), and the degree of interdisciplinary interaction. To manage these variables, a series of control measures will be implemented, including pre-tests and preparatory sessions to account for variations in students' prior experience and teachers' perceptions, structured timetables for programme execution, and continuous monitoring using checklists to ensure consistency in interdisciplinary communication across all participating groups. These strategies are designed to equalise the learning environment and enhance the reliability of the findings.

Data Collection

Data collection for this study was conducted using two primary instruments: a survey assessing Students' Perceptions of Changes in Music Creativity and Attitudes, and a Questionnaire on Teachers' Perceptions of Usability. The student survey incorporated elements from established tools, including the Torrance Tests of Creative Thinking (TTCT), the Runco Ideational Behaviour Scale (RIBS), and Self-Assessment Scales. Its purpose was to gather student insights into their perceived levels of creativity, changes in musical understanding, and attitudes towards music education. The teacher questionnaire was

designed to capture educators' perspectives on the usability of the STEAM-based instructional plans, as well as their observations regarding students' creative development and engagement with music. The student surveys were administered in person to ensure accessibility and immediate clarification if needed, whereas the teacher questionnaires were distributed electronically via email to accommodate professional schedules.

Data Analysis

The survey data were thoroughly analysed employing both descriptive and inferential statistical methods. A range of analytical techniques was applied to address the study's first three research questions. To examine the impact of STEAM-based music education instructional plans on students (Research Question 1), the data were initially screened for normality through the Kolmogorov-Smirnov test, Q-Q plots, and assessments of kurtosis and skewness. The influence of the instructional plans on students' musical creativity and attitudes towards music was then evaluated using Analysis of Covariance (ANCOVA). For Research Questions 2 and 3, which explore the perceptions of teachers and students respectively, Thematic Analysis was adopted. This method facilitated the systematic identification, analysis, and interpretation of patterns and themes within the qualitative data, providing deeper insight into participants' views and experiences.

Findings And Analysis

This section expands on the evaluation process encompassing the lesson plan, survey instruments, observational data, and reflective practices. As emphasised by Sanz-Camarero et al. (2023), a structured assessment of STEAM education implementation is vital for understanding its influence within the context of arts education. In this study, two subject matter experts (referred to as Expert A and Expert B) were engaged to review and assess the lesson plan. According to Ruiz-Martín and Bybee (2022), expert evaluations offer valuable insights into the effectiveness of educational interventions. The study involved 265 teachers who completed the Questionnaire on Teachers' Perceptions of Usability, and 453 students who responded to the Questionnaire on Students' Perceptions of Changes in Music Creativity and Attitudes. Drawing from Polanin et al. (2024), such data provide a structured basis for systematically analysing the impact of instructional plans on learners' creative development and attitudinal shifts towards music education.

Findings of Lesson Plan Evaluation

Based on the lesson plan evaluations, both subject matter experts provided overall positive feedback. Rahman and Duran (2022) identified key domains for assessing lesson plans, including the relevance of content, instructional processes, and anticipated outcomes. In this study, the experts rated all items and also provided qualitative comments regarding the teaching content, instructional strategies, and effectiveness. Spatioti et al. (2022) emphasised that clearly articulated and accessible teaching aims are fundamental to effective instructional practice. For Topic 1, the experts awarded the maximum score of 10 to the teaching objectives, recognising their inclusivity and clarity an assessment that also applied to Topic 4. However, Larasati and Shofiyah (2024) noted that clarity and accessibility may not always align. This was reflected in the evaluations of Topics 2 and 3,

where Expert A identified concerns regarding accessibility, while Expert B raised issues related to clarity. With regard to the teaching content, Expert A allocated full marks to all assessment components across all topics, consistent with the holistic approach advocated by Lasaiba and Lasaiba (2024) for content evaluation. Conversely, Expert B identified areas for refinement within Topics 1, 2, and 3. As noted by Joswick and Hulings (2023), such discrepancies are often attributable to the inherent complexity involved in implementing STEAM-based educational models.

Findings of Questionnaire

Wu et al. (2022) emphasised that a comprehensive analysis of factors influencing STEAM education outcomes must incorporate the perspectives of both educators and learners. Findings from the frequency analysis revealed that more than 198 teachers acknowledged the significance of students' perceptions regarding usability, collaboration, personalisation, and self-regulated learning in enhancing their musical creativity. Walkington and Bernacki (2020) argued that personalised learning plays a pivotal role in fostering creative thinking and learning engagement. Within this study, students' prior musical experience (PME) emerged as the most frequently cited influence, with 207 participants identifying it as a critical factor. These findings align with Barrett et al. (2021), who underscored the foundational role of prior experience in nurturing collaborative creativity. Additionally, 8% of respondents (n=21) strongly agreed that these combined elements significantly shaped students' creative development in music.

The correlation analysis further demonstrated statistically significant positive relationships between the examined variables. Zhang et al. (2023) noted that interdisciplinary integration within music education is closely linked to academic achievement. Correlation testing between TMC1–9 and the overall TMC scale confirmed a linear positive association, supporting Cheng and Southcott (2022)'s findings regarding the influence of self-regulated learning. All TMC1–9 items were found to be either moderately or strongly interrelated. In addition, Benjamins et al. (2021) highlighted the substantial effect of experiential learning on students' creativity and attitudinal development in musical contexts. This was substantiated by the correlation analysis involving SMA1–9, SMA, and SMAS, all of which exhibited strong linear positive relationships. These outcomes further reinforce the conclusions drawn by Kong (2021), who reported that experiential learning enhances students' focus and interest in educational settings.

Observation and Reflection

Eroğlu and Bektaş (2022) noted that students' academic achievement and creative capacities can be significantly influenced by engagement with STEAM education. Observational data from the present study confirmed that learners displayed a positive attitude towards STEAM-integrated music lessons. Wahono et al. (2020) emphasised that the extent of exposure to STEAM-based instruction can produce varied educational outcomes, including heightened motivation and improved learner attitudes. This was evident in the enthusiasm students demonstrated while participating in experiment-based and real-world learning scenarios.

Tang et al. (2023) argued that the use of multimedia technologies enhances interactivity in educational processes. In the design and execution of lesson plans, teachers successfully integrated technological tools into music instruction. According to Lyu and Sokolova (2022), digital resources play an instrumental role in reshaping learners' academic engagement and outcomes. This study similarly observed enhanced instructional quality and learning outcomes within the context of digital integration. Meghan J. Greene et al. (2021) observed that the flexibility embedded in the lesson plans enabled teachers to adapt instruction to the specific learning needs of their students. This adaptability was particularly valuable in fostering learners' practical competencies and in promoting creative thinking strategies. Koyunlu Ünlü and Dökme (2022) reported that the 5E instructional model has shown promising results in STEM education. A similar pattern emerged in this study, where lesson implementation involved interactive pedagogical approaches and multimedia elements, both of which contributed to stimulating student motivation.

Taggart and Wheeler (2023) stated that collaborative learning is rooted in constructivist theory due to its capacity to enrich the learning experience. In this study, students exhibited greater interest, increased classroom interaction, and enhanced collaborative skills through group work and peer discussions. Xiao (2022) further noted that the integration of digital and multimedia tools expands the scope of teaching materials available in music education. This was reflected in the study's findings, which showed that teachers could offer more comprehensive content, including music theory, historical context, and appreciation activities. However, several challenges were also observed. Yang (2023) asserted that STEAM education demands more structured methodologies, clear instructional standards, and cross-disciplinary expertise. Teachers were required to demonstrate competencies beyond their primary subject areas, which placed additional demands on classroom management. Sai (2022) argued that delivering music education through technology-enhanced and multimedia-supported platforms necessitates specific technological skills, highlighting the need for professional development and appropriate infrastructural support. The reflections derived from the study addressed several critical dimensions:

Lesson Plan Design

Sanz-Camarero et al. (2023) emphasised the need for systematic evaluations when assessing the impact of integrated STEAM approaches on arts education. The study revealed that lesson planning in music differs fundamentally from subjects reliant on factual content. Instead, the focus lies in fostering students' artistic engagement and sparking their interest, necessitating the creation of lessons that stimulate creativity rather than simply delivering information.

Teaching Process

Ruiz-Martín and Bybee (2022) highlighted the cognitive foundations of the 5E instructional model, which are known to enhance student motivation and engagement. This was evident in the study, as educators adopted innovative strategies aligned with new curricular frameworks, thereby developing a more scientific and reflective approach to classroom teaching. The 5E model facilitated students' cognitive development through

stages of observation, analysis, synthesis, and comparison, enriching their learning experiences.

Class Management

Salloum et al. (2022) argued that the application of the 5E model within flipped classroom settings significantly supports inquiry-based learning. In this study, its implementation led to heightened student engagement and improved classroom enthusiasm. Nonetheless, some challenges related to maintaining discipline and classroom order were identified, suggesting that while pedagogical innovation promotes learning, it must be balanced with effective management strategies.

Diversity and Inclusion

Walkington and Bernacki (2020) emphasised the importance of tailoring personalised learning to individual student needs, a view supported by this study's findings, which highlight the significance of accommodating diverse musical abilities, preferences, and learning styles. Zhang et al. (2023) also noted that learner variability requires differentiated instructional strategies. The results align with Kong's (2021) assertion that experiential learning enhances participation and interest, showing that effective STEAM-based plans can improve students' creativity and attitudes. Wu et al. (2022) stressed the need for ongoing evaluation of STEAM education through motivation, cognition, and attitude. Though complex, integrating STEAM into the ADDIE model proved effective. Rahman and Duran (2022) maintained that impactful instructional design depends on understanding various interrelated elements, and this study confirms that applying structured models enhances STEAM-based music education.

Discussion

The transition from STEM to STEAM represents a transformative educational paradigm that redefines how interdisciplinary learning is perceived and implemented. By incorporating the arts into science, technology, engineering, and mathematics, this approach acknowledges creativity as an essential dimension of problem-solving and cognitive development. The evidence discussed throughout this study illustrates that STEAM-oriented music education yields numerous benefits, including the enhancement of students' imaginative capacities, more positive learning attitudes, and a deeper appreciation of interdisciplinary connections. Instructional frameworks such as ADDIE and the 5E model have proven particularly effective in supporting this pedagogical shift. These models offer both structural coherence and the adaptability required to meet varied learning preferences and curricular objectives. Within the evolving landscape of education, digital technology emerges as a crucial enabler of learner-centred and impactful instruction. Tools such as digital audio workstations and interactive platforms have redefined how students conceptualise and interact with musical content.

Nonetheless, the practical implementation of STEAM integration in music education is not without challenges. Successful adoption necessitates that educators possess not only strong pedagogical and subject-specific knowledge but also technological proficiency and classroom management skills. Furthermore, effective execution of this approach requires

institutional commitment, adequate resources, and a systemic transformation in educational philosophy and infrastructure. In summary, STEAM-based music education extends beyond mere curricular integration; it embodies a forward-thinking vision aimed at cultivating globally competent learners. By dismantling traditional subject silos, this educational model fosters a holistic development that aligns with the complex and interconnected realities of the contemporary world.

Conclusion

This study has yielded important insights into the viability and effectiveness of STEAM-based approaches within music education, demonstrating that the integration of science, technology, engineering, arts, and mathematics can substantially transform traditional instructional practices. Evaluations conducted by subject experts affirmed that the lesson plans developed for this research were not only distinctive but also pedagogically robust and systematically designed. The findings identified multiple variables that significantly influenced students' musical creativity and perceptions of music education. These included the perceived usability of the instructional plans, the extent of collaboration in the learning environment, opportunities for personalised learning, and the degree of interdisciplinary engagement. One of the study's most critical revelations was the pronounced deficiency in STEAM literacy, as approximately half of the participating teachers and students exhibited limited familiarity with the approach. This highlights an urgent need for targeted educational initiatives and structured professional development to address these knowledge gaps. Moreover, the study advocates for a reconceptualisation of music education—moving beyond traditional disciplinary boundaries to embrace more integrated and technologically enriched learning experiences. Future efforts should prioritise the enhancement of teacher training programmes, the refinement of STEAM-oriented curricula, and the resolution of institutional and pedagogical challenges that currently restrict the broader implementation of this educational model. By advancing research and practice in STEAM-based music education, the field can cultivate a more dynamic and innovative framework that equips learners with the skills necessary to navigate and address the complex, interdisciplinary problems of the twenty-first century.

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