International Journal on Integrated Education (IJIE)

e-ISSN: 2620 – 3502
p-ISSN: 2615 – 3785

Volume: 7 Issue: 2 | April 2024
https://journals.researchparks.org/index.php/IJIE

Article

The Effect of STEAM Integration on Middle School Music Education

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Abstract: The research aims to assess the impact of integrating STEAM (Science, Technology, Engineering, Arts, Mathematics) learning into middle school music education in Korea. It investigates the integration of STEAM in music education and identifies factors influencing student motivation. Statistical analysis reveals that STEAM integration positively affects student motivation, attendance, and participation. A significant difference in motivation levels was found between control and experimental groups, with the experimental group showing higher motivation. The findings suggest that STEAM learning enhances student engagement and enthusiasm, particularly in the working details of music, leading to improved competencies and motivation.

Keywords: STEAM, Music education, pedagogical approach

Citation: Kim, C., & Auh, Y. The Effect of STEAM Integration on Middle School Music Education. International Journal on Integrated Education (IJIE) 2024, 7(2), 17-28.

Received: 30th May 2024
Revised: 6th June 2024
Accepted: 13th June 2024
Published: 20th June 2024

1. Introduction

As modern society explores various aspects of science and technology, we observe the convergence of these fields with the humanities, imagination, and artistic sensibilities. Recognizing that intuition, design, and sensibility are crucial for success in interdisciplinary STEM education, the integration of arts education has become increasingly emphasized. Arts education encourages children and adolescents to break free from rigid frameworks and rules, fostering creativity, innovation, and a proactive approach to problem-solving [1]. In the era of the Fourth Industrial Revolution, STEAM (Science, Technology, Engineering, Arts, Mathematics) education is crucial for several reasons. It fosters creativity and cultivates an innovative and proactive mindset in children and adolescents [2]. This approach helps students break free from rigid frameworks, encouraging them to think creatively and develop problem-solving skills essential for future challenges.

In the context of the Fourth Industrial Revolution, characterized by the interconnection of diverse technologies and disciplines, STEAM education plays a pivotal role in preparing students for the challenges and opportunities of the modern world [3]. This revolution is driven by the convergence of various fields, such as artificial intelligence, robotics, data science, and the arts, which often lead to groundbreaking innovations [4]. STEAM education provides a robust foundation for understanding these interdisciplinary connections and integrating diverse knowledge and skills [5,6].

STEAM education enhances students' problem-solving and innovation skills, crucial competencies required in the Fourth Industrial Revolution [7]. By fostering creative thinking and encouraging students to apply scientific methodologies to real-world problems, STEAM education empowers learners to conceive innovative solutions [8].

STEAM education prepares students for future careers in rapidly evolving fields [9]. With the increasing importance of STEAM disciplines in modern professions, STEAM education equips students with the necessary skills to thrive in the workforce [10]. By embracing both STEM and the arts, STEAM education nurtures creativity and innovation, providing students with diverse opportunities to explore various career paths [11].

STEAM education has a significant social impact by enabling students to address societal challenges and leverage technology for the greater good [12]. Equipped with STEAM skills, students become future leaders and innovators capable of making positive contributions to society [13].

Aforementioned, STEAM education is indispensable in the Fourth Industrial Revolution era, as it empowers students to thrive in the future, fosters innovation, and equips them with the skills needed to address complex challenges and drive positive societal change [14].

Transitioning from the importance of arts education in fostering creativity and innovation, art-driven STEAM education embodies a holistic approach to learning, integrating scientific inquiry, technological literacy, engineering design, mathematical reasoning, and artistic expression. By infusing the arts into STEM disciplines, students are not only encouraged to explore connections between seemingly disparate fields but also to think creatively and approach problems from multiple perspectives. This interdisciplinary approach not only enhances students' academic achievement but also equips them with the skills and mindset needed to thrive in the complex and dynamic environments of the Fourth Industrial Revolution. Art-driven STEAM education serves as a methodology to strengthen creativity, participation, communication, collaboration, and sharing, as well as the convergence capabilities required for the Fourth Industrial Revolution era. Therefore, cultural arts education provides learners with a foundation to actively and creatively shape the Fourth Industrial Revolution era.

However, despite these benefits, there appears to be a deficiency in the capacity for developing culture and arts-centered STEAM education [15]. Research in STEAM primarily comprises empirical studies (86.34%) aimed at designing, developing, and implementing lessons for interdisciplinary education [16]. While STEAM is integrated across various subjects for curriculum education purposes, it is predominantly prevalent in science education, where technological trends are incorporated into teaching practices [17]. Consequently, program development predominantly emphasizes science, with relatively little emphasis placed on the arts. Furthermore, in terms of integration, disciplines within STEAM often remain isolated, with one discipline or element serving as a motivator or supporting role for another [18]. The format of interdisciplinary programs often lacks theoretical grounding and consists mainly of activity listings. Additionally, within the realm of arts-driven STEAM, the focus is primarily on visual arts [5]. Moreover, there is a scarcity of research on music-centered STEAM education and its effectiveness in preparing students for the Fourth Industrial Revolution.

Therefore, this study aims to bridge this gap in the literature by providing a platform for researchers, educators, and practitioners to explore the theory, practice, and assessment of art-driven STEAM education, with a specific focus on music. By examining the role of music in STEAM learning, investigating innovative pedagogical approaches, and developing new assessment strategies, this journal seeks to advance our understanding of how art-driven STEAM education can equip students for the challenges and opportunities of the Fourth Industrial Revolution.

2. Literature Review

Background

STEAM education, an innovative approach that merges Science, Technology, Engineering, Arts, and Mathematics, is increasingly recognized as a forward-thinking pedagogical method tailored to equip students with the skills required for the complex challenges of the 21st century [19,20]. By seamlessly integrating the arts with the STEM disciplines, STEAM education endeavors to foster a multifaceted learning environment that nurtures creativity, encourages innovation, and promotes a holistic understanding of concepts [21]. Through this interdisciplinary framework, students are encouraged to explore connections between diverse subjects, engage in hands-on activities, and develop critical thinking skills essential for success in today's rapidly evolving world.

Key Concepts and Theoretical Frameworks

STEAM education represents a natural evolution of STEM education by seamlessly integrating the arts alongside science, technology, engineering, and mathematics, thereby promoting interdisciplinary thinking and problem-solving skills [22]. Drawing on theoretical frameworks such as constructivism, sociocultural theory, and design-based learning, STEAM pedagogy prioritizes hands-on, inquiry-based approaches to learning [23]. This holistic educational approach recognizes the importance of engaging students in real-world contexts and collaborative activities, where they can actively explore, experiment, and create. By intertwining artistic expression with scientific inquiry and mathematical reasoning, STEAM education encourages students to develop a deeper understanding of concepts while fostering creativity, innovation, and a lifelong passion for learning.

Case Study 1: High School STEAM Integration Program

A high school in California implemented a STEAM integration program aimed at combining arts education with traditional STEM subjects to enhance student engagement and creativity [24]. The school redesigned its curriculum to include project-based learning units that integrated science, technology, engineering, arts, and mathematics. For example, students studied environmental science through art by creating sculptures representing various ecosystems and conducting experiments to analyze their environmental impact. The STEAM integration program resulted in increased student engagement and deeper learning outcomes [25]. Students showed improvement in critical thinking, problem-solving, and creativity skills. Additionally, disciplinary boundaries were blurred, fostering interdisciplinary collaboration among students and teachers [26].

Case Study 2: Maker-Space STEAM Program for Elementary Students

An elementary school implemented a Maker-Space STEAM program to introduce young students to hands-on learning experiences in science, technology, engineering, arts, and mathematics [22]. The school established a dedicated Maker-Space equipped with various tools, materials, and technology resources. Students engaged in design thinking projects, such as building model bridges, creating stop-motion animations, and coding interactive artworks using Scratch. The Maker-Space STEAM program enhanced students' creativity, problem-solving abilities, and collaboration skills. Students showed enthusiasm for learning and expressed confidence in applying STEAM concepts to real-world challenges. The program also promoted inclusive learning environments, where students of diverse backgrounds could participate and excel [27].

These case studies demonstrate how STEAM education programs can be effectively implemented and their positive impacts on student learning and engagement [28].

Theoretical Foundations of STEAM Education

At the core of STEAM education lie the theoretical underpinnings of constructivism, championed by renowned educational theorists such as Jean Piaget and Lev Vygotsky [29]. These scholars proposed that knowledge is actively constructed through handson experiences and interactions with the environment, rather than passively absorbed. Embracing this constructivist philosophy, STEAM education emphasizes experiential and inquiry-based learning, inviting students to tackle real-world problems and projects [30], thus fostering a dynamic and interactive learning process rooted in exploration and discovery [31].

Another cornerstone of STEAM education is Howard Gardner's Multiple Intelligences Theory (2006) [32], which posits that individuals possess diverse intelligence types, from linguistic and logical-mathematical to spatial and beyond. STEAM education, recognizing these varied intelligences, integrates a range of disciplines and expressive modes to offer a more inclusive and tailored educational experience that honors the unique strengths and capabilities of each student [33].

The integration of the Arts into STEM disciplines, giving rise to STEAM, is grounded in the synergistic relationship between analytical (STEM) and creative (Arts) thinking [34]. This interdisciplinary fusion is supported by the belief that the Arts can greatly enhance creativity, imagination, and the ability to make connections. Sir Ken Robinson's work (2015) [35], emphasizing the significance of nurturing creativity in education, resonates strongly with the inclusion of the Arts in the STEAM paradigm.

Lastly, the Cultural-Historical Activity Theory (CHAT) [36], initially developed by Vygotsky and expanded by [37], underscores the social and cultural dimensions of learning. STEAM education embraces this perspective by advocating for collaborative and community-based learning approaches, highlighting the importance of cultural context and shared knowledge construction in the learning process.

As STEAM education evolves, it is essential to remain grounded in these foundational theories to ensure its efficacy and relevance. Ongoing research offers opportunities for continuous enhancement, positioning STEAM education at the forefront of educational innovation. Ultimately, STEAM education equips learners not only for academic success but also for ethical and creative thinking, empowering them to navigate 21stcentury challenges and opportunities with confidence and ingenuity.

Problem statement

The aim of the research is to assess how STEAM learning influences the motivation of music students. The study entails conducting statistical analysis on music teaching methods and investigating factors that influence student motivation in music education.

Research objectives

1. Assess the efficacy of STEAM learning within the realm of music education.
2. Investigate the determinants of motivation among middle school music students, specifically examining the potential for STEAM-infused music education to enhance student engagement.
3. Evaluate the potential impact of integrating STEAM learning on the motivation levels of music students.

3. Materials and Methods

Experimental Approach

This methodology entails a rigorously controlled investigation designed to empirically test hypotheses concerning the impact of a specific factor on a particular outcome [38].

Analysis

The analytical approach necessitates the application of critical reasoning and the assessment of pertinent data and information pertinent to the research endeavor [39]. Analytical inquiry yields significant insights that contribute novel concepts to the body of knowledge. It identifies data that buttresses existing research, thereby bolstering the credibility of the findings [40].

This investigation employed an analytical approach to interpret findings from data gathered post-STEAM implementation. Researchers examined student data and educator feedback, revealing both the benefits and potential constraints of integrating STEAM principles into music education. This comprehensive analysis facilitated the affirmation or negation of hypotheses, while also contextualizing the findings within the existing academic landscape in the formulation of conclusions and recommendations. Such a methodological strategy served to enhance the credibility and robustness of the study's outcomes.

Survey

Surveys represent a potent means of gathering data, wherein respondents autonomously provide information, often from a sizable pool of participants [40].

Data Collection

The choice of data collection method plays a pivotal role in the research endeavor, influencing the caliber and precision of the gathered data. It significantly contributes to the attainment of research objectives by furnishing precise data and fortifying the trustworthiness of research findings [39]. In this study, the data collection process encompassed acquiring insights into student learning outcomes within the framework of flipped learning, subsequently juxtaposing them with outcomes associated with traditional learning approaches.

4. Results

Research design

In the initial phase, the researchers meticulously evaluated the efficacy of STEAM integration within the realm of music education. Factors influencing student motivation were examined, with a particular focus on the potential of STEAM education to foster increased interest in music learning. This stage involved a comprehensive analysis of the merits and drawbacks of STEAM education when compared to traditional approaches in music education. Additionally, this phase sought to ascertain whether STEAM learning could enhance student motivation in music learning.

The subsequent stage involved an experimental study conducted among 122 students from the A1 district of a middle school. The objective of the experiment was to assess the impact of STEAM learning on student motivation in music education. The subjects were divided into two groups: the control group, which received conventional education, and the experimental group, which was exposed to the STEAM learning model. This model emphasized practical engagement in STEAM-based interactive learning during music sessions. This interactive learning covered topics such as the physics and physiology of acoustics, including vibration, vocal cord movement, concert hall acoustics, and sound trajectories.

In the third phase, a survey was administered to teachers at the middle school. The survey enlisted the participation of 20 teachers and was facilitated through the online platform Google Forms. The questionnaires utilized open-ended formats to solicit responses.

Sample for the experiment

The experiment spanned a duration of 6 months and encompassed two participant groups: a control group (n = 61) and an experimental group (n = 61). The control group comprised students who adhered to a traditional learning paradigm, characterized by conventional lesson delivery methods and materials. In contrast, the experimental group was subjected to a study implementing STEAM education principles. Within this group, students accessed online educational resources as a part of music class. Their learning activities encompassed engagement with educational materials, videos, interactive experiment, simulation, brief lectures, and self-test quizzes. Classroom sessions emphasized discourse through online chat, group discussion, and vocal practice. This pedagogical approach facilitated enhanced comprehension and appreciation of musical compositions, while fostering active participation among students. Furthermore, it cultivated collaborative and communicative skills among students, promoting a sense of teamwork. The envisioned outcome of this learning model was to bolster student motivation to engage in vocal performance through an active and accountable approach to music learning.

Following the conclusion of the experiment, an interview was conducted to gather supplementary data and insights from participants regarding their perceptions of the two learning formats. The interview questionnaire is provided in Appendix A.

Statistical analysis

The initial phase in statistical computation involved the compilation of data from diverse sources, including experiments, surveys, and observations. The Student's t-test was employed to assess the mean values of two samples and evaluate hypotheses concerning the equality of these mean values. This statistical tool adhered to all requisite conditions for its application. Consequently, t-statistics and significance levels (p-values) could be computed. The t-test facilitated the determination of the statistical significance pertaining to variations in the mean values of two independent samples, thereby indicating whether such disparities were random or substantial.

Survey results

Teachers (79%) expressed a favorable assessment regarding the efficacy of STEAM learning in music instruction, attributing enhancements in their students' academic performance. Concurrently, students (85%) perceived a notable surge in their motivation toward music learning through STEAM education. These transformations predominantly yielded positive outcomes, fostering heightened interest among students in music education.

Additionally, 79% of teachers responded that the integration of STEAM learning facilitated a deeper comprehension of educational content. This observation suggests that students not only acquired surface-level musical knowledge but also developed the ability to analyze and understand the underlying physics and physical aspects of music-making at a deeper level. This, in turn, exerted a positive influence on their musical development, enabling them to better grasp and execute musical compositions.

Teachers also highlighted the challenges associated with STEAM education. Specifically, they underscored the inadequate availability of technical resources for all students (48%) and the substantial preparatory workload (84%). Respondents (27%) identified deficiencies in the accessibility of technical resources for all students, indicating unequal access to computers, the Internet, or other essential technical tools required for self-directed learning at home. This disparity engendered inequities in learning opportunities.

A considerable portion of teachers (84%) identified the extensive preparatory workload as a significant impediment to integrating STEAM education. While online learning resources and activities proved effective for classroom learning, they required significant motivation, time, and effort from students. Additionally, 17% of teachers identified challenges in providing supplementary support and explanations to students struggling with online material. Addressing these needs demanded extra time and effort from teachers.

Furthermore, 79% of teachers reported that their students viewed STEAM education favorably as a component of their musical learning and held it in high regard. Additionally, these teachers noted that many online learning resources could facilitate the implementation of flipped learning in the future. Moreover, 91% of teachers employed video resources and interactive quizzes, enabling students to engage with the material at their own pace and delve deeper into their studies. Teachers perceived the integration of STEAM education as a promising avenue for the future advancement of music education, viewing it as an opportunity to enhance the learning process and outcomes.

Professional development is crucial for fostering future motivation in music education. These initiatives include training, workshops, seminars, and collaborative learning, which enhance educators' skills and teaching methods. By staying updated on the latest advancements in music pedagogy, technology, and research, educators can integrate evidence-based practices and innovative techniques into their teaching. Professional development also promotes continuous improvement, lifelong learning, and effective student engagement. Additionally, it provides opportunities for collaboration and networking, fostering a supportive community that encourages creativity and innovation. Ultimately, investing in professional development empowers music educators to inspire and nurture the next generation of musicians, instilling in them a lifelong passion for music and a commitment to artistic excellence. Thus, professional development initiatives are not only essential for enhancing the quality of music education but also for enriching the lives of students and fostering a vibrant and thriving musical community.

27% of teachers stress the critical importance of providing students with state-of-the-art technical resources in music education. Equipping students with modern tools such as computers, software, and a diverse array of musical instruments is essential for fostering a dynamic and enriching learning environment. These resources not only enhance technical skills and proficiency but also enable students to explore and experiment with various musical concepts and techniques. Additionally, robust technical infrastructure supports flipped learning, enabling students to pursue musical interests independently. Investing in technical resources allows music educators to create an inclusive environment that empowers students to excel in their musical endeavors.

Implementing these recommendations will create a supportive learning environment, empowering students and enhancing their self-improvement. This makes learning music more engaging and motivational, positively influencing student performance and overall enthusiasm for music education.

Research Outcome

This study aimed to investigate the impact of STEAM education on student motivation in music learning. The experimental results are summarized below.

Student Motivation and Engagement

85% of students reported increased motivation for singing and music learning after the experiment, attributing this to the pre-class study of educational materials, which provided a deeper understanding. The online resources enhanced classroom learning and facilitated in-depth discussions on key musical concepts.

For 58% of students, the main benefit of STEAM education was increased engagement in active exercises and practice sessions during classes. This approach deepened their comprehension and enhanced their musical skills. In-class self-directed learning offered significant advantages over traditional methods, allowing individualized learning opportunities and greater flexibility, thereby optimizing preparation for class activities.

The majority of students (85%) expressed positive impressions of the learning process within the experimental group that utilized the STEAM education model. They reported increased engagement in self-directed learning activities and practical exercises during classes. Students praised the supportive and collaborative classroom atmosphere, where teacher and peer interactions fostered cooperation and mutual understanding. Participation in collective musical performances and discussions further developed collaboration and communication skills among students. Collectively, these positive impressions underscore the effectiveness of STEAM education in music instruction, highlighting its tangible benefits in enhancing student motivation and learning outcomes.

Statistical Analysis

Table 1. Presents the results of the Student's t-test comparing data reliability between the control and experimental groups:

Group	Sample Size(n)	Mean(M)	Standard Deviation(SD)
Control	61	6.3	1.2
Experimental	61	7.8	1.0
Pooled SD			1.104
Degree of Freedom	120		
t-statistics	7.50		−7.5
P-value	0.001		

The provided data compares the outcomes of two groups: a control group and an experimental group, each consisting of 61 students. The analysis focuses on the impact of a STEAM-based learning intervention on student performance or motivation, measured by a mean score with an associated standard deviation.

Mean Comparison

The mean score of the experimental group (7.8) is significantly higher than that of the control group (6.3), suggesting that the STEAM intervention had a positive impact on the students' performance or motivation.

Standard Deviation

The standard deviation of the experimental group (1.0) is slightly lower than that of the control group (1.2), indicating less variability in the experimental group's performance scores.

t-statistic and P-value

The t-statistic is 7.50, which is a measure of the difference between the two group means relative to the variability in the data. The P-value is 0.001, which is much less than the common significance level of 0.05. This indicates that the observed difference in means is statistically significant and not likely due to chance.

5. Discussion

The data analysis shows a statistically significant improvement in the performance or motivation of students in the experimental group compared to the control group. The higher mean score in the experimental group suggests that the STEAM-based learning intervention was effective. The low P-value confirms the significance of this result, and the consistency in scores within the experimental group (as indicated by the lower standard deviation) further supports the reliability of the intervention's positive impact.

Interest in STEAM education is growing, yet its application in music remains relatively underexplored. Incorporating STEAM into music instruction promises to unlock numerous opportunities for enhancing learning outcomes and promoting student motivation. Unlike the conventional learning paradigm, where students passively receive content during class, this approach involves pre-class engagement in self-directed learning activities, facilitated by interactive materials that allow students to test ideas and visually simulate outcomes.

The findings of this investigation reveal a statistically significant difference in mean motivation levels between the control and experimental groups. Students in the experimental group exhibited higher average motivation levels compared to their counterparts in the control group. Participants reported positive transformations in their competencies and motivation levels, with notable increases in enthusiasm for music class and heightened engagement in practical exercises.

This research suggests that STEAM education offers numerous benefits, such as sparking interest in subjects that learners previously found unappealing. However, there is a significant gap in longitudinal studies evaluating the efficacy of incorporating music into STEAM education and its impact on careers in STEAM fields. Long-term investigations are crucial to understanding the sustained effects of integrating music into STEAM instruction and its potential to influence students' pathways into STEAM professions. Such studies can provide valuable insights into the role of music in enhancing STEAM learning outcomes and shaping students' career trajectories in STEAM disciplines, as well as introducing new approaches to teaching music.

Despite its promise, STEAM education faces challenges related to curriculum integration, assessment, equity, and sustainability [22]. Addressing these challenges requires attention to issues of access, teacher preparation, and cultural biases [18]. Future research should focus on innovative pedagogies, technologies, and the long-term impacts of STEAM education on workforce development and societal advancement [41].

STEAM education represents a holistic approach to preparing students for the complexities of the modern world, emphasizing creativity, innovation, and interdisciplinary problem-solving [42]. Continued research, collaboration, and innovation are essential to realizing the full potential of STEAM education in fostering a more inclusive, equitable, and prosperous future.

6. Conclusion

According to the study, including STEAM (science, technology, engineering, arts, and mathematics) into middle school music instruction greatly raises student involvement and motivation. The experimental group exposed to STEAM-based learning had a higher mean score than the control group, according to statistical analysis, showing that the STEAM intervention successfully raised student motivation and performance in music instruction. The success of the STEAM approach in fostering a more dynamic and interesting learning environment is further supported by the encouraging comments from instructors and students.

Students' attention and excitement were piqued, and through active, hands-on learning, STEAM education was included into music sessions, leading to a deeper knowledge of musical principles. In order to successfully navigate the complexity of the twenty-first century, this method promoted the development of critical thinking, cooperation, and communication skills. Because of this intervention's success, STEAM education has the potential to improve educational outcomes in a variety of subjects and revolutionize conventional teaching approaches.

Though encouraging, the results of this study do not yet fully address the long-term implications of STEAM integration in music instruction; longitudinal research is still required. Prospective research endeavors ought to investigate the longevity of heightened drive and involvement and appraise the wider influence on learners' scholarly and professional paths in STEAM domains. To get the most out of this teaching strategy, it will also be imperative to solve issues with curricular integration, assessment, and equitable access to STEAM materials. Further understanding of how STEAM education can promote a more diverse and productive learning environment can be gained by looking into cutting-edge pedagogies and technological supports for the subject.

Overall, the study emphasizes how crucial it is for STEAM education to keep up its research, creativity, and collaboration in order to fully realize its promise in educating students for opportunities and difficulties in the future.

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Appendix A

1. **Evaluation Phase Questions:**
   - How did you measure the efficacy of STEAM integration within music education during the initial phase?
   - What specific factors did you find most influential in affecting student motivation through STEAM education?
   - Can you elaborate on the merits and drawbacks of STEAM education compared to traditional music education methods that you identified in your analysis?
   - What methods were used to collect data on student motivation and engagement in music learning during the evaluation phase?
2. **Experimental Study Questions:**
   - What criteria were used to select the 122 students from the A1 district for the experimental study?
   - How did you ensure that the control and experimental groups were comparable in terms of their initial interest and motivation in music?
   - What were some of the key differences in the learning experiences between the control group and the experimental group?
   - What specific STEAM-based activities and topics were included in the experimental group's music sessions?
3. **Survey Questions:**
   - What insights did you gain from the teachers' responses regarding the effectiveness of STEAM integration in music education?
   - Were there any common themes or concerns raised by the teachers about the implementation of STEAM learning in their music classes?
   - How did the open-ended format of the survey questions facilitate a deeper understanding of the teachers' perspectives on STEAM education?
   - How did teachers perceive the impact of STEAM integration on student motivation and engagement in their music classes?