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Bridging Art and Science: Engaging Girls in the Physics of Sound Through a Transdisciplinary STEAM Approach

Narges Mansouri

University of Victoria, Canada

Abstract: This study explores how adopting a transdisciplinary STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach can deepen elementary-aged girls' engagement with science by integrating artistic expression and scientific inquiry. Building on a shift from a multidisciplinary model—where disciplines remain adjacent—to a transdisciplinary one—where they are interwoven—the research investigates the impact of a one-day workshop for Grade 3 and 4 students centered on sound graph analysis. Framed by the 5E Instructional Model and guided by a focused ethnography methodology, the workshop invited students to interpret and represent sound visually, creating an embodied and intuitive bridge between art and science. Findings reveal that this seamless integration promoted higher engagement, particularly among girls, by connecting abstract scientific concepts to their personal and sensory experiences. The transdisciplinary framework fostered both analytical and creative thinking, validating students' diverse modes of understanding. This approach not only made science more accessible but also challenged traditional gendered perceptions of STEM fields. The study underscores the potential of transdisciplinary STEAM education to create more inclusive learning environments and to empower young girls to see themselves as capable science learners through the lens of creativity and everyday relevance.

Keywords: 5E instructional model, Female students, Focused ethnography, Transdisciplinary STEAM
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Introduction

This paper explores the role of the arts within a transdisciplinary (TD) STEAM approach to enhance the engagement of female students in science education. By leveraging girls' existing interest in the arts, the study seeks to bridge this enthusiasm with science learning through project-based STEAM experiences rooted in a transdisciplinary framework.

Statistical evidence highlights a persistent gender gap in STEM fields, particularly in high-ranking positions. According to UNESCO data cited in Donmez (2023), women constitute only 30% of research and development employees and just 18% of relevant task forces globally (UNESCO, 2020, as cited in Donmez, 2023). Su and Rounds (2015) argue that addressing this imbalance requires a deeper understanding of the factors contributing to women's underrepresentation across STEM sub-disciplines.

One of these contributing factors may be related to early interests and engagement patterns shaped by gender. For instance, a study conducted by Ember Smyth (2016) for the Economic and Social Research Institute (ESRI), commissioned by the Arts Council, examined children's participation in cultural and artistic activities across Ireland. Using school-based data, the study analyzed how variables such as gender, social class, parental education, income, migrant status, disability, and geographic location influenced participation in areas like art and music. The findings revealed that girls, from an early age, show a greater inclination toward painting, drawing, and music, whereas boys tend to prefer computer-based and technology-oriented activities. Similarly, Wikberg (2013) observed that girls spend more of their leisure time engaging in artistic pursuits, while boys are more likely to focus on technology-related interests.

This consistent enthusiasm for the arts among female students presents a promising opportunity to engage them in STEM through integrated approaches. Recognizing this potential, educators and researchers at the turn of the 21st century began advocating for the inclusion of the arts in STEM, resulting in the evolution of STEM into STEAM. By adding 'Art' to the traditional disciplines of Science, Technology, Engineering, and Mathematics, STEAM education aims to foster creativity, personal expression, and interdisciplinary learning (Baizan et al., 2021). Studies by Aguilera and Ortiz-Revilla (2021) and Engelman et al. (2017) support the notion that integrating artistic elements into STEM can increase engagement, particularly for populations historically underrepresented in these fields.

A central question that arises at this point is how the various components of STEAM—science, technology, engineering, art, and mathematics—can be effectively integrated within a lesson or project plan to fulfill the aim of this study: enhancing the engagement of female students in science, and more broadly, in STEM education.

When reviewing STEAM lesson plans, it is possible to categorize them based on their disciplinary integration. As noted by El Bedewy and Lavicza (2023), STEAM approaches span a continuum from multidisciplinary to transdisciplinary models.

- Intradisciplinary: working within a single discipline.
- Cross-disciplinary: viewing one discipline from the perspective of another.
- Multidisciplinary: people from different disciplines working together, each drawing on their disciplinary knowledge.
- Interdisciplinary: integrating knowledge and methods from different disciplines, using a real synthesis of approaches.
- Transdisciplinary: creating a unity of intellectual frameworks beyond the disciplinary perspectives (El Bedewy & Lavicza, 2023, p. 3)

Given that the target group in this study- female students- tend to show a greater intrest in art, it is essential to choose a discipline in which art is seamlessly integrated with all other components of STEM , so that the participants does not percieve any separation between art and the other fields. If there is a clear separation between the STEM components and art in any part of the STEAM project, the audience – due to their presumed inclination – will be more drawn to the artistic aspects of the project and will likely pay less attention to the STEM components. As a result, the main goal of the research, which is to increase female students' engagement for STEM, will not be effectively achieved.

Among these, the transdisciplinary approach emerges as the most effective for engaging female students in science, particularly by leveraging their strengths and interests in the arts. Guyotte et al. described transdisciplinary learning as being "like a watercolor painting where colors bleed together, blurring boundaries between disciplines to create vibrant new spaces" (as cited in El Bedewy & Lavicza, 2023, p. 3).

Given the potential of the arts to serve as an entry point into STEM learning for female students, and the effectiveness of transdisciplinary approaches in creating meaningful, student-centered learning experiences, it becomes essential to examine how these elements interact. This study seeks to investigate a central question: What is the role of the arts in a transdisciplinary STEAM lesson plan in promoting the engagement of female students in STEM?

Project Overview: Bridging Art and Science in the Physics of Sound

In this study, the physics of sound was selected as the focal topic for the transdisciplinary STEAM plan. According to the British Columbia curriculum—relevant to the context in which this project was implemented—sound is introduced in Grade 1 as a basic scientific concept and later revisited in Grade 11 within the broader study of waves, focusing on properties such as frequency and amplitude. In Grade 1, sound is taught as a natural phenomenon, helping students recognize its scientific characteristics. By Grade 11, students encounter a more technical understanding of sound, such as interpreting sound graphs that represent pressure fluctuations over time as sine waves. However, this abstract and technical explanation may not always be accessible or engaging to students. Because sound is also a deeply embedded part of everyday life and closely tied to music—a vital aspect of the arts—it presents a strong opportunity for exploring the integration of art within STEAM education. Thus, sound serves as an ideal subject for investigating how a transdisciplinary STEAM approach can enhance student engagement, particularly through artistic expression.

To explore this potential, students in Grades 3 and 4 were selected as participants in the workshop. This group was intentionally chosen as they represent the youngest learners who have already been introduced to sound as a scientific phenomenon in Grade 1. The goal was to examine how a transdisciplinary STEAM approach could deepen and reshape their understanding of sound beyond its initial scientific framing. Furthermore, because the workshop required students to write brief reflections on their emotional responses to different sounds while listening, it was essential to choose participants with sufficiently developed writing skills. Grade 1 students were considered less suitable due to their emerging literacy skills, which may not support the simultaneous demands of listening and reflective writing. Therefore, students in Grades 3 and 4 provided the ideal balance of prior scientific knowledge and the ability to engage meaningfully in both scientific and artistic activities.

By shifting from traditional Physics to transdisciplinary STEAM, the perspective on sound graphs changes. This shift became the foundation for the workshop plan, which consisted of five carefully designed steps.

A sound graph is unique to each sound, visually representing an auditory experience. It is essentially a visual translation of sound, enabling a connection between auditory and visual learning. This concept formed the basis of steps 1 and 2 of the workshops.

To draw a sound graph on paper, students needed to categorize sounds based on their characteristics. Step 3 of the workshop introduced students to various sounds, encouraging them to group and compare these based on loudness and pitch. Additionally, translating sound into visual form requires consistent drawing rules. These rules—rooted in sound characteristics such as loudness and pitch—formed the focus of step 4.

Finally, the last step of the workshop invited students to explore sounds and their graphs in nature, offering a fresh perspective on the interconnectedness of sound and its visual representation.

The research was conducted during a one-day spring workshop in March 2024. The workshop involved eight girls from grades 3 and 4, running from 9 a.m. to 4 p.m. Detailed activity forms guided the students through various tasks, capturing their observations and reflections. Two volunteer scholars, both holding advanced degrees (PhD and MA) in Physics with teaching experience at university and high school levels, facilitated the workshop and ensured its smooth execution.

Theoretical Framework

A STEAM project requires a comprehensive framework that can address all its components. Finding such an all-encompassing framework is challenging and often seems nearly impossible. In brief, review of the literature demonstrated that both STEM and STEAM education lack a clear conceptual framework with broad consensus within the scientific–educational community. In this sense, the possibilities of implementing this approach in practice are diminished, as well as the rigorous evaluation of its educational potential (Aguilera & Ortiz-Revilla, 2021, p.11).

The 5E Instructional Model, widely used in STEM, and used in STEAM studies, was chosen to cover most aspects of this study. The 5E model was designed to build student understanding through a scaffolded, constructivist approach. It emphasizes hands-on activities, reflection, and continuous assessment to deepen conceptual knowledge in a systematic way. The BSCS 5E Instructional Model has become the foundation for a vast amount of curriculum materials used in science education, consequently having a significant impact on the teaching, and learning of science. It emphasizes integrated team communication and the cooperation and exchange among interdisciplinary talents, responding to changes in the design environment (Bybee et al., 2006, p.2).

Bybee (2019) stated that the concept of instructional units has a long history. Research on laboratory experiences in school science programs (National Research Council [NRC], 2006) and the potential for integrated STEM (NRC, 2014) offers a perspective on instructional units that link laboratory experiences with other learning activities, such as reading, discussions, investigations, and projects. The 5E instructional model guided the pedagogical process of building science understanding and skills by actively engaging students with scientific ways of thinking, generating ideas, and collecting evidence (Skamp & Peers, 2012, as cited in Chu et al., 2018, p. 1256). Moreover, the 5E instructional model can be regarded as a constructivist disciplinary approach. This model supports inquiry-based teaching, “because learning cycles focus on constructivist principles and emphasize the explanation and investigation of phenomena, [and] the use of evidence to back up conclusions…” (Duran & Duran, 2004, as cited in Chu et al., 2018, p. 1256). Bybee (2019) described the components of the 5E instructional model in relation to STEM disciplines.

According to his explanation, the model consists of five phases: Engage, Explore, Explain, Elaborate, and Evaluate (p. 2).

Methodological Consideration

In this section, I presented the chosen methodology and explained the rationale behind it. Then, I describe the methods, data sources, and data analysis employed in this study.

Methodology

This study aims to uncover the role of art in STEAM education and its effects on girls' engagement in STEM. Given the qualitative nature of these inquiries, the most suitable approach for this study is qualitative methodologies.

In this work, I aimed to create a friendly team atmosphere where all members felt equal in knowledge and worked together to solve a real-life problem. This was different from the usual classroom environment and the typical relationships between students, and between students and adults (teachers and educational assistants). I wanted the group to live together for one day, share their feelings, think about their surroundings, and face challenges together. I needed a group with diverse viewpoints about the environment they spent the day in. I designed this environment based on the STEAM principles of the project. I required a methodology with these characteristics.

Given the details provided about the workshop held for this study, and its characteristics, especially the duration of the workshop that is only 1 day, research question and methods of data collection, focused ethnography stands out as the most fitting methodology for this study (See Figure 1).

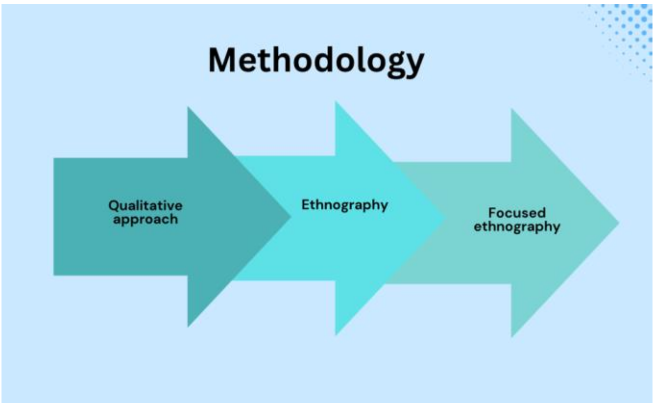
Focused ethnography is a type of ethnography dealing with a distinct problem in a specific context, usually within a limited time frame. Focused ethnography can be characterized by short-term field visits or no field visits, pre-determined research questions, intensive methods of data collection, and the researcher's potential insider status or background knowledge of the cultural group of interest (Sage Publications, 2023).

Methods and Data Sources

In this study, data collection and analysis were conducted through observation and document analysis to investigate student engagement in STEAM activities. A fixed camera recorded the overall workshop dynamics, while a mobile camera operated by a volunteer captured specific points of interest. Photographic documentation was also utilized to track the evolution of student-created artifacts. The participation of two volunteer scholars with extensive academic and teaching experience in Physics enriched the observation process and provided valuable guidance to the students as they explored scientific concepts.

Figure 1

The Hierarchical Relationship of the Study's Methodological Framework



Data Analysis

To analyze the data, a multi-step process was followed:

1. Step-by-Step Analysis

Each step of the workshop was analyzed individually, using the 5E instructional model as framework. The data from each step was then analyzed in relation to the workshop plan to compare the intended outcomes with the actual results (see Figure 2).

2. Comprehensive Analysis

The analyzed data were combined to comprehensively address the research question. This holistic approach provided a clear understanding of how the workshop's design and execution aligned with the research objectives. It ensured a thorough evaluation of the workshop's effectiveness and how its outcomes matched the intended educational goals (see Figure 2).

During this process, I noticed some unexpected outcomes, which required a revision of the initial research questions. This refinement helped sharpen the focus of the final analysis to better reflect these emerging themes. I also documented the iterative process of revising the research questions and analyses to accurately capture the nuances in the data, ensuring that the final conclusions are well-supported by the evidence.

Results

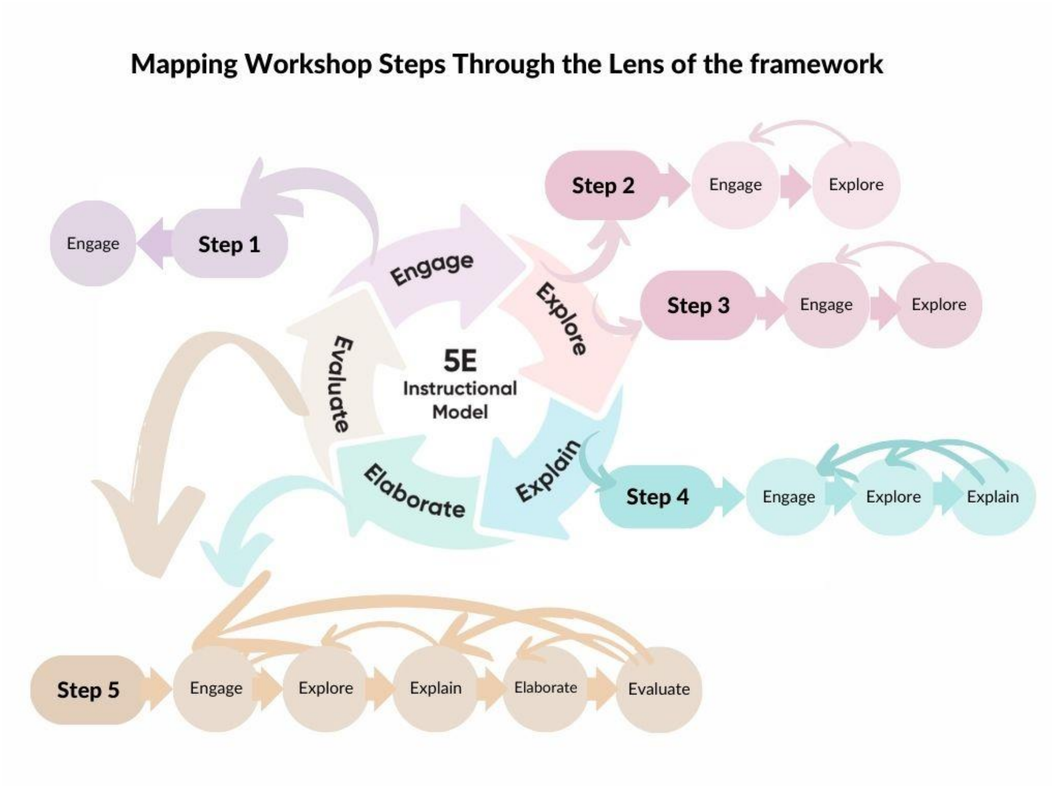
The workshop consisted of five steps (see Figure 3). In this section, I describe how each step was implemented and report participants' responses based on information gathered from various data sources. For each step, the data is then analyzed within the framework of the theoretical model.

Step 1: Creating Connections: Music and Visual Expression

The workshop commenced with an activity aimed at bridging the auditory experience of music with its visual expression. This step served as an introduction to drawing scientific sound graphs, enabling participants to visualize the relationship between sound waves and their visual representation. To initiate this process, we played two contrasting pieces of music: one exuding energy and the other tranquility. Students were encouraged to reflect on their emotional responses and express them on paper using various mediums, including writing, drawing, or coloring.

Figure 2

Interpreting the Workshop Steps Through the Framework's Perspective



Note. Each step of the workshop is designed according to the 5E instructional model. Overall, the steps are sequentially connected, with each building on the previous one while covering different aspects of the 5E model. The final step integrates all parts of the 5E model, synthesizing the learning from the earlier steps. It's important to note that there are iterative cycles between the components of the 5E model within each step, reinforcing the learning process and ensuring a comprehensive understanding.

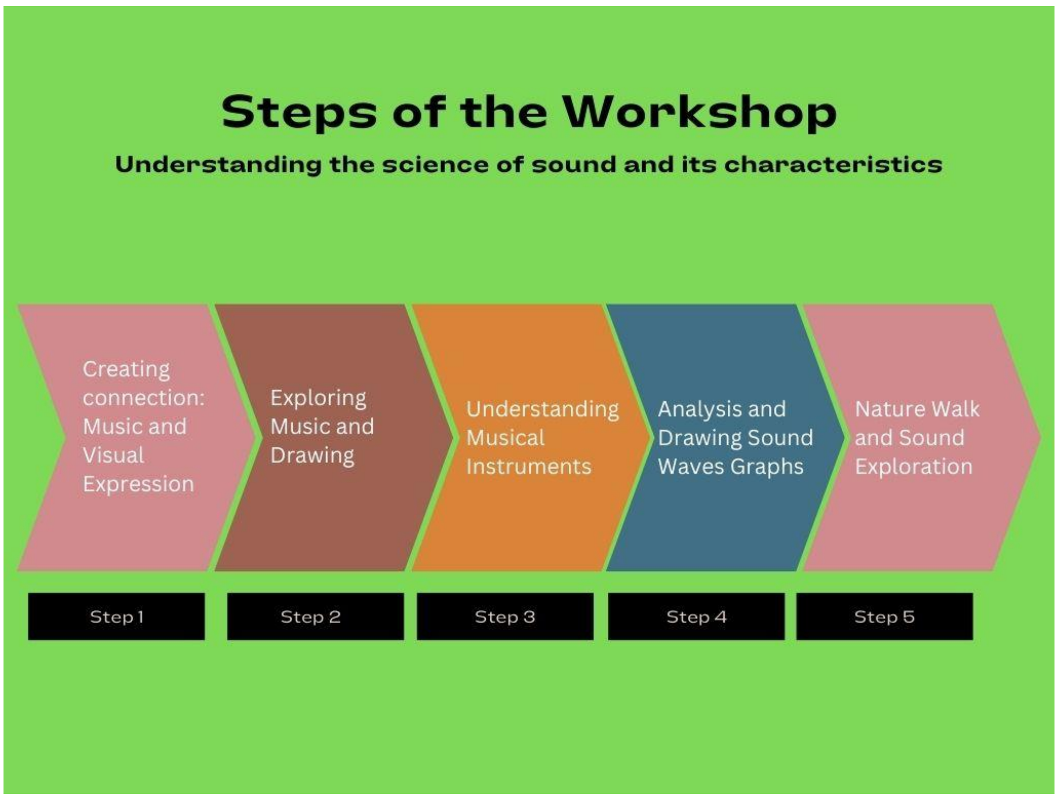
We also explored the interplay between music and visual art, deepening students' understanding of how sound translates into visual perception. This step aligned with the "Engage" stage of the 5E instructional model. By engaging students with two distinct pieces of music and encouraging them to express their feelings through art, we captured their curiosity about the science of sound.

Step 1 Responses

Each piece of music was played twice. During the first round, students closed their eyes and listened. In the second round, they expressed their feelings on paper. The paper had two frames for each piece of music. Two students chose not to participate and left their papers blank. Among the six students who participated, one wrote about her feelings, while others created drawings and combined their artwork with words (see Figure 4).

Figure 3

Steps of the Workshop



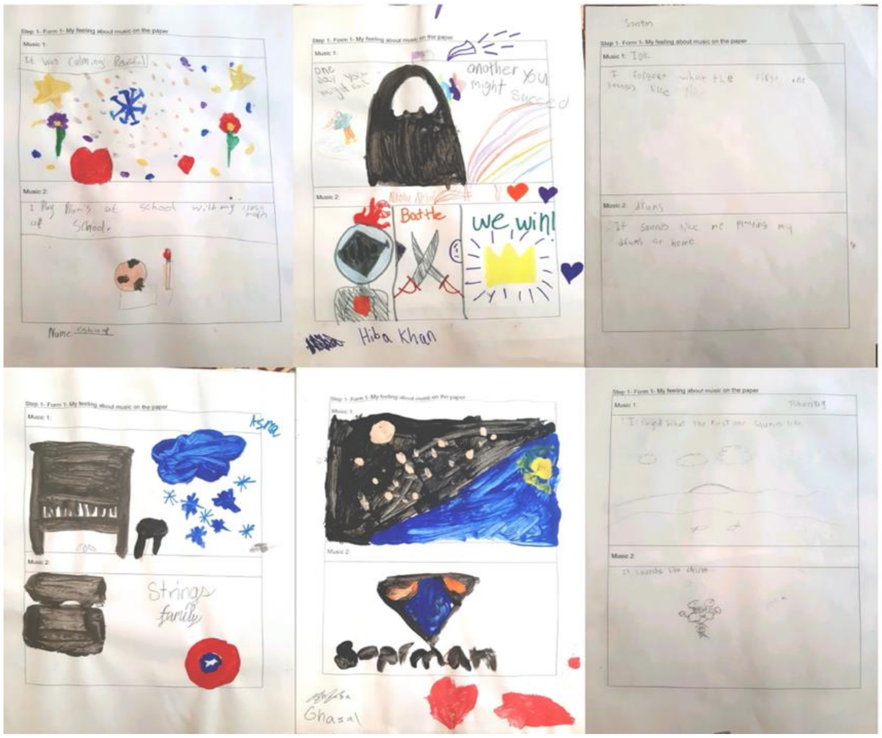
Examining the students' work (Figure 4) reveals differences in their emotional responses to the two pieces of music. Two students expressed their feelings through painting, two combined writing and drawing, and two used a mix of drawing, writing, and coloring. The serene, nature-inspired music elicited calm and peaceful imagery, while the energetic, fast-paced piece inspired dynamic and vivid expressions.

Step2: Exploring Music and Drawing

The second step aimed to transition from visual to auditory expression, building upon the foundational connections established in Step 1. Teaching the science of sound often involves analyzing sound graphs and drawing graphs for specific sounds. Traditionally, this process lacks sensory experiences, creating a disconnect between science education and nature. Our workshop sought to bridge this gap by incorporating practical, sensory-based learning.

Figure 4

Students' Responses to Two Musical Pieces Are Shown Side by Side, Highlighting Shared Emotional Interpretations



Note. Transition from auditory to visual response as the first stage of learning the physics of sound. From "The impact of Art in STEAM on the willingness of girl students in STEM subjects" (p.62), by N.Mansouri, 2024.

We displayed images from Eric Carle's book *I See a Song* (1973) on the wall (see Figure 5) and asked students to guess the type of music that might have inspired each painting. This activity encouraged critical thinking about the relationship between sound and visual art, allowing students to express their interpretations through their own artwork. Students then revisited their paintings from Step 1, identifying which piece of music best matched each painting. This reverse translation of visual representations into audible experiences allowed students to explore the interplay between these sensory modalities.

By analyzing visual representations and matching them with corresponding musical pieces, students used critical thinking and reasoning skills. They considered elements such as colors, shapes, and composition, relating them to the characteristics of the music—tempo, rhythm, and mood. This exploration deepened their understanding of how emotions can be expressed and interpreted across different sensory modalities.

Figure 5

Transitions from Visual to Audible

Note: Students connected visual and auditory learning by identifying sounds that corresponded to paintings installed on the closet door. From “The impact of Art in STEAM on the willingness of girl students in STEM subjects” (p.66), by N.Mansouri, 2024

This hands-on activity exemplified the "Explore" stage by promoting active engagement and collaboration. Students not only developed a better understanding of the relationship between sound and visual art but also enhanced their ability to interpret and express emotions creatively.

Step3: Understanding Musical Instruments

The third step of the workshop involved discussing whether music consists of single sounds or a blend of sounds from different instruments. All students agreed that music comprises various individual sounds. This question piqued their curiosity and set the stage for exploring sound characteristics.

To illustrate this concept, we introduced a drum and a whistle, emphasizing their unique sound features. Additionally, we displayed simple musical instruments that produce one-tone sounds (see Figure 6). Students worked in groups of four to categorize these instruments into groups, such as drum-like or whistle-like sounds. Each group then shared their categories and discussed their reasoning.

Figure 6

Categorization of Drum and Whistle Instruments

Note. Students in two groups were asked to categorize musical instruments into two groups: drums and whistles. This categorization is based on frequency, and the aim of this activity is to focus on the variety of frequency as a sound characteristic. From “The impact of Art in STEAM on the willingness of girl students in STEM subjects” (p.70), by N.Mansouri, 2024.

This step aligned with the "Engage" and "Explore" stages of the 5E model. By considering whether music is composed of individual or blended sounds, students engaged in critical thinking and activated prior knowledge about music. The categorization activity encouraged exploration of sound qualities, fostering an understanding of sound frequency and intensity through active discussion and collaboration.

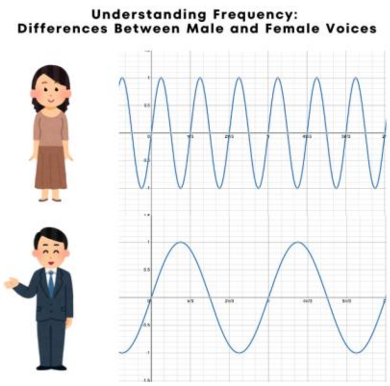
Step 4: Analysis and Drawing Sound Wave Graphs

The fourth step aimed to help students analyze and draw sound graphs using fundamental Physics principles. This required knowledge of frequency and intensity, which students had begun to develop in Step 3. Frequency was introduced through categorizing drum-like (low frequency) and whistle-like (high frequency) sounds. Intensity was defined as the "loudness" of a sound, based on students' everyday experiences.

Students analyzed existing sound graphs and practiced drawing sound wave graphs in the air for simple actions like tapping a drum. They also replicated sound graphs shown in Figures 7 and 8 to explore frequency and intensity further.

Figure 7

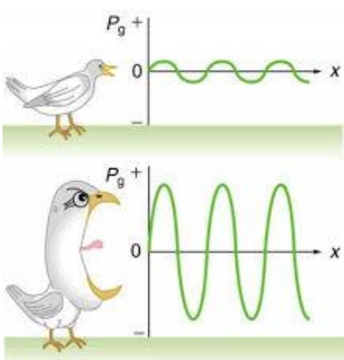
High Pitch and Low Pitch Sound Graphs



Note. Displaying the sound graphs of male and female voices as a real-life example helps illustrate the concept of frequency. Frequency is one of the key factors in sound graph analysis, playing a crucial role in understanding variations in pitch and tone.

Figure 8

Sounds Graph of the Same Sound Resources that Makes Two Different Intensities



Note. Adapted to illustrate intensity as a key factor in sound graphs and demonstrate the qualitative representation of high and low intensity. Adapted from "17.3: Sound Intensity and Sound Level," Lumen Learning, n.d. (https://courses.lumenlearning.com/suny-physics/chapter/17-3-sound-intensity-and-sound-level/)

Armed with this foundational knowledge, students selected four musical instruments from the earlier activity, played each one, and drew the corresponding sound graphs. This activity connected theoretical concepts to practical application, allowing students to visualize sound characteristics effectively.

Step 4 Responses

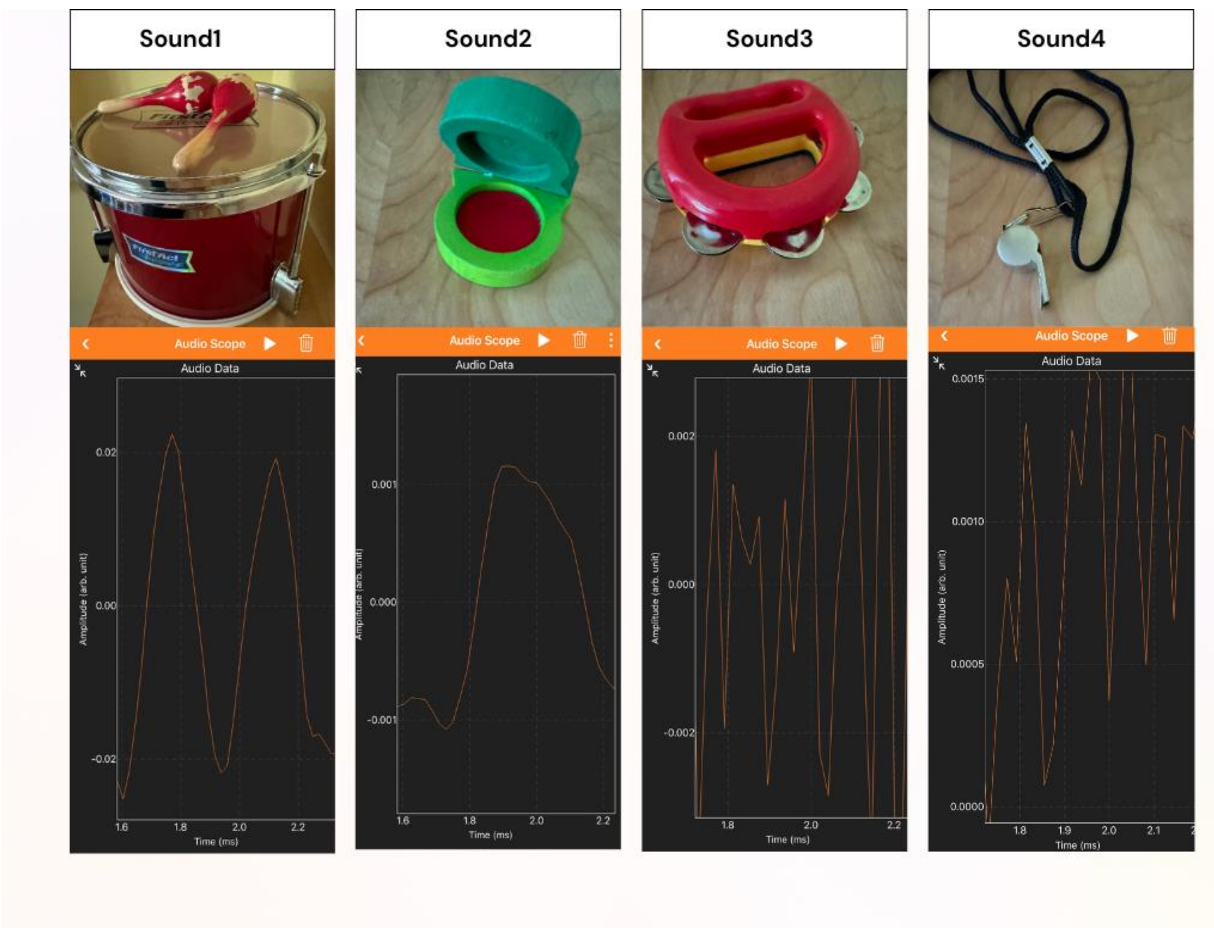
This step provided insights into two perspectives: learning the science of sound and transforming audible art experiences into visual representations by focusing on sound characteristics. Students demonstrated an understanding of frequency and amplitude by recognizing and accurately drawing sound graphs (see Figure 9). Comparing their graphs (see Figure 10) with those generated by the PhyPhox application revealed their grasp of sound properties.

For instance, focusing on frequency, the graphs drawn by one student for Sound 1 and Sound 2 (see Figure 11), illustrate a clear distinction between the two. Her graphs showed that Sound 1 had a longer period (T), which in physics has an inverse relationship with frequency, indicating that Sound 1 had a lower frequency than Sound 2. This observation was consistent with the results generated by the PhyPhox application, (see Figure 9) demonstrating her accurate understanding of the concept.

As another example of student graph analysis, focusing on amplitude, one student's graphs for Sound 3 and Sound 4 clearly illustrated the difference in amplitude (A) between the two sounds (see Figure 12). She supported her visual representations with simple yet meaningful written observations, such as "It is loud" and "It is like shaking." These comments reflected her intuitive understanding of amplitude as it relates to sound intensity. Her graphs accurately captured the variation in amplitude, which was also confirmed by the data from the PhyPhox application.

Figure 9

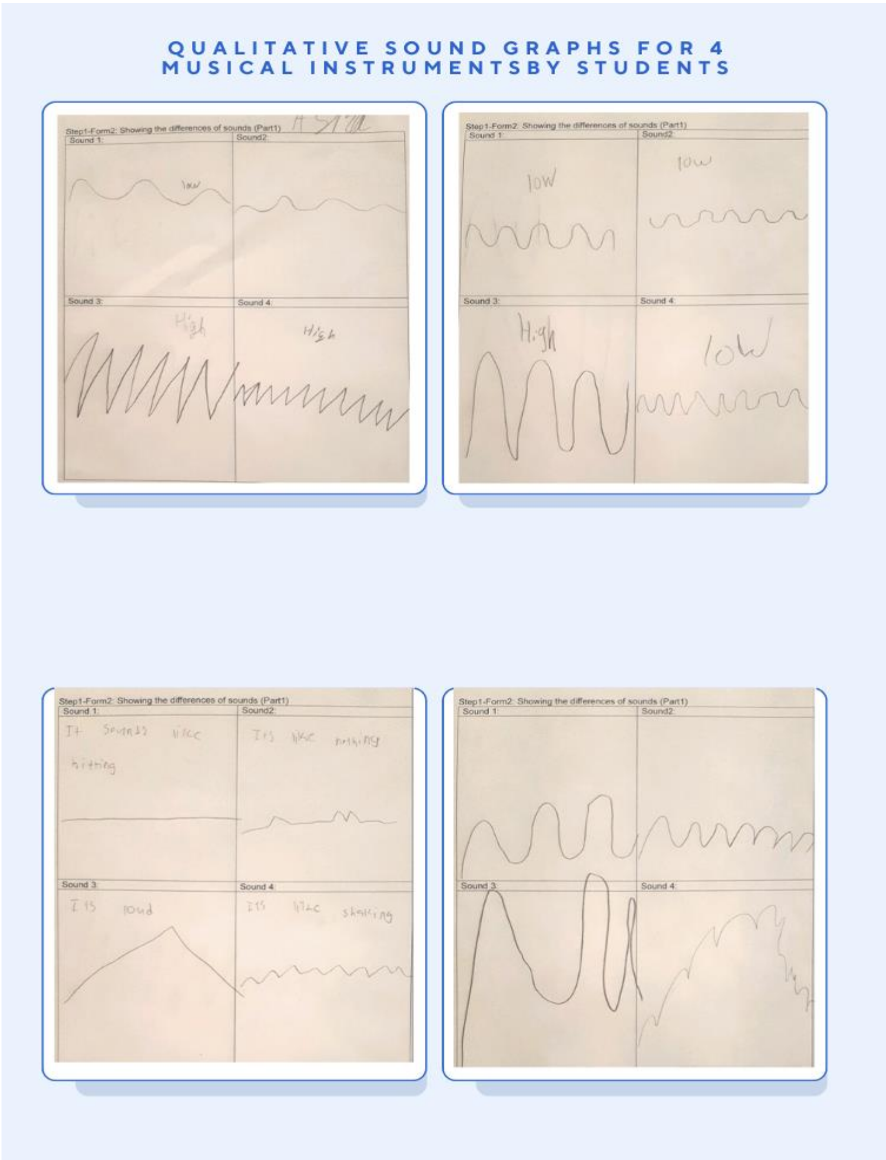
Four Musical Instruments that Played for Students and Their Sound Graphs With PhyPhox Application



Note. From "The impact of Art in STEAM on the willingness of girl students in STEM subjects" (p.82), by N.Mansouri, 2024.

Figure 10

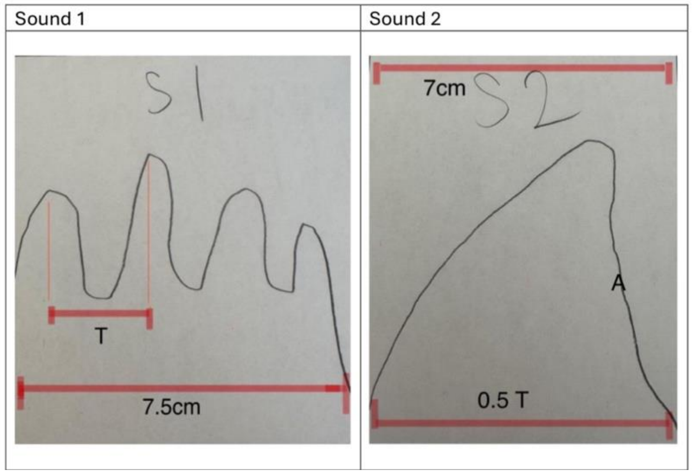
Sound Graphs by Workshop Participants for Sounds of Four Musical Instruments Played for Them



Note. Looking at the students' sound graphs and comparing them with the Phyphox sound graphs (Figure 9) shows that students were familiar with sound characteristics. They accurately identified the differences between the sounds they heard, paying attention to the rules of sound graphs. Although they didn't know the names or formulas in physics, they learned these concepts while playing games and expressing their feelings about the sounds. From "The impact of Art in STEAM on the willingness of girl students in STEM subjects" (p.83), by N.Mansouri, 2024.

Figure 11

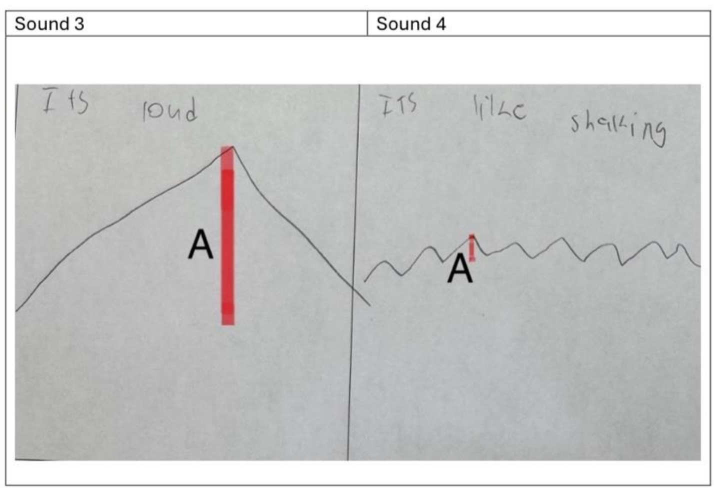
Sound Graphs by Workshop Participants for Sounds of Four Musical Instruments Played for Them.



Note. Sound graphs for Sound 1 and Sound 2, drawn by one of the participants. She represented three wave periods (T) within 7 cm for Sound 1, and half a wave period within 7.5 cm for Sound 2. This demonstrates her qualitative understanding of the difference in frequency between the two sounds, and her ability to express that difference through the visual representation of sound graphs.

Figure 12

Sound Graphs by Workshop Participants for Sounds of Four Musical Instruments Played for Them.



Note. Student's representation of amplitude differences between Sound 3 and Sound 4, supported by written reflections on loudness.

This activity exemplified the integration of art and science, achieving the goal of thetransdicsiplinary STEAM approach: to merge STEM and art as interconnected fields rather than separate disciplines. Students' accurate representations of sound graphs showcased their understanding of sound characteristics through an engaging, creative process.

Step5: Nature Walk and Sound Exploration

The final step of the workshop involved a nature walk, allowing students to apply their knowledge of sound in a real-world setting. During the walk, students actively listened to environmental sounds, strengthening their understanding of sound characteristics. In a quiet spot, they shared their auditory observations and illustrated sound wave graphs in the air using their fingers. For instance, they compared the sounds of a woodpecker and a sparrow and represented their differences through visualized sound waves (see Figure 13).

Figure 13

Students Tried to Illustrate the Sound Graphs With their Fingers

Note. From "The impact of Art in STEAM on the willingness of girl students in STEM subjects" (p.83), by N. Mansouri, 2024.

This step aligned with all five stages of the 5E instructional model—engaging students with real-world auditory experiences, exploring and explaining sound properties, elaborating on differences between sounds, and evaluating their understanding through collaborative discussions. The experience was further enriched by hands-on participation, as shown in Figure 13, where students engaged in the nature walk. By connecting theoretical knowledge to natural sounds, this activity reinforced scientific concepts in a meaningful and interactive way.

Discussion

This study aims to explore the role of the arts in a transdisciplinary STEAM lesson plan in promoting the engagement of female students in STEM.

This focus involves two key aspects: using transdisciplinary STEAM as a lens to approach science and addressing female students as the target group for engagement.

Integrating Art and STEM in STEAM Education: A Transdisciplinary Approach

A transdisciplinary STEAM approach, blends disciplines into a unified intellectual framework (Henriksen et al., 2022). Rather than treating Art and STEM as separate components, this approach intertwines them so that one cannot be fully understood without the other. Bedewy and Lavicza (2023) describe transdisciplinary learning as creating "a unity of intellectual frameworks beyond disciplinary perspectives" (p. 3). In this way, STEAM is no longer just a combination of subjects—it becomes a new way of thinking.

By shifting to a transdisciplinary STEAM perspective, the approach bridged the gap between a purely abstract scientific concept and a personally and emotionally resonant experience. Within this framework, the sound graph—typically used in physics to represent the measurable characteristics of sound—was reimagined through a new lens. Rather than treating it solely as a scientific representation of wave properties, the plan introduced the sound graph as a unique visual interpretation of each individual sound, effectively acting as a bridge between auditory and visual modalities. This reconceptualization informed the design of the first two steps of the plan. In these initial phases, explicit scientific content was not introduced; instead, students were invited to explore sound through art—first by translating what they heard into visual drawings, and then by interpreting visuals back into sound. The goal was to help students internalize the foundational idea that every sound can be "seen" through its unique visual form—a conceptual stepping stone toward understanding the scientific meaning of sound graphs later in the process.

The role of art continued to play a central role in Steps 3 and 4 of the plans**.** In these stages, sound characteristics were taught through two art-based games: first, by categorizing musical instruments based on their sounds, and second, by representing these categories visually on paper using qualitative criteria. While the underlying goal was to help students identify scientific properties such as amplitude and frequency through hands-on experiences, the activities were framed as artistic games that focused on enhancing auditory sensitivity and musical awareness. From a transdisciplinary perspective, this approach allowed students to explore scientific concepts organically, through playful engagement with the arts, rather than through direct instruction.

The transdisciplinary approach in the workshop plan led to the design of activities rooted in artistic structures but oriented toward scientific goals. In this framework, art and science were not treated as separate domains; rather, they were deeply intertwined in every activity. This integration was achieved by shifting the lens through which science was approached—specifically, by exploring the scientific concept of sound through the language and practices of the arts. As a result, each activity reflected a seamless fusion of disciplines, demonstrating how scientific understanding can emerge from artistic engagement.

Understanding the Target Audience: Engaging Female Students in STEAM

Research consistently highlights a persistent gender gap in STEM fields, with fewer women pursuing careers in physics, engineering, and technology. This disparity often begins in early childhood, where girls' interest in STEM subjects gradually declines due to a lack of engagement, confidence, or exposure to relatable and meaningful learning experiences. To address this issue, it was essential to design a workshop that built upon girls' strengths rather than reinforcing existing barriers.

Studies have shown that female students often demonstrate a stronger affinity for artistic expression compared to their male peers and further research indicates that girls tend to exhibit higher motivation and enthusiasm in art classes than in traditional STEM environments (Meece et al., 2006; Savoie, 2009; Wikberg, 2013, as cited in Lee et al., 2023, p.14). Drawing on these insights, the workshop was designed using a transdisciplinary STEAM approach, where art was not treated as a separate element but was deeply integrated into the exploration of scientific concepts.

The workshop spanned approximately eight hours and was conducted as a focused ethnographic study. Two cameras—one stationary and one portable—alongside photographic documentation and the participation of two experienced physics educators, were used to capture scientific and behavioral observations that could inform the analysis. While eight hours may seem a long duration for elementary students to engage with scientific content, the participants remained attentive and enthusiastic throughout the process. Their active participation in the final step—walking in nature, listening to sounds, and using their fingers to draw sound graphs of what they heard—demonstrated sustained engagement and enjoyment.

An analysis of the students' sound graphs (see Figures 10, 11, and 12) revealed a qualitative understanding of key sound characteristics. Their representations showed clear recognition of frequency and amplitude, as they translated auditory experiences into visual form. Compared to the British Columbia science curriculum, which introduces the analysis of sound graphs in Grade 11, these Grade 3 and 4 participants were able to grasp and demonstrate similar concepts—though in a qualitative way—at a significantly earlier stage.

Conclusion and Limitations

By integrating STEM and the arts through a transdisciplinary STEAM approach, this study takes a meaningful step toward making science more engaging and inclusive—particularly for female students. Traditionally, STEM fields have been perceived as technical and abstract, while the arts offer avenues for creativity, emotional expression, and personal connection. Bridging this divide through STEAM allows girls to explore scientific concepts in ways that align with their strengths and interests, fostering curiosity, confidence, and deeper engagement.

In this workshop, students learned to perceive sound graphs not merely as mathematical representations but as sensory experiences—connecting auditory and visual information through artistic expression. By exploring the characteristics of sound in nature and relating them to their own lived experiences, students developed a more intuitive and emotionally resonant understanding of scientific ideas.

This study illustrates how shifting from a traditional, discipline-based STEM model to a transdisciplinary STEAM approach can reduce the perceived disconnect between science and everyday life. It makes scientific concepts more accessible, meaningful, and relevant. By reframing physics education through the lens of STEAM, we can cultivate learning environments where all students—especially girls—feel empowered to explore, inquire, and form lasting connections with science.

However, this study is subject to several limitations. First, while the transdisciplinary approach proved effective for the topic of sound, it is important to acknowledge that not all STEM subjects are equally adaptable to this model. Some topics—particularly abstract areas in mathematics—may not lend themselves easily to transdisciplinary or arts-integrated methods and may require alternative approaches to maintain conceptual clarity.

Second, this research was conducted as a focused ethnographic observation within a short-term workshop involving a small number of participants. As a qualitative study, its findings are not intended for statistical generalization, prediction, or broad extrapolation. Rather, the study offers insights into how STEAM can be implemented in practice and opens pathways for further research and long-term exploration of its effects on diverse student populations.

Moreover, designing a STEAM lesson plan that aligns with the study's goals and the specific characteristics of the target group requires a tailored disciplinary focus. Developing diverse STEAM lesson plans using different disciplinary lenses—based on the unique needs and interests of various student populations—represents a promising direction for future research in STEAM curriculum design.

Finally, while this study contributes to understanding the underrepresentation of female students in STEM education, more reliable and generalizable conclusions can be drawn through large-scale, long-term quantitative studies. Such research would provide valuable data to assess the broader impact of transdisciplinary STEAM education on female participation and success in STEM fields.

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Corresponding Author Contact Information:

Author name: Narges Mansouri
Department: Education
University, Country: University of Victoria, Canada
Email:nmansouri@sd61.bc.ca

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