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Bridging Theory and Practice: Transforming STEM Keynote Presentations Through Experiential and Musical Engagement

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Abstract — This work-in-progress paper examines the educational impact of a keynote presentation delivered by Dr. Victor Hugo Minces at the California Association of Science Educators (CASE) Conference and explores its implications for engineering education. While experiential and hands-on learning are well-established as effective pedagogical strategies in STEM, such practices are seldom modeled in professional development events like keynotes, which typically favor lecture-based formats. In front of an audience of 500 educators, Dr. Minces transformed a conventional keynote into an interactive and immersive experience by guiding participants through collaborative sound-making activities using everyday objects.

Rooted in the *Listening to Waves* program—which introduces children to STEM concepts through music—the presentation integrated principles of sound, vibration, signal processing, and computer science. Participants experienced these STEM ideas through playful, embodied engagement, illustrating how artistic and multisensory approaches can make complex content more accessible and memorable.

Post-session survey data was collected to assess participant engagement and perceptions of the session’s educational value. Quantitative results indicated high intellectual engagement, while qualitative feedback emphasized the session’s interactivity, relevance, and enjoyment. This study contributes to the growing body of literature on multimodal learning, embodied cognition, and active STEM pedagogy.

Preliminary findings suggest that such experiential approaches can be successfully scaled to large-group settings, with potential applications in both K–12 and higher education. Future work will explore the longitudinal impact of music-based experiential learning strategies within engineering curricula.

Keywords—*experiential learning, interdisciplinary education, STEM engagement, engineering education*

I. INTRODUCTION

Keynote This innovative practice work-in-progress paper examines a keynote presentation and explores its implications for engineering education. Experiential and hands-on learning have long been recognized as effective strategies for increasing student engagement and improving STEM education outcomes

[1] [2]. However, traditional education conferences and professional development sessions often rely on passive, lecture-based formats that fail to model these best practices. The keynote by Dr. Victor Hugo Minces at the *California Association of Science Educators (CASE) Conference*, for an audience of 500 educators, incorporated interactive and musical elements to create an immersive learning experience. Survey data demonstrates the potential of interdisciplinary, hands-on approaches to enhance STEM learning and engagement.

Mince’s keynote transformed the conventional lecture into an experiential exploration of sound and vibration, in which the audience used everyday objects to explore the physics of sound and create music collectively. This approach is rooted in *Listening to Waves*, a program that engages children with STEM concepts through music. By integrating vibrations, sound, signal processing, and computer science into playful, hands-on activities supported by physical tools and app-based exploration, this approach fosters a deeper conceptual understanding of STEM topics [3]. The keynote provided participants with direct, embodied experiences of these principles, making complex ideas more accessible and memorable.

The use of music and hands-on engagement in STEM education is supported by research on multimodal learning, embodied cognition, and interdisciplinary teaching [4]. Studies show that integrating artistic elements into STEM instruction enhances conceptual understanding and retention by leveraging multiple learning modalities [5]. Additionally, active learning strategies, such as guided inquiry and experiential engagement, have been shown to improve student motivation and deepen comprehension, particularly in engineering and physics education [6]. It is not clear how these learning principles can be translated into large public events such as a keynote presentation.

To assess the effectiveness of the keynote, participants completed post-session surveys measuring their intellectual engagement. Quantitative findings indicate high levels of intellectual engagement, with most participants indicating that the presentation was ‘super interesting’. Qualitative responses indicated that participants appreciated the interactive, engaging,

and applicable nature of the presentation and its connections with music [7].

This innovative practice offers a model for integrating experiential, interdisciplinary methods into engineering education, with implications for K-12 and higher education. Conference participants can experience how creative, multimodal engagement can enhance STEM teaching, fostering deeper learning and greater accessibility. Future research will explore broader applications of music-based experiential learning in engineering curricula.

Keynote presentations, while often inspiring, tend to adopt a didactic format that prioritizes the unidirectional dissemination of information. Such approaches can inadvertently undermine the active learning principles they often seek to promote within the educational community, which have been shown to foster engagement, comprehension, and retention [8]. This disconnect raises an important question: How can large-scale presentations be reimagined to embody the principles of experiential, active learning?

Dr. Victor Hugo Mince's keynote presentation at the California Association of Science Educators (CASE) conference provides a compelling case study of this reimagining. By incorporating hands-on exploration and musical elements, the session invited participants to engage with STEM concepts in a communal and interactive setting. This aligns with Piaget's (1950) constructivist theory, which underscores the importance of active discovery in cognitive development [9]. Furthermore, the interdisciplinary approach of connecting STEM with music is supported by research emphasizing the benefits of integrating the arts in learning experiences [10].

The keynote presentation drew on the principles of *Listening to Waves*, a program designed to introduce children to concepts such as vibrations, sound, signal processing, and computer science through playful, hands-on methods. These methods resonate with Papert's constructionism, which advocates for learning through making and emphasizes the role of tangible, interactive tools in knowledge construction [11]. *Listening to Waves* creates hands-on activities, web applications, and curriculum for children to explore and playfully create sound, learning the STEM of waves through science and engineering practices. This approach has been shown to be successful in engaging children in science and improving teachers' attitudes toward the field [12][13][14][15].

This paper examines the design and impact of Dr. Mince's keynote presentation, situating it within the broader context of experiential learning, interdisciplinary education, and the integration of music into STEM. It highlights how the session not only conveyed educational content but also modeled an innovative approach to professional development, bridging the gap between pedagogical theory and practice.

II. DESCRIPTION

The presentation was by Dr. Victor Hugo Mince, who was joined at the stage by keyboard player Brody Hess. It took place in the context of the California Association of Science Educators (CASE) in Sacramento, CA, in 2024. It was the opening keynote address for an audience of approximately 500 educators, comprised of K12 science teachers and school administrators.

As the audience entered the auditorium, they were given a bag with several objects. Mince presented examples of how toddlers learn about the physical world through manipulating their senses, specifically, how a toddler can discover that plugging his ears dampens the volume of music. Mince also discussed how young children can enjoy playing and making music together, but that, in adults, these activities are reserved for proficient musicians. He stated that the goal of the presentation was to demonstrate that there were many fascinating sound-phenomena to be discovered by adults, and that adults could also enjoy making sound together even if they are not professional musicians.

Dr. Mince then guided the audience through a series of sound explorations using the objects in the audience's bags. In the spirit of the *Listening to Waves* educational program, the audience was told to explore freely how they could make sounds with the objects, then Mince guided them to manipulate the objects to make surprising sounds and then explained the physics behind the phenomena. The experiences were as follows: 1) Mince asked participants to pull out a rubber band from the bag and figure out what sounds they could make with it. After a moment, Mince demonstrated that by threading the rubber band around one's index finger, sticking the finger in one's ear, and plugging the rubber band, it makes sounds very similar to a stand-up bass (see figure 1). 2) Mince asked the audience to explore how to make sounds with a coffee stirrer, then showed them that by holding it between one's teeth and plucking it, it can make musical notes, the pitch of which depends on the length of the portion of the coffee stirrer that is sticking out from one's teeth (see figure 1), with longer lengths producing lower pitch sounds. Mince explained that larger and heavier objects tend to accelerate more slowly, thereby vibrate more slowly, and thereby create a lower pitch sound. He also noted that only the person holding the coffee stirrer between their teeth could hear the pitch, because the sound travels to their ears through bone conduction, therefore the person next to them was not able to hear the full sound. 3) Mince asked the audience to explore how to make sounds with a metal pipe and a mallet. Metal pipes make a very pure and sustained sound when they are held at the vibrational nodes, which are located at 22% of their length, and struck in the middle. Otherwise, they make a very short and pitch-less sound. When the audience explored the pipes, very few discovered how to make sustained, pitched sounds. Further, Mince made such a sound from the stage and asked the audience to figure out how they could do it. After a few minutes, Mince demonstrated how to hold the pipe by the node (see figure 1) and let the audience practice it with their own pipes. 4) Mince explained that for an object to make a sustained sound, it has to vibrate as freely as possible and guided the audience to hang the metal pipe on the vibrational nodes with the rubber bands, which are in turn hanging from the coffee stirrer (see figure 1). This produces a very long and sustained sound, which people often describe as beautiful. 5) The pipes were numbered and cut to different lengths. Mince asked the audience to compare the sounds of short vs. longer pipes, which, as is the case with the coffee stirrers, respectively produce higher and lower frequencies. He asked the audience to play pipes with the number 1, then number 2, then 3, 4, 5, 6, 7, and 8. This created a melody, since the pipes were cut to different lengths so as to play specific musical notes. As the audience played the

sequence, the keyboard player started playing. Further, Minces guided the audience to play rhythmically, accompanied by the keyboard, which started a sequence of musical moves composed by Hess. A video showing the composition, although in a different context than the keynote, can be seen here [12]. 6) Following the musical piece, Minces demonstrated *Listening to Waves* web applications and explained that, in the *Listening to Waves* curriculum, students undergo a similar sequence of exploration, surprise, and discussion. He further discussed that these experiences can also reach older children and adults, and how *Listening to Waves*' activities were successful for engaging children, and teachers, in STEM.



Fig. 1. Sound exploration activities. Clockwise. Putting a coffee stirrer between one's teeth and plucking it produces pitched sounds that only one can hear. Threading a rubber band between one's index finger, putting the finger in one's ear, and plucking the rubber band produces a standup bass-like sound. Holding a metal pipe at the nodes and striking it produces a sustained pure tone. Hanging the pipe with the rubber bands produces a very long, sustained sound. Images adapted from [12]

III. METHODS

The audience was invited to fill out a short survey, linked through a QR code, to understand their perception of the presentations. In a 7-point Likert scale, they indicated that “*I found the presentation:*” *Super Boring, Boring, Mildly Boring, Neutral, Mildly Interesting, Interesting, Super Interesting*.

To understand the participants' quantitative scores, the survey included an open-ended field asking “why?”. The responses were then analyzed by Claude, a generative artificial intelligence (AI) agent, which used natural language processing techniques to conduct a thematic content analysis of qualitative feedback data. The assistant detected meaningful semantic patterns in the text and established a set of semantic categories, which were then refined by these authors to reflect the focus of this research. These initial semantic fields were then used to systematically scan each response for the presence of relevant linguistic features.

The algorithm quantified theme frequency through binary classification of individual responses containing target semantic elements, rather than applying a simple word-frequency count. The analytical framework also incorporated co-occurrence analysis to identify meaningful thematic intersections by measuring the frequency with which different categorical elements appeared within the same textual unit. This revealed conceptual relationships between distinct thematic domains.

After the assistant analyzed the full list of responses and categorizations, the authors reviewed them to check for accuracy.

IV. RESULTS

257 participants completed the survey. The responses were coded from -3 to 3 along the Likert scale, with the average value being 2.47. The majority of participants rated the presentation as “super interesting”. The distribution of ratings can be seen in Figure 2.

Distribution of Ratings

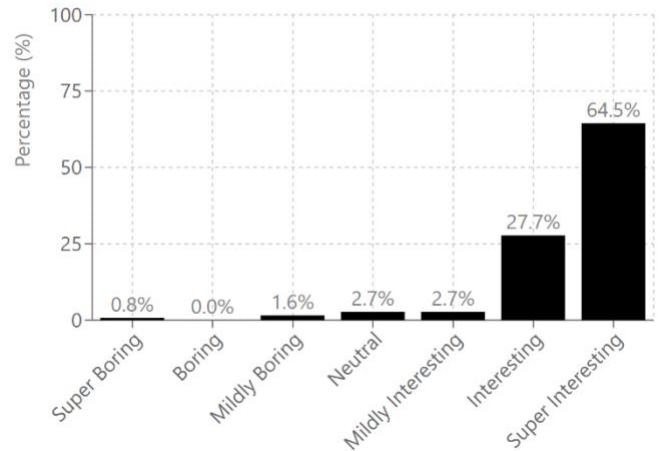


Fig. 2. Participants found the presentation intellectually engaging. This graph shows the distribution of the participants' survey responses evaluating their interest.

The analysis of open-ended responses revealed distinct patterns of engagement with the keynote presentation (See Table 1). The music/sound elements emerged as the predominant theme, appearing in 47.0% of all responses. Participants frequently expressed appreciation for the auditory experiences, collaborative music-making opportunities, and the sensory exploration of sound phenomena. This strong presence of music/sound references underscores how the artistic elements of the presentation created a compelling foundation for scientific exploration. The interactive aspects (28.7%) and engagement elements (27.1%), showed nearly equal importance to participants, suggesting that both hands-on participation and emotional/intellectual connection were valuable components of the learning experience.

The classroom applicability theme appeared in approximately one-quarter (24.3%) of all responses, demonstrating educators' focus on pedagogical implementation. Participants, particularly physics teachers, recognized direct applications for their instructional practices, with many specifically noting how the activities could help students understand abstract wave concepts in tangible ways. The science/physics connections, present in 21.1% of responses, often appeared alongside references to classroom applications (11.6% co-occurrence) and music elements (12.7% co-occurrence). This pattern suggests the presentation successfully bridged scientific principles with artistic expression in a way that teachers found pedagogically valuable.

The less frequently mentioned but still significant themes revealed additional dimensions of the experience. References to curiosity and wonder (11.2%) highlighted the presentation's ability to spark inquiring minds and promote deeper exploration. The accessibility of everyday materials (10.8%) was appreciated for making implementation feasible across diverse educational settings and resource levels. Perhaps most notably, the community and collaboration aspects (9.2%), while appearing less frequently in the data, represented some of the most emotionally resonant responses, with participants describing the collective music-making as "beautiful," "unifying," and "a humane moment."

The analysis of thematic co-occurrences revealed significant relationships between conceptual categories in the feedback data. The strongest connection emerged between music/sound and science/physics elements (12.7%), indicating participants valued how the presentation integrated artistic expression with scientific principles. This was closely followed by the relationship between music/sound and classroom application (12.0%), and between classroom application and science/physics (11.6%), demonstrating educators' recognition of pedagogical opportunities at these intersections. The music/sound theme also showed meaningful connections with engagement (10.8%) and interactive elements (7.6%), suggesting the auditory experiences contributed substantially to both emotional investment and hands-on participation. The engagement and classroom application co-occurrence (7.6%) further highlighted how teachers envisioned student emotional involvement in these activities. Additional notable intersections included music/sound with community aspects (6.8%), interactive elements with classroom applications (6.4%), and music/sound with both curiosity (6.0%) and everyday materials (6.0%). These cross-category relationships paint a multidimensional picture of the experience, where the artistic elements of sound and music serve as the central connecting point that bridges scientific concepts, pedagogical applications, emotional engagement, participatory experiences, and communal interactions.

TABLE I. SEMANTIC CATEGORIES CAPTURED IN THE OPEN QUESTION OF THE SURVEY, ASKING PARTICIPANTS WHY THEY CHOSE THEIR QUANTITATIVE RESPONSE.

Category	Percentage	Examples
Music/Sound	47.00%	-It was great to see, and hear a room full of educators make music - I loved being physically and aurally engaged with science and music -Playing music with a group was amazing!
Interactive	28.70%	-Very interactive and brought great ideas on how to engage students -It was interactive. Better than just sitting listening to a lecture -The interactive nature of the presentation and the music really brings you in
Engagement	27.10%	-Really engaging, fun, and connects to the NGSS performance expectations! -Super engaging and provided experiments to visually and hear sounds -Very engaging and great at sparking interest

Classroom Application	24.30%	-I got to explore, and I teach waves/sound to my 8th graders and got a lot of cool ideas -I teach 8 th grade and waves are hard to teach kids to get engaged -I will absolutely take what was presented today and apply it at the county office I work at
Science/ Physics Connection	21.10%	-I was fascinating to see how the matching of the hand changed the pitch of the sound -Everyday objects can make for deep science -Being able to teach about waves, frequency, and pitch with really simple things
Curiosity/ Wonder	11.20%	-Fun trying out sounds and wondering why other pipes made different sounds -Engaging with the science of sound sparks curiosity to everyone! -Created a lot of wonderment and questions to be asked
Everyday Materials	10.80%	-I loved being able to try the simple sounds with everyday object -Materials were easily purchasable and usable by all grade levels and economic statuses -Music from everyday objects. Great blend of art, science, and exploration
Community/ Collaboration	9.20%	-The feeling of community and love while we all created music together -Playing music with a group was amazing! -So much engagement and working together! A great community event for the opening keynote

V. DISCUSSION

The results from this analysis offer insights into what makes for an effective science education keynote presentation. The predominance of music/sound elements in participant feedback, combined with high mentions of interactive components and engagement, suggests that multisensory, participatory approaches resonate strongly with educator audiences. Traditional keynote presentations often rely heavily on visual slides and spoken content. Yet, this analysis indicates that incorporating hands-on activities and collaborative experiences can significantly enhance the impact of the session. The strong co-occurrence between music/sound and science concepts demonstrates how artistic elements can serve as vehicles for conveying complex scientific principles, making abstract concepts like wave physics more accessible and engaging.

The significant presence of classroom application themes indicates that science teacher audiences clearly value presentations that provide concrete strategies they can implement in their teaching contexts. The high co-occurrence of classroom applications with both science content and music elements indicates the teachers' appreciation of arts and science integration. Keynote organizers should note that presentations achieving this balance between content knowledge, pedagogical application, and engaging delivery appear to generate the most enthusiastic responses from educator audiences.

It is noteworthy how the community/collaboration theme, while mentioned less frequently, generated some of the most emotionally resonant feedback. This suggests that keynote

presentations can do more than transmit information—they can build community and create shared experiences. The co-occurrence of music/sound with community aspects points to how collaborative activities can transform a roomful of individuals into a connected learning community, even within the typically passive keynote format. A subsequent workshop presented at the Constructionism Conference 2025 support these findings and how they might translate to a classroom setting [16]. Science education keynotes might therefore benefit from incorporating elements that foster connection among participants, not merely as an engagement strategy but as a way of modeling the collaborative nature of scientific inquiry.

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