BOARD # 379: IMPROVING TEACHERS' ATTITUDES TOWARD PHYSICS BY INTEGRATING MUSIC IN ONLINE AND IN-PERSON PROFESSIONAL DEVELOPMENT. AN ITEST STUDY.

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Abstract

In recent years, the use of virtual meetings in work settings has dramatically increased, and society has become more open to having large online meetings. This has expanded the possibilities of reaching and training teachers nationwide through online professional development. This expansion calls for a more thorough understanding of the effectiveness of online training. Building on previous research demonstrating the positive effects of music-centered PD on teachers' perceptions of teaching the physics of sound and waves, we examine the comparative effectiveness of in-person and online PD modalities. The study utilizes a curriculum developed by our team, emphasizing hands-on and browser-based applications that allow teachers and students to playfully explore and create sound. Surveys conducted before, after, and following the classroom implementation of the curriculum assessed changes in teachers' enjoyment, confidence, and content knowledge related to teaching science, physics, and sound. Results from 79 participating teachers, including 46 in virtual and 33 in-person workshops, reveal no significant differences in effectiveness between the two formats. Both modalities resulted in significant improvements in teachers' attitudes. Teachers highlighted the value of well-organized resources, such as Google Slides with video tutorials, teaching tips, and structured lesson plans, which enhanced the ease of classroom implementation. These findings suggest that PD programs integrating music and science are equally effective across modalities and benefit significantly from teacher-friendly resource design. This study contributes to the ongoing evaluation of online and in-person PD, offering insights for designing impactful educational experiences. This work was funded by NSF's Innovative Technology Experiences for Students and Teachers (ITEST).

1. Introduction

Professional development (PD) is an essential tool for equipping teachers with the knowledge and skills necessary to foster student learning and engagement. With the rapid advancements in technology and the increasing normalization of virtual meetings, online professional development (OPD) [1], [2] has become a viable and often preferred alternative to traditional in-person PD. OPD offers unique advantages, such as accessibility for teachers in remote and rural areas, scalability for nationwide implementation, and flexibility in scheduling. The expansion of virtual meetings in recent years has not been accompanied by a commensurate increase in research and evaluation of OPT, particularly considering that virtual meeting technology has been rapidly evolving. Fundamental questions regarding OPD are how its effectiveness compares with in-person PD and what adaptations are necessary to make it effective. Studies addressing the first question have been few and have mixed results, and the strategies for success have not been thoroughly discussed [3], [4], [5], [6], [7]. In this paper, we report on our experience offering virtual and in-person PD for *Listening to Waves*, a program that seeks to engage children in science through the connections with music.

Listening to Waves has developed browser-based applications that replicate standard tools used in STEM labs, such as a signal generator, a spectrogram, and an oscilloscope, and modified them so children can interact with them playfully. *Listening to Waves* has also created a standards-aligned eighth-grade curriculum centered on the applications and including physical hands-on activities. Through *Listening to Waves*, children learn the physics of waves and the basics of signal processing. The program has been shown to increase children's interest in STEM [8], and a PD experience centered on the resources has been shown to improve teachers' attitudes toward sound and waves [9].

Feedback from previous teacher participants revealed that the resources provided were too many and not clearly organized, which degraded the fidelity of classroom implementation, particularly considering that classroom implementation often occurred several months after the training sessions. Therefore, for this round of training, we refined the curriculum, narrowing the scope of activities to focus on those that children found more engaging. The increased focus allowed us to organize the resources into a streamlined learning sequence and facilitate its implementation by providing Google Slides so teachers could use them directly in their classrooms. The slide decks include teacher-facing video resources in which we thoroughly explained the scientific concepts, teaching-tips, and recommended teaching practices. The learning sequence consists of ten lessons centered on the question of 'how are sounds combined to create music,' in which children explore how sound is created, how it travels, and how it is measured and transformed through technology. Each lesson includes moments of free exploration, guided focused exploration, and collective discussion. All the resources, including the web applications and the Google Slides, are publicly available at *Listeningtowaves.com*.

2. Methods

Both workshop modalities were six hours long. The in-person workshop was a one-day experience, while the virtual workshop consisted of three two-hour sessions. In these sessions, teachers experienced the curriculum as learners and took a deep dive into the subject matter. We conducted a survey study to evaluate whether there were changes in teachers' attitudes toward science, life science, physics, and sound and to what extent the changes vary by workshop format (in-person vs. virtual). Teachers completed the surveys before the workshop, after the workshop, and after teaching the curriculum. The surveys included six-point Likert scale items (1-strongly disagree; 2- disagree; 3- somewhat disagree; 4-somewhat agree; 5-agree; and 6-strongly agree), designed to measure teachers' enjoyment, confidence and content knowledge of teaching science, physics, and sound, as well as their perception of their students' enjoyment of learning sounds. For each category, surveys included open-ended questions asking them to justify their responses. The items can be seen on Table 1.

3. Results

A total of 79 teachers completed at least one of the three surveys (pre-workshop, post-workshop, and post-teaching surveys). Most teachers had taught the topic of waves or sound before (66 out of 79 teachers). More than half of the teachers (46 out of 79) participated in the virtual workshop. Among the 79 teachers, 67 answered both the pre and post-workshop surveys (27 teachers in the in-person cohort and 40 teachers in the virtual cohort), and 32 teachers answered

both the pre-workshop and post-teaching surveys (16 in-person and 16 virtual). Figure 1 shows the average scores for each cohort (in-person cohort and virtual cohort) and time points. Using a two-sample t-test analysis, We found no significant difference between in-person and virtual cohorts across any time point (pre-workshop vs. post-workshop and pre-workshop vs. post-teaching). Because there were no differences, we combined these groups to analyze the effect of workshop participation. For this, we ran paired t-tests for the teachers who completed all surveys. We run a paired t-test comparing surveys before and after the workshop, and another comparing surveys before the workshop and after teaching. Significant results can be seen in Figure 1. Compared to pre-workshop responses, teachers' enjoyment, confidence, and content knowledge of teaching sound significantly improved after the workshop. Their confidence and content knowledge of teaching science and physics significantly improved after the workshop. In addition, their content knowledge of teaching life science also improved after the workshop. Figure 1 shows the average results and statistical significance for the teachers who completed the surveys on items related to attitudes toward science, physics, and sounds.

	Before Workshop	**After Workshop**	**After Teaching**
Enjoyment	Teaching sound makes me cheerful.	After this workshop, I feel that teaching sound will make me cheerful.	During the unit, teaching sound made me cheerful
Confidence	I feel confident teaching about science.	After this workshop, I feel confident teaching about science.	I feel confident teaching about science.
	I feel confident teaching about physics.	After this workshop, I feel confident teaching about physics.	I feel confident teaching about physics.
	I feel confident teaching about sound.	After this workshop, I feel confident teaching about sound.	I feel confident teaching about sound.
Content Knowledge	I have enough content knowledge to teach science.	I have enough content knowledge to teach science.	I have enough content knowledge to teach science.
	I have enough content knowledge to teach physics.	I have enough content knowledge to teach physics.	I have enough content knowledge to teach physics.
	I have enough content knowledge to teach sound.	I have enough content knowledge to teach sound.	I have enough content knowledge to teach sound.
Perception of students' enjoyment	In my past experience, students have enjoyed learning about sound.	I think students will enjoy learning about sound.	I think students enjoyed learning about sound.

Table l. Survey items.

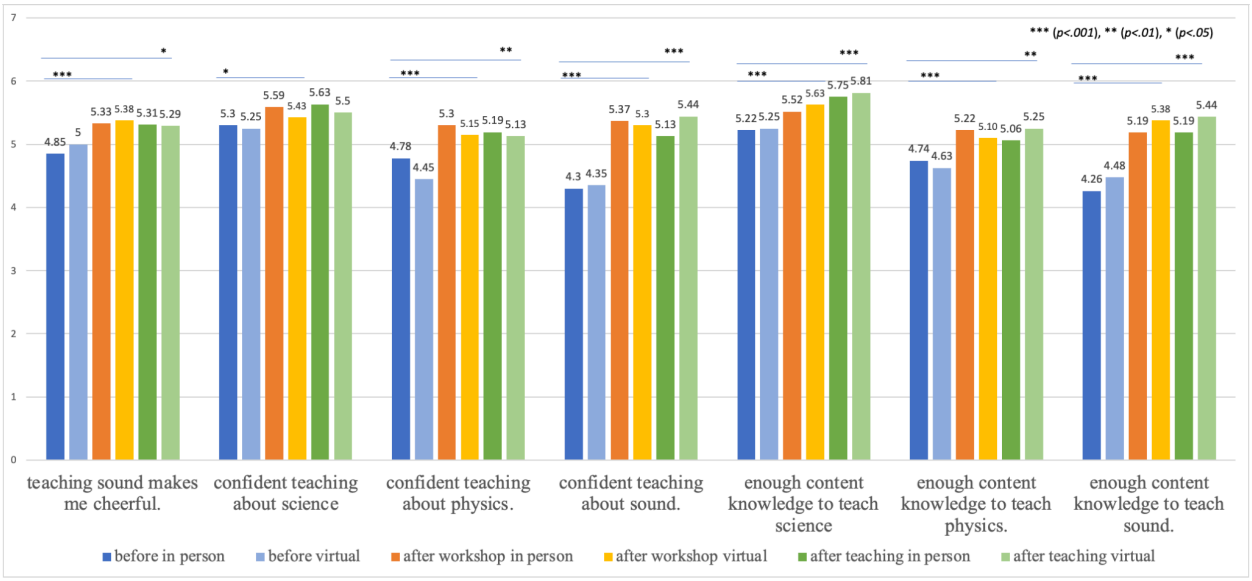

Figure 1. Participating in the virtual or in-person workshop connecting music with the science of sound and waves improves teachers' attitudes toward the subject: Average survey scores across three measuring points, before the workshop, after the workshop, and after teaching the materials in their classrooms.

Teachers reported that the Science of Music workshop is more enjoyable (mean= 4.84 vs. mean= 5.59) and useful (mean= 4.85 vs. mean=5.60) than their past science teaching workshops. After the workshop, teachers tended to show a strong agreement (mean=5.10) with the statement, "After this workshop, I learned practices I can use in other lessons that I teach." and a strong agreement (mean=5.50) that "I would recommend other teachers to take this workshop."After teaching, they tended to strongly agree that their students were more engaged in learning about sound (mean=5.48), developed a better understanding of sound (mean=5.63), and did better in the assessments about sound (mean=5.42).

The qualitative open-ended teacher responses indicate that a contributing factor to the overall effectiveness of the workshop was the helpfulness of the teaching materials and resources, such as the slides. Most teachers overall appreciated the resources' ease of use and organization. Teachers praised the teaching materials for being well-organized, easy to navigate, and visually clear. Features such as color-coded tips, boxed ideas, and structured lesson flow were particularly appreciated due to their accessibility. For instance, one teacher emphasized:

> *"I felt the curriculum was very organized and easy to follow. I loved how the slides were easy to read and not crammed with information. The color coding of the teacher's suggestions and tips, plus the shading and boxing of main points and ideas made it all very easy on the eyes."*

Another teacher similarly echoed, "The curriculum was very well organized and easy to use. All information and supports required were easily accessible and I particularly liked that teaching tips were provided. This all really helped with curriculum planning time."

Additionally, teachers also appreciated the comprehensive support offered by the materials. Teachers felt the curriculum provided all the necessary components, such as slides and plans, to teach effectively – even for teachers newer to the subject. One teacher particularly expressed, "If

I was a newer teacher I would have found more of that to be useful…I think there is huge value in including it and having those resources available." Another teacher mentioned, "I appreciate how… detailed the lesson plans and slides are for us. It was nice to be able to experience some of the activities also."

Overall, most teachers considered the materials highly effective, particularly due to the organization of the materials, as well as the depth and detail afforded by the resources.

4. Conclusion

This study highlights the transformative potential of integrating music into professional development programs to enhance teachers' attitudes toward teaching physics. By comparing in-person and virtual PD formats, our findings reveal that both modalities are equally effective in fostering teacher confidence, enjoyment, and content knowledge. A key factor contributing to this success is the thoughtful design and organization of teaching materials, which support seamless classroom implementation. This work contributes to the growing body of literature advocating for innovative and inclusive approaches to teacher training, fostering a deeper appreciation for science among educators and their students.

Acknowledgments

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