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Abstract

Culturally responsive content, accessible and inclusive tools, and meaningful interdisciplinary tasks can aid in developing equitable and creative learning environments. Music and mathematics are ideal disciplines for interdisciplinary creative learning. In this article, we reflect on our experiences engaging in interdisciplinary music and mathematics tasks with preservice teachers. In particular, we highlight specific efforts taken to design and implement a creative music and mathematics workshop for use in a mathematics methods course. Guided by these experiences, we offer examples of tools and practices that have helped preservice teachers collaborate, engage in inquiry, improvise, develop empathy, and take intellectual and social risks while building musical and mathematical skills, knowledge, and confidence.

Keywords

music, mathematics, inclusive learning, culturally responsive learning, teacher education, creativity

Cover Page Footnote

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Creative Learning with Music and Mathematics: Reflections on Interdisciplinary Collaborations

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Based on experiences with traditional curricula and education systems, teachers often believe that teachers and students cannot engage in creative tasks in content areas they do not specialize in (Dogani, 2008; LaJevic, 2013), or that some content areas are inherently uncreative (Bolden et al., 2010). Music and mathematics are two disciplines that have reputations for requiring specialized training to unlock creative potential; therefore, teachers might think they need to be experts in both disciplines before they can design and implement interdisciplinary tasks that bridge them. If teachers lack expertise or confidence to engage with both disciplines, they might avoid interdisciplinary tasks in STEAM (science, technology, engineering, arts, and mathematics) contexts that promote an accessible and inclusive, creative learning environment.

To ensure teachers have the skills and confidence to engage in interdisciplinary STEAM learning, teacher education and in-service professional development must provide opportunities to explore meaningful and relevant interdisciplinary connections in music and mathematics. These opportunities can demonstrate how music and mathematics can be made accessible, inclusive, and equitable when presented through collaborative inquiry in interdisciplinary (LaJevic, 2013; Longo & Gates, 2021) and culturally responsive (Gay, 2002; Ladson-Billings, 1995) projects. In such contexts, teachers can share power and learn with students, modeling collaboration, curiosity, open-mindedness, empathy, and intellectual and social risk-taking.

In this article we share how teacher education and P–12 education can cultivate inquiry, improvisation, empathy, and risk-taking in interdisciplinary learning. Too often, traditional schools teach content areas in isolation from each other, obscuring opportunities for interdisciplinary learning. Teachers must take the initiative to collaborate across content areas, so teacher education must equip them with the training and tools to do so. With interdisciplinary STEAM learning opportunities, teachers and their students can see themselves as collaborators, problem finders and solvers, and stakeholders in an interdisciplinary and interconnected world. Luria et al. (2017) suggest that collaborative risk-taking by students and teachers challenges personal and task-related stereotypes and builds confidence to explore new ideas. The arts (Chappell & Cahnmann-Taylor, 2013; LaJevic, 2013; Rinkevich, 2011; Rufo, 2013), music (Custodero, 2002; Huang, 2020; Longo & Gates, 2021), and mathematics (Boaler, 2016; Papert, 1980) can inspire inquiry, improvisation, empathy, and risk-taking as students build skills, knowledge, and confidence through creative exploration and co-creation with teachers and peers.

Preparing Preservice Teachers with Creative Music and Mathematics Tasks

As teacher educators specializing in music and mathematics, respectively, we aim to model instructional practices and beliefs we hope our preservice teachers will employ with their future students. We encourage collaboration, curiosity, open-mindedness, empathy, and risk-taking when attempting new skills. Our experience working with each other and other colleagues to lead interdisciplinary learning demonstrates how collaboration between teachers of different disciplines can be both efficient and effective. For example, the courses we teach for preservice teachers incorporate ideas and methods from our colleagues that specialize in visual art and science. In our courses, we stress

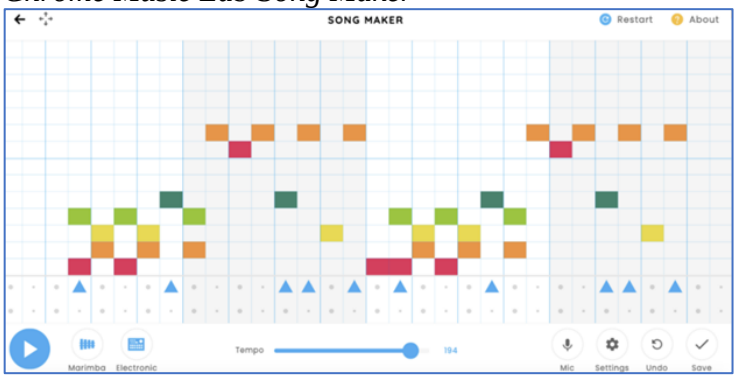
that preservice teachers do not need to be experts in a particular content area before they can teach lessons in that content area. In fact, if they are comfortable with improvisation and learning alongside their students or allowing a collaborator to take the lead in places where they are developing their expertise, they can lead lessons in new content areas with minimal preparation outside the time they normally spend preparing lessons. When preservice teachers try something new and are open about it with their students, and when they share power with others who might be equally or more knowledgeable in a particular domain, they model instructional practices and beliefs that can inspire and empower students to do the same. Thus, we encourage our preservice teachers to engage in creative music and mathematics learning opportunities so they can collaborate and develop accessible and inclusive tools to work with. Through participation in culturally responsive STEAM tasks, they can overcome anxiety related to self-doubt about their music and mathematics abilities and build creative music and mathematics skills and knowledge they can pass on to their students.

Tools for Fostering Creative Learning

Both traditional musical instruments and new music technology can give students choices of different modes of expression. When students learn traditional musical instruments, those instruments can reflect their interests, experiences, and cultural backgrounds. For example, students in some neighborhoods of New York City might choose to study Latin percussion instruments because they are prominent in the music they hear in everyday contexts. Virtual and electronic instruments can be adapted to student needs and interests. Some of the virtual and electronic tools we recommend are Chrome Music Lab (see Figure 1), which is online and free, and Makey Makey (see Figure 2), which can be ordered online at https://makeymakey.com/ for roughly $50. Chrome Music Lab, available at https://musiclab.chromeexperiments.com/, provides a variety of virtual instruments and applications that invite intuitive exploration and improvisation. Makey Makey connects a virtual musical instrument on a computer with any object that conducts electricity. Using tools like these, students can find the right level of challenge and take an active role designing musical instruments, improvising, and composing. When students choose a musical instrument, whether traditional, electronic, or virtual, their musical instruments become extensions of their bodies (Nijs et al., 2013) and objects-to-think-with (Papert, 1980; Rosenbaum, 2015), thereby encouraging them to see relationships between themselves and the world in which they live.

Figure 1

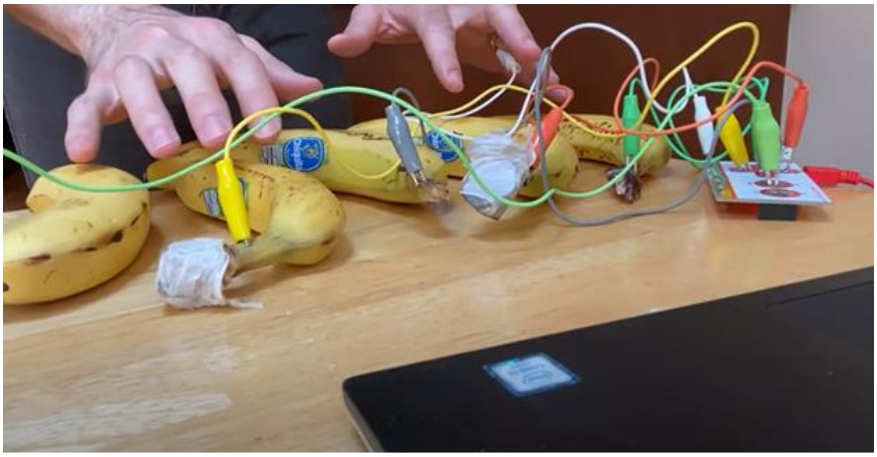
Chrome Music Lab Song Maker



Note. This piece, composed by a preservice teacher during a workshop on culturally responsive music and mathematics tasks, shows pitches and percussive sounds on a coordinate plane with time on the x-axis and pitch on the y-axis.

Figure 2

Makey Makey Banana Piano

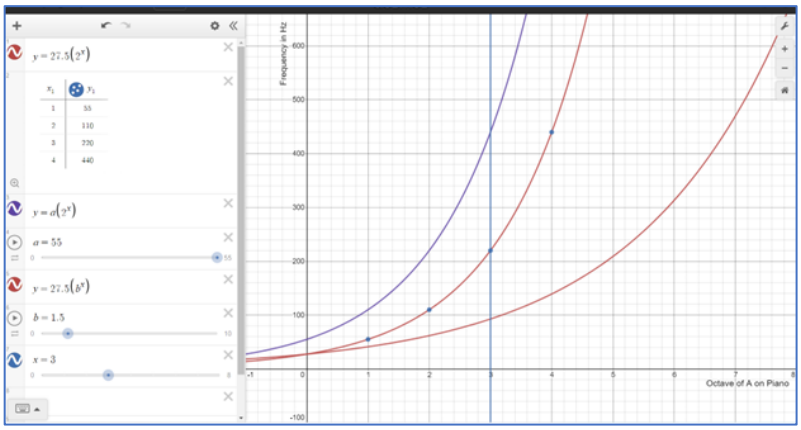


Note. The laptop, USB cable, Makey Makey circuit board, and alligator clips connecting the Makey Makey to bananas comprise an instrument that has physical and virtual components.

Just as there are tools we can use to make music more accessible and inclusive, there are tools that we can use to make mathematics more accessible and inclusive as well. An example of such a tool is the Desmos Graphing Calculator, which is free and available at https://www.desmos.com/calculator . This tool allows for the creation of interactive graphs that can be used to model concepts. For example, we created a graph of the frequencies on a piano, where frequencies, measured in hertz, appear on the y-axis and the octave number for each "A" on the piano (ranging from 0 to 8) appears on the x-axis (see Figure 3). If we changed the x-axis to time, we could plot points on the coordinate plane to represent pitches played over time and create a graphical musical composition. This is similar to the grid on Chrome Music Lab Song Maker, which places pitch on the y-axis and time on the x-axis. Tools like the Desmos Graphing Calculator make mathematics more accessible and inclusive by allowing students to experiment with different functions, variables, and values and see how graphs change as different parameters change. They can also customize the colors, labels, animations, and other aspects of their graphs' appearance, all without needing to buy an expensive graphing calculator.

Figure 3

Desmos Graph



Preservice Teachers in a Creative Music and Mathematics Workshop

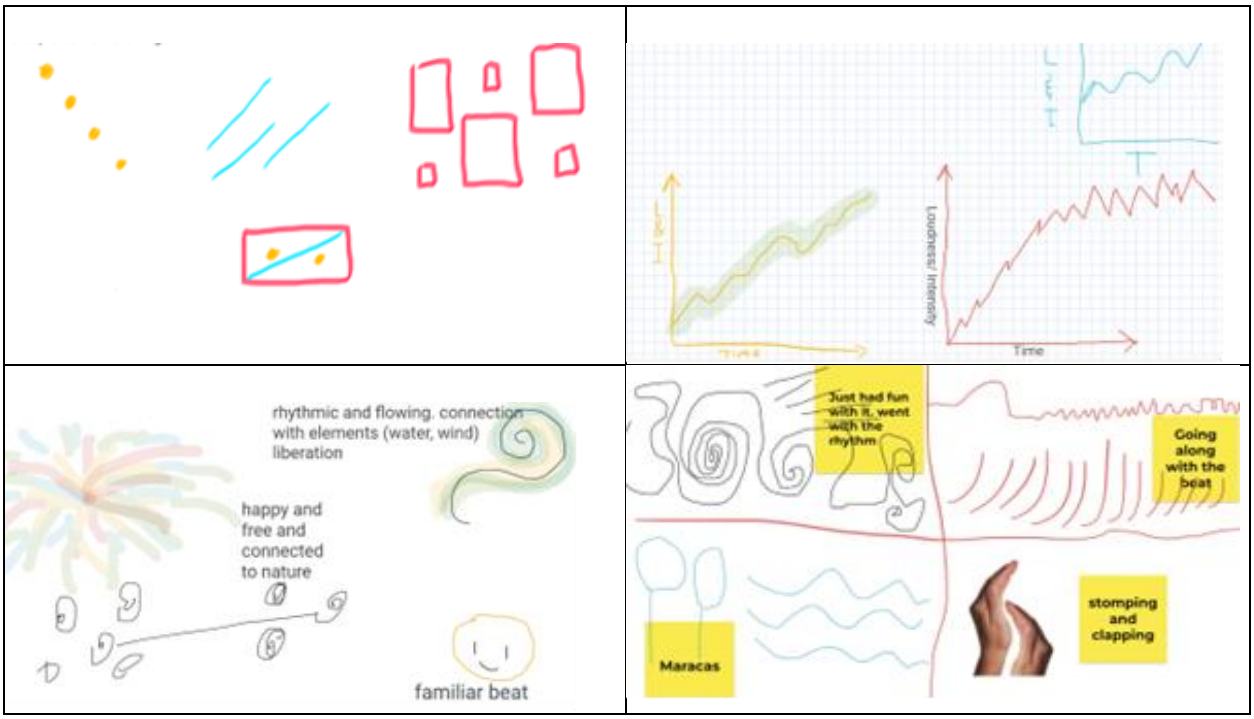
In the fall of 2021, we led an hour-long workshop for preservice teachers on culturally responsive, interdisciplinary music and mathematics tasks. Despite expressing some anxiety about music and/or mathematics before engaging in the workshop, preservice teachers collaboratively created music and graphs, participated in discussions that allowed them to express themselves and their ideas, and, after the workshop, shared that they felt more confident engaging in integrated music and mathematics tasks (see Johnson & Moldavan, 2022).

A highlight of this workshop was collaborative musical improvisation on traditional and virtual musical instruments, including virtual instruments found on Chrome Music Lab. When improvising together, even students with relatively low levels of experience or skill can generate ideas that are novel and interesting to the group. We have experienced this phenomenon when teaching music and mathematics. Sweller (2011) explains how the "randomness as genesis principle" (p. 43) underlies the creation of novel information, including evolution by natural selection and the problem-solving process in human cognition. As people improvise music together, especially in new contexts, they will both randomly and intentionally come up with musical ideas that they find pleasing and choose to repeat. Reflecting on their collaborative musical improvisation experience in a post-survey, preservice teachers in our workshop commented, "It was enjoyable, fun to make noise, [and] fun to try to collaborate with my colleagues," and "Everyone added an important part to our class's composition."

Through experiences listening to and creating music in a collaborative learning environment, preservice teachers might realize what jazz pianist and composer Vijay Iyer (2002) notes is universal and affirmed by neuropsychological studies: "musical phenomena might evoke the dynamic swells associated with breathing, the steady pulse associated with walking, and the rapid rhythmic figurations associated with speech" (p. 392). In the process of explaining their responses to a music video using mathematics, pictures, words, and improvised music, preservice teachers made connections with their embodied musical and mathematical experiences and cultural backgrounds (see Figure 4).They also notated their own musical compositions on graphs (see Figure 5). Reflecting on this experience in a post-survey, a preservice teacher in our workshop commented, "I was surprised at how much fun it could be to learn about math through the lens of music." Another preservice teacher commented that the idea of having students "make their own beats and incorporate math into [them] is very exciting," and went on to say, "I found the connection between written music and graphs to be mind-blowing and never thought of music like that before."

Figure 4

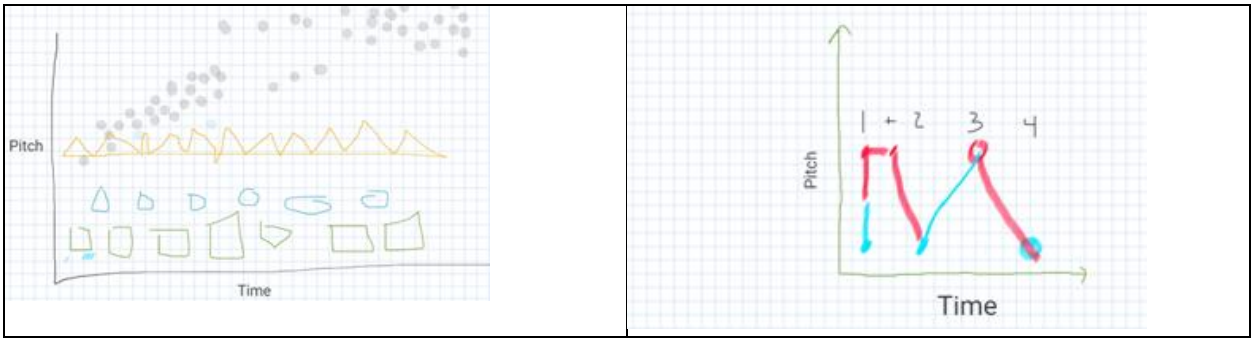
Workshop Participants' Responses to Watching a Music Video



Note. The graphs show changes in the music over time and the drawings illustrate various aspects of music listening experiences.

Figure 5

Workshop Participants' Compositions Notated on Graphs



Note. Graphs could include symbols and axes labeled with any parameters that make sense to the composer, including time, pitch, or loudness.

Process Over Product

The examples of the preservice teachers' work in the previous section show that preservice teachers and, in turn, their students, can engage in creative and culturally responsive music and mathematics tasks without specialized training. They showed genuine curiosity and open-mindedness as they took risks trying tasks that were new to them. They also supported each other to improvise and

compose music, drawing on their background knowledge and experiences. The tools they used, such as Chrome Music Lab, allowed them to create intuitively. The song they played along with, Lido Pimienta's "Eso Que Tú Haces," exemplified culturally responsive content in our workshop setting. We chose this song because we expected its contemporary pop sound would appeal to our preservice teachers, its familiar harmonies and steady moderate tempo would encourage musicians with various levels of experience to follow along, and its incorporation of a variety of cultural influences might spark our preservice teachers' curiosity or inspire them to find connections. Thus, the tools and content of the workshop made music and mathematics learning accessible and inclusive, supporting learners to create an equitable space for meaningful learning. As teachers and learners in this workshop, the collaborative process we engaged in led us to achieve states of flow where we moved together as we improvised music and shared ideas openly, learning about ourselves and each other. This experience is consistent with research that shows collaborative music improvisation and synchronous movement build trust, cooperation, and empathy among people (Trainor & Cirelli, 2015). It is an example of students and teachers engaging in an authentic task (improvising music) in a manner similar to professionals in the field (as in professional musicians at a jam session) in a setting where the focus is on the process of learning together. It is also consistent with the Teaching for Artistic Behavior (TAB) model of choice-based pedagogy, which advocates setting up classrooms like professionals' work environments so learners can engage in processes similar to those of professionals (Hathaway & Jaquith, 2014).

While the preservice teachers in our workshop created products (e.g., live music, graphical compositions) that had value in the moment, there was no pressure to produce a high-quality product or earn a passing score as a goal of this workshop. Such pressure might stifle empathy if it introduces a competitive aspect into the learning environment, or stifle risk-taking if learners are afraid to try new things and fail. The tasks we like to create for our preservice teachers could be thought of as brainstorming sessions, where premature evaluation of ideas or products that might diverge from norms could hinder creative thinking (Bransford & Stein, 1984). Also, like a brainstorming session, these tasks are relatively "goal-free" (Sweller, 2011, p. 63), with a wide range of possible outcomes being sought, reducing the strain on working memory that is required to work toward a more specific goal.

Conclusion

The focus on process in our work with preservice teachers is intended to help them replicate in their future classrooms conditions that inspire collaboration, curiosity, open-mindedness, empathy, and risk-taking, which are required for learners to grow and find creative opportunities. Preservice teachers should be prepared to lead culturally responsive STEAM tasks that develop creative processes. They can collaborate with experts in content areas other than their own to lead interdisciplinary work even when they are not experts in each discipline. And they can learn with their students to develop new expertise and model creative learning. While we specialize in music and mathematics, respectively, and we believe these disciplines lend themselves particularly well to interdisciplinary creative learning, other STEAM disciplines can also be integrated to inspire inquiry, improvisation, empathy, and risk-taking. In STEAM learning environments teachers can select inclusive and accessible tools and content to support equitable and meaningful learning.

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