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Arts-Based Interdisciplinary Music and Mathematics Tasks: Exploring Conceptualizations of Equitable Creative Learning in Teacher Education

Alesia Mickle Moldavan

Georgia Southern University, amoldavan@georgiasouthern.edu

Graham Johnson

Fordham University, gjohnson53@fordham.edu

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Arts-Based Interdisciplinary Music and Mathematics Tasks: Exploring Conceptualizations of Equitable Creative Learning in Teacher Education

Abstract

Preservice teachers need opportunities in teacher education courses to explore arts-based interdisciplinary learning that can inspire connections between communities of practice and allow learners to integrate concepts and imagine creative possibilities. This study reports on preservice teachers engaged in a workshop on arts-based interdisciplinary music and mathematics tasks. Data included surveys, task-related artifacts, and participant observations to examine how preservice teachers conceptualize and engage in such tasks. Three resonating themes were identified, revealing that preservice teachers generally thought (a) music and mathematics are more engaging and relatable in interdisciplinary contexts than when taught alone, (b) interdisciplinary music and mathematics tasks can and should be adapted to the needs of all learners, and (c) some uncertainties and concerns about implementing such tasks still exist. Based on these findings, suggestions are made for purposeful ways teacher education can engage preservice teachers in arts-based interdisciplinary music and mathematics tasks that can prepare them to create equitable and creative interdisciplinary learning opportunities for their students.

Keywords

Teacher Education, Arts-Based Interdisciplinary Learning, Music, Mathematics, Creativity

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Preservice teachers and P-16 students often have limited opportunities to explore music and mathematics in arts-based interdisciplinary contexts and real-world applications (Gresham, 2021; Lowe et al., 2017). A growing body of research suggests that interdisciplinary learning with music and mathematics can deepen preservice teachers' conceptualizations of music and mathematics and help preservice teachers and their students build confidence in and affinity for these disciplines (An et al., 2016; Twohill et al., 2022). This study examines how preservice teachers think about music and mathematics when considering content in arts-based interdisciplinary contexts and how they engage in interdisciplinary music and mathematics tasks. The following research question is examined: *How do preservice teachers conceptualize and engage in arts-based interdisciplinary music and mathematics tasks?*

Literature Review

Students need opportunities to engage in arts-based interdisciplinary learning, which can be referred to as STEAM (science, technology, engineering, arts, and mathematics) learning. We understand arts-based tasks as those that center learning through art creation (see Crampton & Lewis, 2020; Dixon, 2009; Kraehe & Brown, 2011), and we understand arts integration to be inclusive of arts-based interdisciplinary learning in STEAM contexts. Teachers can provide spaces where students can make purposeful connections between disciplines and communities of practice, encouraging students to integrate concepts and imagine creative possibilities (Tsurusaki et al., 2013; Wenger, 2009). Teacher education can equip preservice teachers with the knowledge and skills to facilitate such spaces for their future students. To adequately do this work, the field must understand what barriers and possibilities exist to arts-based interdisciplinary learning, particularly in the context of music and mathematics spaces.

Barriers to Arts-Based Interdisciplinary Learning

Students with minoritized identities often have fewer creative learning opportunities outside core subject areas than students with privileged identities (Chappell & Cahnmann-Taylor, 2013; Emmer, 2018; Jackson et al., 2021). One reason for this lack of opportunity is the dearth of teacher education centered on creativity and the arts (Austin, 2021; Henriksen et al., 2021; Hipp & Sulentic Dowell, 2019; Kraehe & Brown, 2011; Pavlou, 2021). While teacher educators are responsible for providing high-quality education to prepare effective teachers knowledgeable about content and pedagogy, content and methods courses often teach siloed content apart from creative interdisciplinary contexts that empower learners (Chappell & Faltis, 2013; Kraehe & Brown, 2011). Thus, there is a need

for teacher education to integrate ideas from multiple disciplines, including the arts, to advance students' understanding in more authentic experiences that reflect real-world problems, which are multi-faceted and complex rather than compartmentalized into neat discipline-specific issues. Providing these experiences ensures that future teachers can create spaces for their students to experience meaningful and creative learning across disciplines.

Possibilities With Arts-Based Interdisciplinary Music and Mathematics Learning

We find that integrating music and mathematics in arts-based tasks opens possibilities for deep exploration of content as well as culturally responsive, collaborative, and creative learning. Music allows learners to build conceptual understandings of, for example, ratios, proportions, fractions, and common multiples (Lovemore et al., 2021) and discover mathematical patterns in meaningful contexts (Bamberger & diSessa, 2003). Mathematics provides various ways to describe musical phenomena like sound waves, pitch, and tempo. Collaborative musical improvisation and composition can push individuals to move to a common pulse and create musical ideas that are in sync with what they hear from the collective group, inspiring a state of flow (Gershon & Ben-Horin, 2014; Shehata et al., 2021). Additionally, collaborative risk-taking can challenge personal and task-related stereotypes while building confidence to explore new ideas (Luria et al., 2017). Our study builds on prior research, like An et al.'s (2016) study, to explore how to create impactful learning experiences using arts-based interdisciplinary music and mathematics tasks for preservice teachers.

Theoretical Framings

We created a workshop based on social constructivist and transformative learning theories. Both theoretical framings advocate for learning environments that allow students, teachers, and other community members to work cooperatively to construct knowledge. More specifically, a social constructivist learning environment centers on active learning, which promotes active intellectual inquiry by giving students autonomy and control of how they engage in meaningful learning activities (Anthony, 1996). Given accessible, user-friendly tools, like the resources provided in our workshop, learners can engage in intuitive, exploratory learning with guidance from their peers and teachers.

Transformative learning theory informs a learning environment that can help learners overcome negative feelings and identities. Johnson and Olanoff (2020) offer examples of college students and preservice teachers overcoming

misconceptions and negative self-images related to mathematics learning, where professors employed transformative learning practices and modeled learning from mistakes in university mathematics courses to help their students develop positive mathematical identities. Similarly, when preservice teachers have negative self-images related to creativity and the arts, they can begin to develop positive identities through transformative learning experiences in supportive learning communities (Kraehe & Brown, 2011; Pavlou, 2021). The transformative learning cycle for adult learning includes a disorienting dilemma, critical reflection, rational dialogue to solve the dilemma, and discussion of how previous assumptions fit with new understandings (Johnson & Olanoff, 2020; Mezirow, 2009). Our workshop followed this cycle, asking preservice teachers to respond to arts-based interdisciplinary music and mathematics tasks in new ways.

Methods

This research is part of a larger qualitative case study where preservice teachers engaged in a workshop on arts-based interdisciplinary music and mathematics tasks during two mathematics methods courses (see Johnson & Moldavan, 2022, 2023). The workshop centers on inquiry that is in-the-moment and collaborative (Gershon & Ben-Horin, 2014; Scripp & Gilbert, 2016). The workshop aimed to provide opportunities for preservice teachers to build on their prior knowledge and experiences with music and mathematics and consider ways to do the same in their future classrooms. The preservice teachers listened to Lido Pimienta's "Eso Que Tú Haces" and were asked to compose short musical compositions using graphs and visual representations.

Consenting participants included preservice teachers ($n=24$) who self-reported their demographics (see Table 1) as female ($n=21$) or male ($n=3$) and Asian ($n=3$), Black ($n=1$), Hispanic/Latinx ($n=4$), or White ($n=16$). Most of the participants were in their early 20s seeking elementary certification. Data included surveys, task-related artifacts, and participant observations. The surveys (see Appendix) inquired about the preservice teachers' experiences with music and mathematics integration, including perceived purposes and how they and their future students might engage in such tasks. The data collected before, during, and after the workshop depict how the preservice teachers conceptualized and engaged with arts-based interdisciplinary music and mathematics tasks.

Table 1
Characteristics of Preservice Teachers

Characteristic	Number of Responses	
	n	Percentages
Gender		
Female	21	87.50
Male	3	12.50
Race/Ethnicity		
Asian	3	12.50
Black	1	4.17
Hispanic/Latinx	4	16.67
White	16	66.67
Age		
22–25	17	70.83
26–29	3	12.50
30+	4	16.67
Area of Focus		
Elementary	17	70.83
Secondary	7	29.17

Note. The characteristics data are self-reported by the participants.

Data sources were triangulated to corroborate the research findings (Gibbs, 2007). Preservice teachers were randomly assigned numbers (PST 1 through PST 24) to preserve their anonymity. First-level descriptive and in vivo codes (Saldaña, 2016) were created based on the initial analysis. Then, second-level codes were generated, defined, and applied to the data. The researchers cross-checked all codes to confirm strong interrater reliability to preserve and justify the trustworthiness of the analysis (Grbich, 2013). Following, Dedoose qualitative data analysis software was used to analyze code co-occurrence and frequency, organize excerpts into groups, and identify patterns and themes in the data. See Table 2 for the coding chart that informed the findings' themes.

Table 2
Coding Chart Used to Inform Themes

Themes	Second-Level Codes	Definitions
Theme 1: Music and mathematics are more engaging and relatable in interdisciplinary contexts than when they are taught alone.	Engaging, motivating, or fun	Settling, inspiring, animating, or focusing learners
	Engaging different types of learners	Inspiring use of multiple brain regions, types of thinking/senses, or including hands-on learning reflective of diverse cultural backgrounds
	Real-world connections	Bridging learning in and out of school
	Unusual learning experience	Involving classroom practices/content that are not typical
	Inherent creativity	Implying that some disciplines are naturally creative or interesting and others are not
Theme 2: Arts-based interdisciplinary music and mathematics tasks can and should be adapted to the needs of all learners.	Observing or analyzing	Actively listening to or looking at content; finding patterns
	Movement	Relating to dance or kinesthetic learning
	Rhythm and counting	Using math to measure or describe a musical pulse
	Standards*	Connecting learning to standardized curricula
	Visual representations	Drawing to express music and mathematical ideas or patterns
	Instruments or technology	Needing materials for music or mathematics instruction
	Mnemonic device	Music assisting as a memory aid for mathematics learning
	Choice	The ability to make decisions about one's learning
Collaboration	Working together to create something	

Theme 3: Various uncertainties and concerns exist about arts-based interdisciplinary music and mathematics tasks.	Uncertain	Unsure when writing about music- mathematics tasks
	No/limited experience	Claiming to lack exposure to music learning
	Not for all learners	Implying that some students are better able to engage in some types of learning than others
	Formal music training	Implying that only traditional, focused, or direct music instruction, and not passive or unstructured music experiences, count as music experience
	Balancing fun with content	Implying that the most important learning of content is not fun
	Standards	Connecting learning to standardized curricula

Note. The coding chart notes the second-level codes and the associated definitions grouped by the respective themes.

Findings

We report on three themes depicting how preservice teachers in the workshop conceptualized and engaged in arts-based interdisciplinary music and mathematics tasks. These themes can be used to inform ways that teacher education can be responsive to preservice teachers' prior experiences, beliefs, and knowledge of music and mathematics when considering tasks that encourage interdisciplinary connections through creative endeavors.

Theme 1: Music and mathematics are more engaging and relatable in interdisciplinary contexts than when they are taught alone.

Preservice teachers expressed that arts-based interdisciplinary music and mathematics tasks allow learners to make connections between disciplines and their personal interests, experiences, and cultural backgrounds. Such tasks offer more entry points than discipline-specific tasks because they encourage learners to leverage their interests to make new connections. As noted by one preservice teacher, “[Integrating music and mathematics] makes math seem less scary for those who enjoy music; it also makes music less scary for those who may like math but have no experience in music” (Post-survey, PST 8). Similarly, another participant saw integrating music and mathematics “as a method of alleviating

anxiety in either subject” (Post-survey, PST 17). Regarding the approach of music or mathematics from a different perspective, one participant wrote that such tasks make “math [look] fun and not that rigid” (Pre-survey, PST 21). At the same time, another participant said the tasks provide “a mathematical experience that is more emotionally enriching by incorporating music [and] a musical experience that is more intellectually stimulating by incorporating math” (Pre-survey, PST 5).

The preservice teachers also made analogies between patterns in music and mathematics. One participant wrote, “There is a pattern/rule to every song just as there is a pattern or rule to solving every math problem” (Post-survey, PST 9). Sometimes, one discipline explains a phenomenon in another, as in the case of mathematically expressing sound frequencies or rhythms. As the participant explained, this can provide clarity for learners, offer opportunities to concretize abstract ideas, and deepen learning. Another participant explained, “Math can be used to understand music on a deeper level—math is inherently in music” (Post-survey, PST 11).

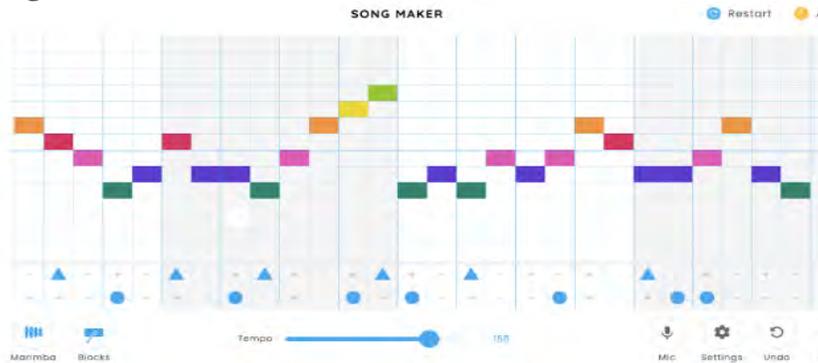
Furthermore, the preservice teachers expressed that music helps engage learners in mathematics. One participant wrote that music could help “understand how math is applicable outside of the classroom, especially in ways that are interesting and relatable to students” (Post-survey, PST 1). Other participants wrote that music “can make learning math more fun for students and help them remember certain mathematical processes” (Pre-survey, PST 11) and that “music interests, engages, and motivates the students, especially in a math class” (Post-survey, PST 3). However, some participants cautioned that students could be “too focused on the music and not understand the math content” (Post-survey, PST 2).

Theme 2: Arts-based interdisciplinary music and mathematics tasks can and should be adapted to the needs of all learners.

The preservice teachers noted that musical instruments, music technology, and the structures of arts-based interdisciplinary music and mathematics tasks could and should be adapted to the needs of all learners. One participant wrote that music assists with learning needs because it “taps into different parts of the brain and different students’ strengths, which helps with learning and memory” (Pre-survey, PST 19). Another participant wrote, “I have a cousin who has a speech impediment, and when music is involved, it helps her” (Pre-survey, PST 6). Music can also offer student choice alongside considerations for accessibility. One participant wrote, “Having options for students (physical musical instruments and online simulations such as Chrome Music Lab Song Maker) is very helpful” (Post-survey, PST 3). Another participant wrote, “For me personally, I found it

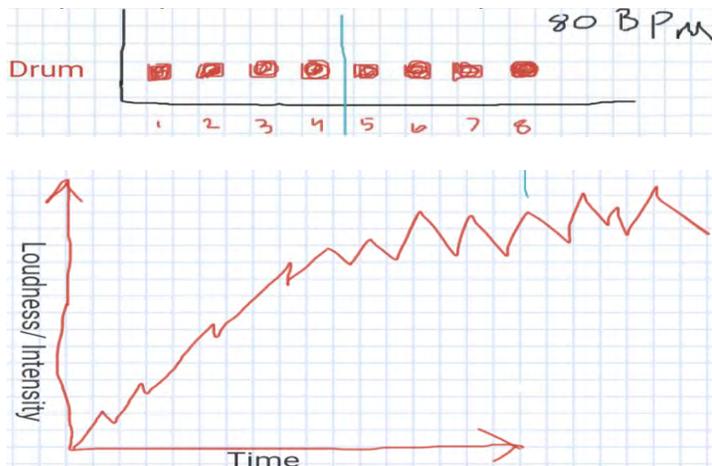
important to be able to manipulate things physically—whether that was having the opportunity to actually play with an instrument in my hand or actually draw out the graph with pen and paper” (Post-survey, PST 17). The preservice teachers’ work, which included reflective drawings, improvised musical performances, written compositions using iconic and graphical notation (see Figures 1 and 2), and written reflections, demonstrated how their various learning needs were met when they were allowed to choose from a variety of musical instruments and concepts to explore.

Figure 1



Note: This screenshot shows a preservice teacher’s composition on Chrome Music Lab Song Maker.

Figure 2



Note: These are screenshots of preservice teachers’ work graphing music on coordinate planes.

Theme 3: Various uncertainties and concerns exist about implementing arts-based interdisciplinary music and mathematics tasks.

Some preservice teachers expressed various uncertainties and concerns when considering ways to implement arts-based interdisciplinary music and mathematics tasks. These concerns are an important reminder that arts-based interdisciplinary learning is neither a panacea nor always preferable to discipline-specific learning. Preservice teachers experiencing anxiety or self-doubt related to music and/or mathematics could feel even more overwhelmed when music and mathematics are presented in an unfamiliar interdisciplinary context. One participant wrote, “I think it is relevant to have not just prior knowledge but also a personal connection to at least one of the subjects. But for the student who may not feel too great about either subject (me), this is a lot” (Post-survey, PST 17). When learners like this participant express that they lack a personal connection to music and mathematics, we try to help them as teacher educators discover that they do have connections, however insignificant they may seem. Sometimes, learners must overcome deficit views of their personal experiences with music and mathematics. For example, one participant reflected, “I enjoy music, I listen to it, and I like dancing, but I cannot make it” (Pre-survey, PST 23). We encourage learners like this preservice teacher to see their experience with music as an asset they can use to build on and connect with others’ experiences.

Additionally, the preservice teachers expressed concern about learners being unwilling to engage in arts-based interdisciplinary music and mathematics tasks. One participant wrote about the possibility of students being “self-conscious about their artistic abilities in all forms” and feeling “insecure and withdrawn during this type of activity” (Post-survey, PST 19). Another participant thought students might “copy off of each other” or “be shy” (Post-survey, PST 4). Multiple participants expressed concerns about classroom management. One participant wrote, “Especially with students who have minimal exposure to instruments, getting the opportunity to play with them could create behavioral issues” (Post-survey, PST 11). Arts-based interdisciplinary music and mathematics tasks look and sound more active than traditional classroom tasks where students sit and work quietly. Hence, it is natural to wonder if these tasks elicit a chaotic learning environment.

Finally, the preservice teachers expressed concern about learners being unable to engage in arts-based interdisciplinary tasks due to disabilities. One participant wrote, “I think it depends on the group of students you work with—I work with special needs students, and doing an activity like this would be extremely overwhelming and overstimulating for them” (Post-survey, PST 10).

Another participant wrote, “My only concern would be if a student were hearing impaired, what would you do in that scenario?” (Post-survey, PST 16). To address concerns like this, we show preservice teachers that there are plenty of examples of people with disabilities creatively engaging in music and other disciplines.

Discussion and Conclusion

Learning can be engaging and responsive to learners’ needs, interests, and cultures when it is interdisciplinary and connects communities of practice (Tsurusaki et al., 2013; Wenger, 2009). Preservice teachers must be prepared to engage their future students in arts-based interdisciplinary learning and be willing to take risks that encourage creativity and critical reflection on such experiences in the classroom (An et al., 2016; Luria et al., 2017). Thus, teacher education must provide preservice teachers with interdisciplinary and transformative learning experiences that serve as models for their work with their students.

Our workshop established a shared context for thinking about arts-based interdisciplinary learning with preservice teachers. We built on our shared understandings to engage in meaningful creation and discussion inspired by educational research focused on equitable processes and results. This work helped preservice teachers develop mindsets that we hope will allow them to engage with their students, colleagues, and students’ families and develop creative solutions so all learners can participate in equitable learning opportunities. The preservice teachers’ engagement during the workshop, diverse and meaningful work products, and thoughtful reflections demonstrate possibilities and considerations for how preservice teachers and their future students can participate in arts-based interdisciplinary music and mathematics tasks in social constructivist and transformative learning environments.

Future research must consider how preservice teachers’ identities, beliefs, and self-efficacy influence their experiences with arts-based interdisciplinary learning in teacher education settings and their teaching practices with their students. Moving to an arts-based interdisciplinary form of teaching requires practice with specific creative tasks and the development of mindsets open to exploration, risk-taking, and uncertainty. While arts-based interdisciplinary learning may appear daunting, preservice teachers can support one another in communities of practice and look for ways to augment discipline-specific learning at the foundation of traditional learning environments. Thus, preservice teachers can develop their professional practice while broadening academic opportunities for their students to build knowledge and work creatively through arts-based interdisciplinary learning.

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Appendix

Survey Questions

Pre-Survey

Respond to the following questions:

1. What is your race/ethnicity?
 - a. White
 - b. Black/African American
 - c. Hispanic or Latinx
 - d. Asian
 - e. American Indian/Alaskan Native
 - f. Native Hawaiian/Other Pacific Islander
 - g. Prefer Not to Answer
 - h. Other

2. With which gender identity do you most identify?
 - a. Male
 - b. Female
 - c. Non-binary
 - d. Transgender Female
 - e. Transgender Male
 - f. Transgender Non-binary
 - g. Gender Fluid
 - h. Gender Variant/Non-Conforming
 - i. Prefer Not to Answer
 - j. Other

3. What is your age?

4. To which grade level are you getting your certification (check all that apply):
 - a. Preschool
 - b. Elementary
 - c. Secondary
 - d. Special Education

5. Are you currently working with learners? (Yes or No)
6. If yes, what is your experience working with learners? (Urban, Suburban, Public, Charter, Private/Parochial, Head Start, Home Day Care, other)
7. What is your role/position? (Full-time teacher, teacher assistant, paraeducator, building substitute, other)
8. Are you currently student teaching? (Yes or No)
9. In what type of school setting are you currently student teaching? (Urban, Suburban, Public, Charter, Private/Parochial, Head Start, Home Day Care, other)
10. Describe your experience with music.
11. Do you have any experience working with music in your instruction? (Yes or No)
12. If yes, what did your experience look like?
13. Do you have any experience engaging in a class where music and mathematics are integrated? (Yes or No)
14. If yes, what did your experience look like?
15. Describe what is meant by integrating music in a mathematics class. What does it look like?
16. What is the purpose of engaging students in tasks where music and mathematics are integrated?
17. What factors, materials, or conditions are needed to make a meaningful music connection in a mathematics task or a meaningful mathematics connection in a music task?

Post-Survey

Respond to the following questions:

1. Describe what is meant by integrating music in mathematics class. What does it look like?
2. What is the purpose of engaging students in tasks where music and mathematics are integrated?
3. What factors, materials, or conditions are needed to make a meaningful music connection in a mathematics task or a meaningful mathematics connection in a music task?
4. What went well when you were experimenting during today's workshop?
5. What would you do differently next time you or your students perform a similar task?
6. Describe how your appreciation has grown (or not) for incorporating music in your mathematics instruction to help make meaningful connections to mathematics concepts.
7. Describe any challenges and concerns for incorporating music in your mathematics instruction.
8. Please share any feedback regarding this workshop. What did you like about the workshop? What did you not like about the workshop?