

Elementary Teachers' Design of Arts Based Teaching

Investigating the Possibility of Developing Mathematics-Music Integrated Curriculum

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EDUCATORS HAVE A LONG HISTORY OF IMPLEMENTING ARTS-BASED INTERDISCIPLINARY CURRICULUM—linking the arts with other school subjects can be traced back as early as Plato's academy (Gutek, 2004). Since the end of nineteenth-century, modern educational philosophers and researchers such as Francis Parker and John Dewey have endeavored to provide schools with the theoretical and curricular supports for this comprehensive type of integrative teaching approach. For example, Dewey (1938) conducted a series of exploratory research studies examining impacts upon students' development that resulted from the integration of curricular subjects into an interdisciplinary pedagogical approach. In present times, Dewey's educational philosophy remains fundamentally connected with the contemporary progressive education movement, which incorporates his conception of the arts as an important—but often neglected—part of the general school curriculum that should be available to all students, not just those with recognized artistic talents or proclivities.

During the 1920s and 1930s, Dewey and other likeminded educators proposed specific integrative approaches to education including the project-based method, the experience-based curriculum, and activity-based movement in the classroom. In Dewey's view, the separation of education into isolated curricular subjects resulted in an unnaturally decontextualized learning environment that was unfamiliar to students whose everyday experiences taught them that real-life problem-solving usually requires an interdisciplinary approach (Beane, 1997). Another progressive educator, Kilpatrick (1941) advocated for teachers to use an interdisciplinary project-based curriculum, and to teach with an emphasis on solving problems via cooperative processes.

Within Kilpatrick's project-based curriculum framework, educators were encouraged to examine and teach about the relationships between the arts and other subject areas (Bresler, 2006).

After World War II, Kierkegaard and Sartre steered the development and refinement of an existentialist philosophy that built upon Dewey's pedagogical approach but with an added emphasis placed on the importance within education of preparing each student to experience individually their own authentic awareness of their freedom to make choices that they find meaningful (Gutek, 2004). Based on the guiding philosophical principle of "existence precedes essence," existentialist educators since the 1960s have often utilized the arts, as well as other formats for expressing creativity, to develop innovative curriculum theories and practices (Gutek, 1997). Within curriculum theories grounded in existentialist philosophy, the arts have often been incorporated into the classroom so as to provide a variety of mediums and resources for students desiring to create their own creative works expressing their personal consciousness of what they have learned (Dorn, 1994).

Heavily influenced by existentialist learning theories, Maxine Greene (1973) believed the process of utilizing and developing imagination was the key learning experience for all students, and that, therefore, teachers should offer students opportunities to think, question, and understand school subjects through imagination-based activities such as those found in the arts. Maxine Greene (2001) further argued that interdisciplinary academic creation within the arts, including poetry, dance, theater, and music, were mechanisms for opening students' minds to move beyond the tacit but implicit boundaries that abound within society. In the view of Maxine Greene and Karen Greene, the process of appreciating, creating, and interpreting artworks within collaborative classrooms through interactions among students and teachers (1) allowed students to understand school subjects more deeply as well as increase their creativity within a safe environment (M. Greene 1991), and (2) released students from the limitations of their verbal inarticulateness by helping them become empowered during their own experiences with creation (K. Greene, 1982; M. Greene 1995).

During the post-Sputnik era that lasted until the end of the Cold War, curriculum approaches that integrated the arts were mainly discarded or forgotten by educators as the educational field was plunged into a rigid, discipline-based approach that gave distinct attentiveness to science and mathematics education (Barrow, 2006). Then in the 1970s, due to the influence of multiculturalism and the open education movement (e.g., open classes), educators proposed that interdisciplinary education emphasizing student-centered exploration and examination could have positive impacts on both cognitive and affective skills, and this in turn would result in improved students' academic achievement as well as ethnic and cultural awareness and sensitivity (Gay, 1975; Horwitz, 1979). By the late 1980s the movement for curriculum reform had again been revitalized, due to a large extent because of the influence of constructivist learning theory and pedagogy (Hinde, 2005). Educational researchers, again vocally and reasonably, argued that education should be made relevant to students' real-life interests and experiences—and once again integrated, interdisciplinary curriculum using the arts to connect multiple subjects was a heated topic among practicing educators and educational theorists (Gehrke, 1998).

More recently, scholars including Derrida and Foucault have led the postmodernist philosophy into the popular consciousness over the past three decades, resulting in the creation of postmodernist educational theories that place importance upon acknowledging local narratives based on the experiences of individuals and their communities. Within this postmodernist perspective, the arts were seen as an aesthetic modality for stressing the cooperative nature of the

artistic production, with special attention given to the dynamic interactions that occur between an artistic product and its audience (Slattery, Krasny, & O'Malley, 2007). Within a typical postmodernist educator's pedagogical viewpoint, teachers should preferably intersperse the arts with other academic disciplines towards the purpose of helping students intentionally traverse ambiguous, and often arbitrary, subject-area borders—such as in the “theatre of the oppressed” configuration fashioned by Augusto Boal (1979), based upon his interpretation of teaching philosophy from Paulo Freire (1970) wherein stage actors would engage in conversational interactions with members of their audience during a partially scripted, partially dynamically-generated theater performance. Similarly, Slattery's (1995) theoretical framework viewed curriculum as a “kaleidoscope” wherein the ultimate goal of high-quality education was to teach students how to generate personalized meanings during their learning experiences so that the lessons would become memorable and impactful. Similarly, Slattery's (1995) theoretical framework viewed curriculum as a “kaleidoscope” wherein the ultimate goal of high-quality education was to teach students how to generate personalized meanings during their learning experiences so that the lessons would become memorable and impactful. Within Slattery's framework the arts perform a crucial role in supporting the breadth of this kaleidoscope curriculum, in that via the arts students can examine school subjects from multiple perspectives thereby increasing the diversity of their understanding (Slattery & Langerock, 2002).

Purpose of the Study

While some theories of curriculum integration design focus on linking core school subjects together (e.g., a mathematics-science integrated curriculum, or a literacy-history integrated curriculum), in contrast, an integrative arts-based interdisciplinary curriculum emphasizes enabling students to transfer their developing understanding and knowledge between the arts and subjects not traditionally associated with the arts (e.g., a music-math integrated curriculum, or a dance-science integrated curriculum) (Catterall, 2005). By transcending traditionally uncrossed disciplinary boundaries between superficially unrelated subjects, integrative arts-based learning opportunities can engage students in investigation and reflection within an interdisciplinary framework (Parsons, 2004). This type of arts-based interdisciplinary education not only allows students to develop a broader and more interconnected view of school subjects but it also helps teachers to reduce the redundancy of content across curricular subjects while simultaneously addressing the interdisciplinary issues that arise during the discussion, which in a non-interdisciplinary curriculum are often ignored because the curriculum has been divided into rigid, discipline-specific subjects and paradigms (Hargreaves & Moore, 2000). For example, Fiske (1999) and Erickson (2001) summarized some of the benefits that arts-based integrative curriculum can offer to students and teachers as: (a) providing enjoyable and engaging learning environments; (b) appealing to students with special needs; (c) facilitating communication between students and teachers; (d) allowing the involvement of parents; (e) providing alternative assignments for successful students who seek more complexity; (f) addressing problems, issues, and concepts that society has deemed important; (g) decreasing the amount of curricular fragmentation and decontextualization; and (h) connecting the students' school-based education with their real-world interests and experiences.

A number of mathematics educators and mathematics education theorists have developed methods for associating the musical arts with mathematics instruction as an interdisciplinary

approach to improving K-12 students' (1) math achievement based on both standardized test and learning during class activities and (2) mathematics disposition including students' mathematics attitude and motivation (e.g., An, Ma, & Capraro, 2011; Carrier, Wiebe, Gray, & Teachout, 2011; Colwell, 2008; Costa-Giomi, 2004; Courey, Balogh, Siker, & Paik, 2012; Johnson & Edelson, 2003; Lesser, 2001). However, much remains to be understood about the impacts of such interdisciplinary pedagogy and development of robust correlating curriculum theory. One such specific area requiring further refinement of both theory and practice is our understanding of teachers' experiences with constructing music-mathematics integrated lessons for classroom instruction as an implementation of the type of interdisciplinary-based curriculum we have been discussing. Therefore, in the current study presented in this paper, we aimed to examine preservice and in-service teachers' strategies while planning mathematics lessons that integrated music-themed activities. Two dimensions of each lesson plans were analyzed: (1) the content dimension, meaning the strategies and methods used to integrate mathematics and music together within the lesson plans and (2) the process dimension, meaning the strategies and methods used to introduce and operationalize music-mathematics connections to generate mathematics pedagogy incorporating music-themed activities.

The two specific research questions addressed in this study were:

- (1) What types of strategies, and implementations of those strategies, did preservice and in-service teachers use to integrate mathematics education into music-themed activities?
- (2) What were the differences between the preservice and the in-service teachers' strategies regarding the process for designing and developing mathematics curriculum integrating music-themed activities?

Methods

Research Setting and Data Sources

As part of a larger project dedicated to improving preservice and in-service elementary teachers' pedagogical content knowledge—specifically with an emphasis upon teaching mathematics through interdisciplinary approaches—participating teachers' were assigned to develop and implement mathematics lessons that integrated music-themed activities. Data collected from the participating teachers included: (1) a lesson plan and (2) a video of the teacher implementing the lesson plan with age appropriate students. For the current study, only the first part of the data sources (e.g., the lesson plans) were utilized during the data analysis.

The research took place at two large public universities, one of which is on the west coast and the other is in a southwestern bilingual metropolitan area. The participants were 45 teachers (39 females; 6 males) pursuing either an undergraduate or graduate level degree in elementary education. Demographic data collected from the participants indicated that the age range for all of them was between 21 to 49, with 78% of the participants self-reporting that they are Hispanic, 16% of participants self-reported that they are Caucasian, and 6% of participants self-reported that they are Asian. For the level of participants' self-reported music competency, 93% of participants stated that they do not have any music background and 7% of participants reported

that they had received music or music-education related courses in college. Specifically, a total of 78 lesson plans were collected, of which 37 lesson plans were developed by the preservice teachers and 41 lesson plans were developed by experienced in-service teachers.

Coding Process and Data Analysis

As discussed earlier, two dimensions (e.g., the content dimension and process dimension) of the lesson plans were coded and analyzed. This was performed through a two-tiered process wherein: (1) the strategies and methods used to integrate mathematics content and music content within the lesson plans were identified and (2) the strategies and methods used to integrate mathematics pedagogy with music-themed activities were identified. To facilitate in implementing these two series of assessment, grounded theory (Corbin & Strauss, 2008) was utilized in the analysis of the preservice and in-service teachers' lesson plans. Specifically, all mathematics and music content areas were coded into thematic clusters or categories using an inductive approach—first, lesson plans were compared instance to instance to generate content categories until there was category saturation, after which the rest of the lesson plans were coded by using categories previously developed (Patton, 2002). Throughout the coding process, multiple discussions among the research study authors further developed and refined the categories and clusters and during the coding process consensus were reached after discussions of any disagreements. This same process was also utilized for the analysis of pedagogical strategies within the music-mathematics integrated lesson plans.

Results

The analysis of the 78 lesson plans showed multiple strategies for teaching mathematics integrated with music—coding resulted in a typology of 15 different ways that the teachers addressed music-mathematics content interactions across the lesson plans. For the most, music-themed activities were generally based on four musical content areas: (1) *listening and singing*, (2) *composing and performing*, (3) *musical notating*, and (4) *musical instrument designing*. These four general areas of music-themed activities were utilized throughout the lesson plans to teach mathematics content from five general content areas: (1) *numbers and operations*, (2) *geometry*, (3) *algebra*, (4) *data analysis and probability*, and (5) *measurement* (National Council of Teachers of Mathematics [NCTM], 2000). A comparison of the lesson plans created by the preservice teachers with those created by the in-service teachers was then used to determine how different types of music-themed activities and mathematics content foci varied between the two groups.

Four Main Types of Music-themed Activities Within Mathematics Lessons

During our content analysis of the collected lesson plans, a variety of music activities were identified and coded. These music activities were categorized into four music content areas: (1) music singing and listening activities, (2) music composing and performing activities, (3) musical notation learning activities, and (4) musical instrument designing and making activities.

Although a variety of strategies for linking music and mathematics were found throughout the lesson plans, some types of music activities demonstrated noticeably broader opportunities to be integrated with multiple mathematics content areas. For example, music composing and performing activities showed in the lesson plans to have a wide variety of mathematics content connections. In contrast, musical notation learning activities within the lesson plans were only connected with a single mathematics content area, thereby demonstrating a much more limited spectrum of mathematics content integration opportunities.

Music listening and singing. Content analysis of the lesson plans showed music listening and singing activities integrated with all of the mathematics content areas, and lessons within this music-theme consisted of 17.9% of the mathematics lessons. The most prominent strategy for integrating mathematics content within this category was to use mathematical concepts, terms, and formulas as song lyrics for students to hear and sing. Many teachers in their lessons plans mentioned playing existing “math songs” from video-sharing websites for their students—some of these math songs changed the lyrics to traditional children’s melodies such as “Twinkle, Twinkle, Little Star.” Other songs were original music created by educators with the intent of helping young students learn mathematics. As an illustrative example, a participating preservice teacher Amy (all names have been changed to pseudonyms) described in her lesson plan the process of using the “Counting By Tens Song” as a way to facilitate students remembering a new counting strategy: “Show the students the video of the counting by tens song. Explain that we will watch and listen to it again during the activity, and then at the end of the class we will sing it together as a class summary.”

While some teachers were satisfied to find an already created math song from the internet and play it for students, a number of teachers in their lesson plans created their own original lyrics based on a specific topic related with target mathematics objectives. For example, in-service teacher Ben proposed to use a revised version of the song titled “Five Little Speckled Frog” with new lyrics designed to help students practice whole number subtractions. Teaching goals set for students participating in Ben’s lesson plan included:

Start the lesson by singing “Five Little Speckled Frogs”.

- (1) Original Song: “*Five Little Speckled Frogs*,” sat on the speckled log.
- (2) Eating most delicious bugs, yum, yum.
- (3) One jumped into the pool where it’s nice and cool.
- (4) Now there is four little speckled frogs, glub, glub.

Challenge students to response as we sing the song with different numbers.

- (1) New Song: “*Twenty little Speckled Frogs*,” sat on the speckled log.
- (2) Eating most delicious bugs, yum, yum.
- (3) ____ jumped into the pool where it’s nice and cool
- (4) Now there is ____ little speckled frogs, glub, glub.

Class will reflect on the song and start writing subtraction number sentence corresponding to the problems stated in the song and sing the song until there’s none left on the log. (For example: $20 - 7 = 13$; $13 - 4 = 9$; $9 - 3 = 6$; $6 - 5 = 1$; $1 - 1 = 0$).

Music composing and performing. Music composing and performing activities were identified as the most popular way of teaching mathematics lessons, with 48.7% of the lesson plans using this strategy for linking music activities with mathematics topics. In general, musical composition activities offered student opportunities to compose, decompose, and recompose using graphical notation such as colors to represent musical notes or numeral notations such as numbers to represent musical notes. Within the lesson plans, after students finished their composition activities, classroom musical instruments such as handbells and keyboards are provided for the students to let them play their own musical compositions. Several lesson plans focused on teaching algebra and particularly the important foundational concept of pattern recognition. Preservice teacher Dave organized a lesson plan for introducing patterns according to the following stages:

Stage 1: I will open up by asking students if they can describe in their own words what a pattern is. Afterwards I will have them give me examples of patterns or where I can find patterns. I will then show the dictionary definition of what a pattern is. From this we will have a group discussion of how patterns can be helpful in our everyday lives.

Stage 2: The group leader will collect a set of bells and color tiles for their group. I will show the students a pattern of colors up on the projector. As a group the students will decide who gets which color of bell. I will demonstrate how the bells are properly used. I will explain how the color of the tile represents the color of the bell being played. I will give the students 4-5 minutes to play the bells and try to copy the pattern they see up on the projector based on the colors. For the most part the students will believe they are just learning about music and playing some notes. I'll explain how this is a pattern and patterns can be found in math. I will show them some examples of patterns in math.

Stage 3: Other than modeling and demonstrating the use of the bells, I will show the students different patterns found in math. For example I will show them different examples of number patterns such as 1,1,2,2,3,3,4,4,5,5.... or 1,1,2,3,5,8,13.... I will explain how these are considered patterns.

Stage 4: Each group will be given a copy of a song. Each group has a different song assigned to them depending how many people are in their group. They will have 7-10 minutes to practice their song. When time is up they will go to the front of the class and present their song while the rest of the class tries to guess which song it is that they are playing. Afterwards I will ask the group what kind of patterns they saw in their song. Groups will discuss what patterns they saw in their song and get prepared to share their findings with the rest of the class.

Some teachers went beyond asking students to use graphical notations composition cards with different colors to compose music by using mathematics patterns, and instead they developed lessons to introduce more advanced algebra concepts such as coordinate systems as well as complex music composition activities based on chords. For example, preservice teacher Eva developed music composition activities linked with teaching number pairs by having students compose music within a coordinate system where students compose by putting a

sequence of numbers on an x-axis and a y-axis, and then two group of students play the music simultaneously:

I will have already set up a coordinate plane on a large table. Each unit on the y and x axis will be labeled with a number and a bell. The students will get in groups of 3 and then they will get around the large table. Each group will get one pom-pom. On the whiteboard there will be several data points ready for them to plot. I will do the first one to show them how we will do the activity. I will start with the first point, which corresponds to the x axis, and I will move to the right the number of units on the data point, then I will go up the number of units on the data point that corresponds to the y axis, and I will leave my pom-pom there. The pom-pom will represent my data point on the coordinate plane. Once I leave my pom-pom I will play the bell on the x and the y axis. Each group will repeat the procedure while the rest of the groups have to keep an eye on them to make sure they are doing it correctly. As the students work on the activity the teacher will be walking around correcting any errors and/or misconceptions.

Musical notation learning. Teaching musical notation together with number concepts, especially fractions, was another proposed strategy to integrate music and mathematics. The content analysis of all the lesson plans showed that 10.3% of the lessons connected musical notation activities with mathematics topics. The only mathematical content area that this kind of lesson plan focused on was that of numbers and operations and, specifically, linking note values with fractions or fraction computations. By exploring the mathematical patterns behind different kinds of musical notes, teachers attempted in their lesson plans to associate half-note to whole-note relationships with part-whole concepts in fractions. One of the most popular ways among the teachers' lesson plans to integrate notation with number concepts was to introduce the symbol of notes with different values on staff and then provide some auditory representations by asking students to clap or sing these notes with different length of time. For example, preservice teacher Fred stated in his lesson plan the following goal for the lesson:

Do you know there is a very close relationship with fractions and musical notes? Learning about musical notation will help us understand how fractions are parts of a whole number. As the lesson continues we will understand how fractions are derived, and check [*sic*] with your hand bells if the music note values can tell us something about fraction size. At the end of the lesson we will create our own music in groups using our new knowledge of music and fractions. Everyone will have time to share with the class their musical creations.

This teacher also described how to introduce music notation and fractions via five specific steps beginning with music notation instruction and assessment and then progressing towards introducing fraction-related concepts:

A. Introduce vocabulary words (music staff, time signature, measure, bar line, whole note [4 beats], half note [2 beats], quarter note [1 beat], eighth note [$\frac{1}{2}$ beat], whole rest, half rest, quarter rest, eighth rest).

B. Explain that a fraction is part of a whole number much like other notes are derived from a whole note, or rests from a whole rest:

- A whole note has 4 beats per measure
- A half note has 2 beats per measure
- A quarter note has 1 beat per measure
- An eighth note has $\frac{1}{2}$ beat per measure
- A whole rest means there is no sound for 4 counts
- A half rest means there is no sound for 2 counts
- A quarter rest means there is no sound for 1 count
- An eighth rest means there is no sound for $\frac{1}{2}$ count

C. Demonstrates to students note counts with hand bells and by clapping

D. Assess students' understanding the value of music notes

- How many beats does a whole note get?
- How many beats does a half note get?
- How many beats does a quarter note get?
- How many beats does an eighth note get?
- Repeat process for rests.

E. Review the concept of each note representing a fraction of a measure, and then provide students with some sample math problems using notes to represent fractions.

- [an eighth note] + [an eighth note] = _____ (Answer: $\frac{2}{8}$ or $\frac{1}{4}$)
- [an eighth note] + [a quarter note] = _____ (Answer: $\frac{3}{8}$)
- [a quarter note] - [an eighth note] = _____ (Answer: $\frac{1}{8}$)
- [4 eighth notes] + [2 eighth notes] = _____ (Answer: $\frac{6}{8}$ or $\frac{3}{4}$)
- [3 sixteenth notes] + [1 sixteenth note] = _____ (Answer: $\frac{4}{16}$ or $\frac{2}{8}$ or $\frac{1}{4}$)

Musical instrument designing and making. The content analysis of all the lesson plans showed that 23.1% of the mathematics lessons featured musical instrument designing and making activities. While none of the lesson plans within this music theme focused on data analysis and probability, all of the other four major content areas in mathematics were found to have been integrated with this type of activity. Lesson plans showed that musical instrument designing and making can include asking students to: (1) use physical materials such as wood, plastic, or other resources to make string, wind, and percussion instruments and (2) design the shapes of instruments on papers such as proposed designs for electrical guitars, classical guitars, and pianos. Many teachers who had developed a lesson associated with musical instrument designing using physical materials designed the activities so that students had to apply mathematics during the instrument making process. For example, preservice teacher Gina specified strategies in her lesson plan for guiding students to participate in music-mathematics integrated activities making pan flutes:

- (1) Explain to the students that they are going to use the measuring ruler to subtract an additional quarter to each straw to create their own pan flute;
- (2) Describe the process of creating pan flute, and pass out about ten straws to each group, scissors, tape, and ruler;
- (3) Model how to begin to cut their straw to 6 inches long (after the first straws will subtract 1/4 to each straw), and demonstrate the different sounds the straws make after cut them;
- (4) Show students how to tape their straws to create the pan flute
- (5) Ask students to make their own pan flute and walk around the class to check if the students need any assistance with the activity;
- (6) Ask students how they are subtracting each straw to verify the accuracy of their pan flutes;
- (7) Discuss with the students the different pitch sounds each straw makes and ask certain tables to make the straw sound and discuss why it makes a high pitch or lower pitch.

Directing students to design the shapes of original instruments on paper was another way lesson plans related mathematic topics to instrument design, especially the teaching of geometric figures. The lesson plans that involved students designing musical instruments on paper typically started by introducing the background and history of the particular musical instrument and often suggested playing a recommended video to show students how the instrument looks and sounds. The lessons then generally would have students use specific geometrical shapes or combinations of shapes to create their own version of the target instrument. For example, in-service teacher Heidi provided the following teaching phases in her lesson plan on designing electric guitars:

- (1) Display images of various electric guitars from Google Images and play 2 different video clips from Youtube of a musician playing a classical music piece with an electric guitar.
- (2) Discuss the sharp edges of some of the guitars that were shown. Ask: What shapes can you think of that could make up a guitar's shape?
- (3) Explain that the students will each create the body of an electric guitar.
- (4) Distribute 2 pieces of colored paper to each student (each student receives 2 different colors), and instruct them to use a ruler to draw a large triangle on each piece of paper. The triangles do not need to be identical to one another. The students may cut out their triangles after they are drawn.
- (5) Using a protractor, students will measure each angle of their triangles, and record the measurements in the corresponding angle on the triangle.
- (6) The students will finally record the sum of the angles of each triangle in the center of each triangle. (Some students will have sums that are greater than or less than 180°. This is a great opportunity to discuss how the students can check their work.)
- (7) Lastly, students will glue their triangles (overlapping a little) together on a piece of black paper. This is the body of their electric guitar

Comparing Preservice and In-Service Teachers' Content Foci and Instructional Processes

This section presents results from analysis of the data comparing the preservice and in-service teachers' lesson plans in regards to their: (1) content foci and (2) instructional processes. In terms of the content foci of music-themed activities involving mathematics, composing and performing activities combined with numbers and operations were identified as the most popular areas respectively across both preservice (37.8%) and in-service teachers' (31.7%) lesson plans. However, preservice and in-service teachers' lesson plans were found to contain different content foci in both music and mathematics (see Table 1 and Table 2). In terms of interdisciplinary music-mathematics instructional processes, in-service teachers overall generated higher percentages than preservice teachers of coverage for all five instructional phases (see Table 3).

Mathematics and music content foci. This paper previously described that the data analysis performed resulted in a codification of 15 different ways of linking music with mathematics content areas across all of the lesson plans. However, in-service teachers demonstrated different preferences than preservice teachers in adopting particular music-mathematics content foci while developing lessons. Specifically, in music content foci: 27.0% of preservice teachers' lesson plans were based on music listening and singing activities while only 9.8% of in-service teachers applied this type of music activity. In contrast, 53.7% of in-service teachers' lesson plans adopted composition as their music content focus while fewer preservice teachers (43.2%) applied this type of music activity in their lesson plans. For the other two music content areas—notating and instrument designing—similar percentages were found in both preservice and in-service teachers' lessons plans.

Table 1
Interactions Between Mathematics and Music Content Foci in Preservice Teachers' Lesson Plans

n=37 Math Content Focuses	Music Content Focuses				
	Listening & Singing	Composing & Performing	Notating	Instrument Designing	Overall
Number & Operation	5 (13.5%)	4 (10.8%)	4 (10.8%)	1 (2.7%)	14 (37.8%)
Geometry	2 (5.4%)	3 (8.1%)	0	5 (13.5%)	10 (27.0%)
Algebra	0	6 (16.2%)	0	0	6 (16.2%)
Data Analysis & Probability	1 (2.7%)	3 (8.1%)	0	0	4 (10.8%)
Measurement	2 (5.4%)	0	0	1 (2.7%)	3 (8.1%)
Overall	10 (27.0%)	16 (43.2%)	4 (10.8%)	7 (18.9%)	

Table 2
Interactions Between Mathematics and Music Content Foci in In-Service Teachers' Lesson Plans

n=41	Music Content Focuses
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Math Content Focuses	Listening & Singing	Composing & Performing	Notating	Instrument Designing	Overall
Number & Operation	3 (7.3%)	6 (14.6%)	4 (9.8%)	0	13 (31.7%)
Geometry	0	0	0	4 (9.8%)	4 (9.8%)
Algebra	1 (2.4%)	10 (34.1%)	0	1 (2.4%)	12 (29.3%)
Data Analysis & Probability	0	4 (9.8%)	0	0	4 (9.8%)
Measurement	0	2 (4.9%)	0	6 (14.6%)	8 (24.3%)
Overall	4 (9.8%)	22 (53.7%)	4 (9.8%)	11 (26.8%)	

In terms of mathematics content foci, different percentages for the areas were also found between preservice and in-service teachers' lesson plans. Specifically, 27.0% of preservice teachers' lesson plans targeted geometry but only 9.8% of in-service teachers' lesson plans focused on this mathematics content area. Moreover, experienced teachers' lesson plans had more algebra content than preservice teachers' lesson plans—29.3% versus 16.2% respectively. In-service teachers' lesson plans also focused more often on measurement-related content than preservice teachers' lesson plans—24.3% versus 8.1% respectively. The content area of data analysis and probability had the least number of lessons, with both preservice and in-service teachers' lesson plans having less than 10% of their lessons focused on this content area—perhaps indicating the teachers' own discomfort with teaching this content area.

Interdisciplinary music-mathematics instructional processes. The instructional processes presented within the preservice and in-service teachers' lesson plans were also analyzed. Specifically, the instructional sections within the lesson plans were independently analyzed and compared across: (1) the objective of integrated music-math; (2) the rationale of music-math integration; (3) a guided sequence for students' investigation; (4) math pedagogy based on music activities; and (5) math pedagogy that transcended music activities. In all sections of the lesson plans the in-service teachers demonstrated higher percentages of achieving these instructional processes compared with the lesson plans generated by preservice teacher.

Table 3

Interdisciplinary Music-Mathematics Instructional Processes Coverage in Lesson Plans

Music-Math Integrated Lesson Plans Provided:	Preservice Teachers' Lesson Plans (n=37)	In-service Teachers' Lesson Plans (n=41)
The objective of integrated music-math	15 (40.5%)	25 (60.1%)
The rationale of music-math integration	18 (48.6%)	30 (73.2%)
A guided sequence for students' investigation	34 (91.9%)	39 (95.1%)
Math pedagogy based on music activities	17 (45.9%)	38 (92.7%)
Math pedagogy that transcended music activities	13 (35.1%)	27 (65.9%)

Specifically, for *the objective of integrated music-math*, 60.1% of in-service teachers' lesson plans and 40.5% of preservice teachers' lesson plans clearly stated the specific goals of the lessons in regards to what are the concrete mathematics and music goals students are going to

reach. For *the rationale of music-math integration*, 73.2% of in-service teachers' lesson plans and 48.6% of preservice teachers' lesson plans had a section that clearly explained how the music activities were related with the mathematics topics in the lesson. For *a guided sequence for students' investigation*, 95.1% of in-service teachers' lesson plans and 91.9% of preservice teachers' lesson plans provided a detailed route on how to direct students to participate in the activity and provide assistance to help students finish the music-mathematics activities. For *math pedagogy based on music activities*, 92.7% of in-service teachers' lesson plans and 45.9% of preservice teachers' lesson plans proposed to use students' music products as a resource to offer further mathematics concepts or process examples or assign mathematics tasks based on students' own musical works. For *math pedagogy that transcended music activities*, 65.9% of in-service teachers' lesson plans and 35.1% of preservice teachers' lesson plans prepared to introduce, explain, and discuss more advanced topics at mathematically rigorous levels that went beyond the music-mathematics activities.

Discussion

Research analyzing teacher created lesson plans can: (1) provide insight into the linkages between the instruction that will be delivered to students in the classroom and the requirements from the curriculum guides and (2) help calibrate the alignment between teaching objectives and instructional practices (Stein, Remillard, & Smith, 2007). Teachers that integrate the arts into their curriculum encourage the transfer of student learning from the arts to non-arts areas (Catterall, 2005). This might partially alleviate the dearth of art in schools that has resulted due to the impact of high-stakes, standards-based tests increasingly marginalizing those content areas that are not prioritized on the tests. With a goal of investigating the lesson plans that the participating teachers created through interdisciplinary approaches, this study examined and compared preservice and in-service teachers' content foci and instructional processes in strategizing mathematics-music integrated pedagogy into their own original lesson plans. Findings from this study were consistent with existing studies—that there exist a number of ways to present mathematics lessons through music activities and most mathematics content areas can be associated with multiple music content areas (An, Capraro, & Tillman, 2013). Further, this study contributed to the literature by highlighting findings that examined the differences between preservice teacher and in-service teachers' lesson plans in terms of both content foci and instructional processes.

Coherences Across Preservice and In-Service Teachers' Lesson Plans

Analyses of the 78 lesson plans collected from the study participants presented a picture of lesson plans developed by preservice and in-service teachers on the overlaps between music and mathematics—with the goal of supporting students in comprehending, investigating, and applying mathematics through different routes. For those lesson plans that focused on the same music content areas, the sequencing and structuring procedures for teaching mathematical topics were more consistent than in those focused on different musical content areas. For example, the lesson plans in which music *listening and singing* were utilized as the music-mathematics integration foundations, usually located the music activity: (A) at the beginning of the class as a

means to create an entertaining learning environment for the students or (B) at the end of the lesson as a means to summarize key mathematics concepts, vocabulary, and formulas in a manner memorable to students. Similarly, the lesson plans in which music *composition and playing* were utilized as the music-mathematics integration foundations, usually located the music activity in the middle of the lesson by providing students opportunities to explore patterns, conduct experiments, and analyze data through inquiry based learning.

The coherence in the lesson plans is evidenced not only in terms of how and when to introduce mathematical concepts through music-themed activities but also in the structuring of classroom instruction processes that utilized music activities to contextualize and conceptualize mathematics content areas. Theorizing across the pedagogical methods presented in the lesson plans resulted in recognition of numerous mathematical processes—including (1) *problem solving*, (2) *reasoning and proof*, (3) *communication*, (4) *connections*, and (5) *representation* (NCTM, 2000)—that were emphasized within the lesson plans as bridges for linking various mathematics content with music content areas. The connections between music and mathematics are deep—algebra, geometry, and measurement all appear in musical notation, composition, and instrument designs processes (Fauvel, Flood, & Wilson, 2006; Harkleroad, 2006; Loy, 2006). However, in order to develop music and mathematics content as overlapping pedagogical resources that enable students to understand mathematics, music-mathematics activities must be developed into viable mathematics lesson plans. In the current study, interdisciplinary music-mathematics lessons plans were developed by both in-service and preservice teachers', and these lesson plans were designed to help students: (1) solve mathematics problems that were based on the students' own musical works; (2) apply mathematical concepts to create their own musical works; (3) share ideas with their group members and classmates through applying mathematics to creating music; (4) find connections among various mathematics and musical-themed content areas; and (5) represent mathematical ideas in multiple ways including musical notating, singing, playing, composing, and instrument designing.

Superficial Versus Sophisticated Music-Mathematics Integration

As reported earlier in the results section, preservice and in-service teachers' lessons plans differed in selection of content areas for both music and mathematics: 37.8% of preservice teachers versus 19.6% of in-service teachers' lessons plans used musical *singing and listening* or *notating* as the activity to present mathematics content. Similarly, 62.2% of preservice teachers versus 80.4% of in-service teachers' lessons plans applied music *composition and playing* and *instrument designing* as the activities to present mathematics content. This difference might be interpreted as indicating the more experienced teachers' lessons plans were constructed based on a more sophisticated level of pedagogy, as opposed to the preservice teachers' more superficial level of music-mathematics integration.

Generally, musical *singing and listening* and *notating* were the two types of musical content areas that teachers attempted to utilize contextualized mathematics. However, many of the strategies employed by preservice teachers to relate these kinds of music activities to students' understanding of mathematics were fairly limited in scope, with only limited connections offered between the music and mathematics or music elements utilized only for entertainment purposes. Other lessons sometimes used music topics as a cover-story for introducing mathematics but did not entail explicit presentation of any authentic connections.

Different from the superficial level music-mathematics integrations of *notating*, the lesson plans that were developed based on musical *composition and playing* and *instrument designing* in most cases offered a deeper level of music-mathematics integration at a more sophisticated level. In addition to providing an enjoyable learning environment for students, these two types of music activities were designed to allow students to: (1) explore mathematics such as algebraic patterns and geometrical patterns within existing musical works and (2) apply mathematical concepts such as measurement and data analysis to the creation of original music and musical instrument designs. Along with a focus on more sophisticated connections between music-mathematics integration, a wider variety of mathematics content topics were explored through these kinds of music-themed activities. For example, our analysis found that while *notating* only related within the lesson plans to *numbers and operations*, *composition and playing* as well as *instrument designing* activities were both found to be related within the lesson plans to all five mathematics content areas.

These differences in music and mathematics content foci among the types of music-themed activities also occurred with the differences in teachers' instructional processes. As we reported previously in the results section, all segments of the lesson plans from the in-service teacher participants demonstrated higher percentages of mathematics content coverage compared with the lesson plans from preservice teacher. To illustrate this point, more than half of the preservice teachers' lesson plans failed to provide an explicit rationale for music-mathematics integration or use students' musical products as a resource for further teaching. In contrast, most in-service teachers' lesson plans contained a written description of the rationale for music-mathematics integration within the lesson plans, as well as utilized artifacts from the music activities as part of the instructional processes planning. Explanations for these differences between the in-service and preservice teachers can be interpreted from the perspective of content foci connections and differences demonstrating pedagogical maturity—meaning that if some of the preservice teachers only proposed to use music activities at superficial levels such as singing a math song, it may be because they don't yet have the pedagogical skills development needed to generate more sophisticated lesson plans.

Conclusion and Educational Implementation

This study investigated in-service and preservice teachers' lesson plans on the topic of mathematics and music integration. Analysis of the results showed that 78 lesson plans were developed in total by the teachers, demonstrating 15 different ways to link music and mathematics content areas. However, preservice teacher and in-service teachers' lesson plans showed differences in content selections for both music and mathematics and such content differences also correlated with differences in the instructional processes coverage. Although no data was analyzed in the present study to demonstrate the pedagogical effectiveness of the integrated music-mathematics lesson plans investigated, the current study nonetheless identified the existence of potential opportunities for teachers to facilitate their students' understanding of mathematics through different types of musical approaches. The findings from this study invite further longitudinal research on the impacts from classroom implementation of music-mathematics integrated lessons, as well as the effects of this type of curriculum on students' dispositions towards and achievement in mathematics. The findings also invite further interdisciplinary curriculum research and development expanding beyond music-mathematics

integration to a broader relationship between the arts and the sciences—including potentially the visual arts, drama, and dance being intertwined as creative elements across the STEM (science, technology, engineering, and mathematics) fields.

The first and foremost objective of teacher education and professional development is to support the crafting of high-quality pedagogical capability. Research on developing, implementing, and evaluating lesson plans that teach students through innovative, interdisciplinary means is intended to contribute to an increase in opportunities for students to learn by making connections to their existing knowledge through guided explorations, meaningful activities, and authentic experiences. By examining the utilization of music-themed activities as a resource for developing interdisciplinary lessons, this study aimed to serve the effort to support teachers in developing pedagogical approaches for associating mathematics concepts with problem-solving activities, simulations, discoveries, contextualized challenges, and games—an effort that may in turn reshape teachers’ beliefs and attitudes about teaching mathematics (Bursal & Paznokas, 2006; Vinson, 2001). The music-mathematics integrated teaching strategies identified and examined in the current study is most certainly not a comprehensive typology, but instead includes some of the many possible pedagogical opportunities that teachers can explore as they approach the goal of teaching school subjects like mathematics in innovative ways.

As Blumenfeld-Jones (1997) commented about the value of arts in education, “all of those interested in the arts and in aesthetic education ought to find opportunities to come together in order to find an honored place for the imaginative— for the opening of possibilities — in our classrooms and in public spaces, wherever they exist” (p. 66); our current study provided evidence that music not only has an aesthetical value as a form of art that students can create their own work connecting imaginations and reality but also can be used as an educational resource for teaching school subjects, such as mathematics, through innovative experiences. The results in the current study contribute an alternative model for mathematics teachers to build their pedagogical content knowledge: teaching mathematics linked with music is a new strategy to design and teach mathematics lessons effectively in an enjoyable way with sense-making. The current study is part of a line of curriculum inquiry that appears to be gaining increasing empirical evidence for the effectiveness of curriculum theories that advocate for arts-based and/or arts-integrated curriculum development (e.g., Blumenfeld-Jones, 1995, 2008; M. Greene, 1995, 2001; Slattery, 1995; Springgay, 2005). The results from our study provided more evidences to confirm that the curriculum development during the postmodern era is not a simple and routine procedure by listing contents that students supposed to learn but an extremely complex process involving numerous components in the existing society throughout the reconceptualization movement.

Pinar (2004) in his book, *What is Curriculum Theory?*, claimed that the standardization of education is one of the most important nightmares in the current education, which seriously harmed the fundamental principle of academic freedom. In this “standards-based” era—when standardized assessment is in all education systems for evaluating students, teachers, principals, and schools—arts are marginalized in the school curriculum, and the value of arts are ignored (Oelkers & Klee, 2007). We agree with Pinar’s (2004) perspective that the standardization of education limited the “complicated conversation” between teachers and students. The essential difference between students and the manufactured products is the diversity among the students. As Pinar (2004) proposed that the intelligence will be limited and even damaged without arts experiences: the goal of education is not to train test-takers but to teach students how to acquire

knowledge and seek truth in the real life. We believe the school curriculum should have enough flexibility to facilitate all students with various characteristics to learn through different approaches, and the school should not be a place to remold all the students into the same shape. Rather, school should be a place to identify student's unique characteristics and strengths then develop these characteristics in order to help students have enough ability to acquire and analyze beauty in the future.

Acknowledgements

This research is based upon work supported by the National Science Foundation under Grant No. HRD-1342038. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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