Fostering Elementary Students’ Mathematics Disposition through Music-Mathematics Integrated Lessons

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Abstract: Two classes of third grade students \( n=56 \) from an elementary school located on the western coast of the United States participated in this research study. A pretest-posttest control group design was utilized to examine changes between two groups of participating students’ in mathematics achievement and dispositions, including beliefs about success, attitude, confidence, motivation, and usefulness. The students in the music group received music-mathematics integrated lessons, while the students in the control group received traditional lecture and textbook based mathematics instruction. Analysis of the results demonstrated that despite statistically equivalent pretest scores prior to the intervention, after the intervention the music group students had statistically significantly higher positive mathematics dispositions scores than their non-music group peers. These findings provide empirical evidence that there are advantages to teachers utilizing music-themed activities as a context for offering students the opportunity to learn mathematics in a challenging yet enjoyable learning environment.

Keywords: music-math integrated curriculum, mathematics disposition, innovative mathematics instruction, and interdisciplinary education.

Introduction

Researchers studying mathematics pedagogy have identified numerous drawbacks to the traditional instructional methods and curriculum employed to teach students mathematics in the United States, including students generally exhibiting low mathematics achievement while often developing mathematics-related anxiety (Furner & Berman, 2005; Scott, 2005; Vinner, 1997). Traditional mathematics instruction primarily consists of assigning the same problems to every student, lecturing content from the textbook, insisting on one correct way to solve problems, and neglecting students’ conceptual understanding. The Equity Principle has been established by the National Council of Teachers of Mathematics (NCTM, 2000) to encourage math teachers to develop methods for supporting all of their students including those that are historically underserved such as women and minorities. Strategies recommended by NCTM for achieving the Equity Principle include: developing students’ conceptual understanding through the use of problem-solving activities, challenging game-themed activities, and using models and simulations to encourage discovery, might have the potential to increase students’ mathematics achievement and positive dispositions towards mathematics (NCTM, 2006; Tobias, 1998). Interdisciplinary activities that integrate mathematics education into engaging contexts such as music provide an opportunity for students to understand and apply mathematical knowledge in a
meaningful environment, and have been shown to facilitate students’ learning of mathematics (An, Capraro, & Tillman, 2013; Costa-Giomi, 2005; Omniewski & Habursky, 1998).

There are numerous links between music and mathematics. Mathematical concepts such as numerical relations, proportions, integers, logarithms, arithmetical operations, trigonometry, and geometry are related to musical elements such as melody, rhythm, intervals, scales, harmony, and tuning (Beer, 1998; Harkleroad, 2006). These naturally occurring overlaps between music and mathematics offer opportunities for teachers to demonstrate mathematical concepts and processes through music-themed activities (An, Ma, & Capraro, 2011). During the past two decades researchers have pursued a line of inquiry into outcomes for students resulting from including music activities in mathematics instruction (e.g., An, Kulm & Ma, 2008; Benes-Laffety, 1995; Bilhartz, Bruhn, & Olson, 2000; Costa-Giomi, 1999; Omniewski, 1999). These studies have provided empirical evidence that music has the potential to improve students’ mathematics achievement and attitudes. Continuing the line of inquiry explored in these previous studies, the current study examined a sequence of classroom activities integrating mathematics education into an authentic music-themed context. Specifically, the current study investigated the effects of integrating music activities into formal classroom mathematics lessons with a group of third grade students, and determined any changes in their dispositions towards learning mathematics.

**Literature Review**

**Mathematics Dispositions and Performance**

The emotional experience of mathematics learners during education is a crucial element of their learning, and a student’s ability to focus on learning can be motivated by positive emotions (Sylwester, 1995). Regrettably many mathematics teachers neglect the development of students’ positive mathematics dispositions, instead solely emphasizing developing students’ procedural fluency and strategic competence (Kilpatrick, 2001). Previous studies have shown that negative dispositions toward mathematics were widely identified among not only middle school and high school students but also among lower elementary students and even kindergarteners (Rameau & Louime, 2007). Students with negative mathematics dispositions displayed significantly higher levels of anxiety towards mathematics than their peers, and generally demonstrated lower confidence with mathematics and less motivation to learn mathematics (Ashcraft, 2002; Tobias, 1998).

There are multiple explanations for the potential causes of negative mathematics dispositions, including the decontextualization of content that often occurs during traditional teaching methods (Geist, 2010), and a dearth of opportunities for students to develop their own conceptual understanding (Furner & Berman, 2005). Previous studies have identified that traditional teaching methods often lead to students’ negative mathematics dispositions because of a tendency to: (a) assign the same problem to every student, (b) teach by lecturing from the textbook, (c) insist on only one way to solve a problem, (d) neglect real-world applications, (e) emphasize rote memorization and repetition, and (f) primarily aim to improve scores on standardized multiple-choice tests (Tobias, 1998; Tsui & Mazzocco, 2007). Furthermore, past negative experiences with mathematics education, such as deficits of conceptual understanding requiring remediation and previous math teachers that were unempathetic to those struggling with the subject, can contribute to students entering a math classroom with preformed negative
dispositions that are difficult to undo (Beilock, Gunderson, Ramirez, & Levine, 2010; Geist, 2010).

Previous studies examining the origins of negative mathematics dispositions have found correlation with a variety of other undesirable mathematics learning outcomes, including poor mathematics achievement and detrimental mathematical behaviors (Ma, 1999; Ashcraft, 2002; Tobias, 1998). Specifically, students with negative mathematics dispositions tend to avoid mathematics-related activities such as attempting challenging mathematics problems or investigating more advanced mathematical concepts, which in turn has a negative impact on these students’ decisions regarding classes and career choices that involve mathematics (Ho et al., 2000). To develop and maintain students’ positive dispositions towards mathematics, teachers should incorporate multiple instructional approaches emphasizing real-life contextualized activities that build conceptual understanding and application (Bursal & Paznokas, 2006). Methods that have been found effective include teaching mathematics in non-traditional ways, such as using problem solving activities, simulations, challenges, discoveries, and games (Geist, 2010). Offering students interdisciplinary mathematics education is one recognized strategy for developing students’ mathematics dispositions and content knowledge, with recognized benefits including: (1) motivating students to engage in reflection, (2) providing students with a context for real-world inquiry, and (3) facilitating students in making connections between their newly acquired knowledge and their existing knowledge (Ellis & Fouts, 2001; Hargreaves & Moore, 2000).

Teaching Mathematics through Music

Teaching mathematics integrated with music not only improves students’ attitudes toward learning mathematics by teaching it in a meaningful and engaging context that is relevant to the students (An & Capraro, 2011), but also increases students’ mathematics achievement because they are offered multiple approaches to understanding and applying mathematical concepts (Cox & Stephens, 2006). Music can assist students in developing an understanding of mathematics concepts by encouraging them to have diverse cognitive and affective experiences (Selwyn, 1993). Learners who are intrinsically motivated to learn mathematics are prone to exhibit initiative, independence, sense making, and enjoyment in learning mathematics (Csikszentmihalyi, 1996). For example, performing and analyzing original musical works can be used as a resource for teachers aiming to present and design mathematical problems in non-routine ways, as well as for students to connect existing and advanced mathematical knowledge in meaningful ways (Fiske, 1999).

Learning mathematics in a music-based interdisciplinary curriculum has provided students with opportunities to comprehend the world from a different perspective, leading to success in mathematics (Gamwell, 2005). Learning mathematics associated with music can help students complete the transferring of mathematical knowledge from other content areas (Johnson & Edelson, 2003). One result from learning mathematics in a music context is that students can develop a wider understanding of the interconnections between school subjects (Hargreaves & Moore, 2000). Learning core school subjects such as mathematics within a music context has enabled students to go beyond artificially established disciplinary boundaries, and venture into exploring interdisciplinary overlap (Parsons, 2005). By providing opportunities to participate in
creativity during the learning process, mathematics lessons integrated with music can also increase students’ intrinsic motivation to learn mathematics (Glastra, Hake, & Schedler, 2004).

Previous studies have investigated ways of integrating music themed activities into mathematics instruction as a means for improving students’ achievement and attitude toward mathematics. Findings from these studies indicated that music had a positive impact on the participating students’ mathematics achievement and attitudes (An, Kulm, & Ma, 2008; An, Ma, & Capraro, 2011; Benes-Laffety, 1995; Bilhartz, Bruhn, & Olson, 2000; Costa-Giomi, 2005; Omniewski & Habursky, 1998). Most of these studies were conducted in either laboratory or informal education settings, with results indicating that music is a context that students find authentically engaging, with corresponding increased motivation to learn due to the meaningfulness of the activities (Costa-Giomi, 1999; Rauscher et al., 1993, 1995, 1997). However, only a few studies investigating music activities as a context for teaching mathematics instruction have been conducted within a formal classroom setting (Cox & Stephens, 2006).

Building upon the results from this previous literature, the present study examined an intervention characterized by a sequence of classroom music activities providing a context for teaching mathematics integrated with music. The overarching goal of the current study was to increase understanding of effects from music-mathematics integrated instruction and curriculum upon elementary students’ mathematics dispositions. Two specific research questions guided this study: (1) What were the results from comparing the pretest and posttest mathematics dispositions of 3rd-grade students who experienced a music-math intervention? (2) What were the results from comparing mathematics dispositions of 3rd-grade students who experienced a music-mathematics intervention compared to their counterparts who experienced traditional lecture based mathematics instruction?

Method

Setting and Participants

As part of a larger project dedicated to improving elementary teachers’ knowledge of teaching mathematics and students’ mathematics achievement and dispositions, the current study emphasized investigating the effects of teaching mathematics through interdisciplinary approaches on students’ dispositions. The study took place at an elementary school from a large unified school district within a metropolitan area located on the western coast of the United States. At the time of the study, the elementary school served approximately 700 students from kindergarten through 6th-grade, with around 60% of the student body having Asian ethnicity. The majority of students were from middle class families, with only 8% of students attending this school belonging to the reduced/free-lunch program.

Participants in the current study included two third grade classes with 28 students each, one of which was assigned to participate as the experiment group and one as the comparison group. Prior to the start of the school year, the students were randomly assigned to each classroom. The group randomly selected to serve as the music intervention group consisted of 15 boys and 13 girls, with ethnicities of 19 Asians, 2 African Americans, 2 Caucasians, and 5 Hispanics. Among the students in the music intervention group, 14 were English language learners at the intermediate, early-advanced, or advanced language levels. In the control group, there were 14 boys and 14 girls, with ethnicities of 18 Asians, 3 African Americans, 2
Caucasians, and 5 Hispanics. Among all the students in the control group, 12 were English language learners at the intermediate, early-advanced, or advanced language levels.

Two female elementary school teachers who taught at the target school volunteered to participate in the present study. Each teacher was randomly assigned to one of the two classrooms, and teacher A was assigned as the treatment group teacher while teacher B was assigned as the comparison group teacher. Both teachers had nearly identical patterns of student achievement on the end of grade California State Test, as well as similar teaching backgrounds based upon historical analysis of their teaching files. Specifically, teacher A had 11 years of 3rd-grade teaching experience while teacher B had 9 years of 3rd-grade teaching experience. Additionally, both teachers attended annually an approximately equivalent number of hours of regular teacher professional development programs offered by the school district, as well as workshops offered by professional organizations such as the National Council of Teachers of Mathematics (NCTM) and the California Mathematics Council (CMC).

Prior to beginning the intervention, both teachers were: (1) offered a series of workshops (total of 10 hours per teacher) demonstrating how a variety of music activities can be incorporated with different mathematics content areas to develop mathematics-music integrated lessons, and (2) assigned to develop and implement music-themed mathematics lessons. These professional development workshops were led by college professors and had the support of the authors of this paper. During these workshops, the teachers were provided a music-mathematics curriculum and additional related resources such as musical instruments and mathematics manipulatives for them to develop their own music-mathematics integrated lessons as a part of their regular mathematics teaching component.

Research Design

A random assignment pretest-posttest control group design (Shadish, Cook, & Campbell, 2002) was used to examine changes in mathematics dispositions between the two groups of participating students. One class was randomly assigned to learn from the teacher utilizing music-mathematics integrated lessons; the other class was assigned to the teacher using standard mathematics lessons. As Shadish and his colleagues (2002) showed, a randomized experiment is the preferred design for obtaining unbiased precision estimates of the effects from an intervention. The random assignment in the current study helped to neutralize any differences between the two groups, reducing the potential for alternative causes confounding the impacts assessed from exposure to the music-mathematics intervention. A pretest was administered to students in both groups to assess their mathematics dispositions before the intervention. The aim of the pretest was to investigate if the two groups initially differed from each other, and to identify whether there was any pretest difference which may lead a selection bias (Shadish et al., 2002).

Intervention Procedures

Non-Music Group’s Curriculum and Instruction. For non-music group students, the teacher provided mathematics lessons based on traditional curriculum and implemented mathematics lessons by using the regular method of instruction that did not involve any music related activities, but instead used the textbook adopted from the school district. The lessons
taught to this group covered all the required mathematics content areas based on the State’s Mathematics Standard for 3rd-grade. The teacher leading the non-music group took a teacher-centered approach for delivery of mathematics lessons, with her instruction often starting with a lecture based on the new content in the textbook, followed by assigning in-class mathematics practice activities from the textbook and upcoming homework. Compared with the music group students, for the non-music group students received less opportunities to perform interdisciplinary activities, and no music-mathematics integrated activities were provided during their regular mathematics lessons.

**Music Group’s Curriculum and Instruction.** The present study utilized an interdisciplinary curriculum consisting of a series of music-mathematics integrated activities as the intervention, providing students opportunities to experiment with, practice, and apply mathematics concepts and skills through hands-on lessons (An & Capraro, 2011). The teacher leading the music-group assisted the research team in designing music activities that integrated with her regular mathematics lessons, and then taught the lessons over a nine-week period. During this intervention period, a sequence of 14 music-integrated mathematics lessons (see Appendix A) was introduced to the music-group 3rd-grade students. Each of these individual music-mathematics integrated lessons was focused on at least one major mathematics content area (see sample lesson plan in Appendix B).

The two chief music activity themes that the music-group teacher incorporated into her mathematics lessons were music composition and music playing. In the music-mathematics integrated lessons, students had opportunities to use graphical notation such as color-cards representing musical notes, with a variety of musical instruments such as handbells, drums, musical sticks, and keyboards, as mathematics learning manipulatives. The students were provided with pre-composed musical pieces, which they used to learn mathematics by investigating some of the fundamental components of musical theory. Students had multiple opportunities to share their emergent knowledge of mathematics concepts with their classmates, often during music-themed small group activities. As an illustration, during a mathematics lesson involving composing original music, color-cards were provided to the students as a tool enabling them to quickly compose their own music based on the color patterns they created. The students would then use colored handbells to perform their original music compositions for their classmates, both learning and demonstrating the mathematical concepts corresponding with the color patterns they had utilized.

**Instrument and Data Collection**

The mathematics disposition survey used in this study was adapted from the Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976) but because Fennema and Sherman’s test was designed for high school students, the current study developed a modified version of this attitude test through consultation with elementary teachers and experts in assessment in this area. Changes performed included such as operations as simplifying the vocabulary in order to facilitate unbiased elementary student responses to the survey items. After consultation with experts and several iterations of changes, the final modified survey included 36 items covering the following six themes: (1) mathematics success, (2) mathematics attitude, (3) mathematics confidence, (4) mathematics motivation, (5) mathematics usefulness, and (6) mathematics beliefs. So as to strengthen internal validity, each theme had six items. A five-point
Likert scale was used on the survey for each item, with participants choosing a single picture within the range from big-smile-face (indicating score of 5), small-smile-face (4), no-smile-face (3), small-frown-face (2), and big-frown-face (1). Such illustrated symbols are often used as response options in children’s surveys (e.g., Fello, 2010; McKenna & Kear, 1990) with these five symbols illustrating the corresponding opinions of “Strongly Agree,” “Agree,” “Neutral”, “Disagree,” and “Strongly Disagree” respectively. The overall alpha reliability coefficient of the mathematics disposition survey was 0.852, and samples from the final survey items are displayed in Table 2.

The data collection was conducted during regular class meetings, with the pretest dispositions survey collected from the participating students one week before the intervention, and an identical posttest dispositions survey collected from the students one week after the intervention. In order to ensure that the students fully understood the meaning of each of the items on the survey during the pretest and the posttest, during the dispositions assessments the two teachers adhered to the following structured process for administering the assessment to their students with four steps. Firstly, the teacher used a projector to show her students each individual survey item while simultaneously reading them the item using a loud voice. Secondly, the students then quietly re-read the individual survey item to themselves and marked their response on the survey instrument. Thirdly, the teacher walked around the classroom and offered assistant to any individual students who appeared to need additional help understanding the survey item. Finally, once the teacher was confident that all students had understood and completed the survey item, she would then switch to the next individual survey item from the survey and repeat the process again until all of the survey items were finished. Both groups of students each utilized approximately 30 minutes to complete the pretest survey, as well as about the same amount of time to complete the posttest survey.

Data Analysis

Prior to running any statistical analyses, the original alpha value to determine significance of .05 was adjusted into .0083 (Thompson, 2006) to account for the six analyses (e.g., mathematics success, mathematics anxiety, mathematics confidence, mathematics motivation, mathematics usefulness, and mathematics beliefs). For the mathematics disposition survey, total scores were calculated for all six factors, using a score of 5 for “Strongly Agree” through 1 for “Strongly Disagree” which was the lowest level of agreement within the response options.

As stated earlier, one chief research question guiding this study was aimed at understanding if there were any significant differences between the two groups regarding changes in mathematics disposition after the intervention. The other chief research question was aimed at understanding if there were any differences in mathematics dispositions within the music group from before to after the intervention. Prior to the intervention, a t-test analysis indicated that the participating students in the two groups did not significantly differ in their mathematics dispositions, and that therefore subsequent comparisons of the groups would be based on a similar starting point. To address the first research question, paired sample t-tests were performed comparing changes between pretest and posttest of students’ mathematics disposition scores within the music group, as well as within the non-music group. To address the
second research question, an independent $t$-test was used to compare posttest mathematics disposition scores between the music group and non-music group.

**Results**

The results of students’ mathematics dispositions were compared at two different levels. At the macro-level, the examination of differences in mathematics dispositions between students who experienced the music-mathematics intervention versus their counterparts who experienced traditional lecture-based instruction demonstrated that the music group students had a statistically significant higher disposition score than their non-music peer group. In particular, analysis of the posttests revealed that the music group students had statistically significantly higher scores in mathematical dispositions than the non-music group students after the intervention ($p<0.001; t=5.79$), meaning that the music group had more positive attitudes about mathematics than the non-music group. On the posttest the music group students had significantly higher scores than the non-music group students on five out of six disposition areas including mathematics confidence, attitude, usefulness, success, and beliefs. A practical significance test using Cohen’s $d$ determined there were small effect sizes between the music group and non-music group during pretest comparisons, but within the posttest comparisons there were large effect sizes found between music group and non-music group. As an illustration, a small effect size was found between music group and non-music group within pretest on the overall disposition scores ($d=0.19$), while middle to large effect sizes were found between the music group and non-music group within posttest comparison of both the overall disposition scores ($d=0.1.37$), as well as of all the specific disposition areas which had a range of effect sizes from 0.49 to 2.00 (see Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Music Group</td>
<td>Non-Music Group</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>3.41 ± 0.51</td>
<td>3.51 ± 0.55</td>
</tr>
<tr>
<td>$p$ &amp; $t$ Values</td>
<td>0.65 (-0.22)</td>
<td>&lt;0.001 (5.79)</td>
</tr>
<tr>
<td>Cohen’s $d$</td>
<td>0.19</td>
<td>1.37</td>
</tr>
</tbody>
</table>

At the micro-level, examining the specific changes between pretest and posttest in mathematics dispositions for the music group students within each of the areas (e.g., mathematics confidence, attitude, usefulness, success, motivation, and beliefs) showed that the music group students demonstrated a statistically significant higher disposition score in the posttest than pretest in all six mathematics disposition areas measured (see Table 2). Specifically: (1) For the disposition theme of confidence, the results of the paired $t$-tests showed that there were statistically significant improvements from pretest to posttest ($p<0.001$, $t=3.87$). (2) For the
disposition theme of attitude, the results of the paired t-tests showed that there were statistically significant improvements from pretest to posttest ($p<0.001$, $t=6.24$). (3) For the disposition theme of usefulness, the results of the paired t-tests showed that there were statistically significant improvements from pretest to posttest ($p=0.016$, $t=4.45$). (4) For the disposition theme of success, the results of the paired t-tests showed that there were statistically significant improvements from pretest to posttest ($p=0.004$, $t=2.58$). (5) For the disposition theme of motivation, the results of the paired t-tests showed that there were statistically significant improvements from pretest to posttest ($p<0.001$, $t=3.87$). (6) For the disposition theme of beliefs, the results of the paired t-tests showed that there were statistically significant improvements from pretest to posttest ($p<0.001$, $t=5.90$). To determine practical significance, Cohen’s $d$ values were calculated for each of the six specific disposition areas, and it was determined that all six areas had medium-large to large effects sizes, with their specific Cohen's $d$ values ranging from 0.74 to 1.98.

### Table 2

**Comparison of Results within Music Group for Each of the Disposition Themes**

<table>
<thead>
<tr>
<th>Disposition Themes</th>
<th>Pretest Mean ± SD</th>
<th>Posttest Mean ± SD</th>
<th>Sample Items</th>
<th># of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence</td>
<td>3.61 ±1.01</td>
<td>4.39±0.65</td>
<td>I am sure I can learn math.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$p$ &amp; $t$ values</td>
<td>&lt;0.001 (3.87)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cohen's $d$</td>
<td>0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitude</td>
<td>2.96±0.63</td>
<td>4.13±0.78</td>
<td>Math scares me sometimes.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$p$ &amp; $t$ values</td>
<td>&lt;0.001 (6.24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cohen's $d$</td>
<td>1.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usefulness</td>
<td>3.54±0.79</td>
<td>4.66±0.40</td>
<td>I need math for my future work.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$p$ &amp; $t$ values</td>
<td>0.016 (4.45)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cohen's $d$</td>
<td>1.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>3.92±0.74</td>
<td>4.66±0.52</td>
<td>I feel proud to be the best student in math.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$p$ &amp; $t$ values</td>
<td>0.004 (2.58)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cohen's $d$</td>
<td>1.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivation</td>
<td>3.58±0.96</td>
<td>4.27±0.90</td>
<td>I would like to do more math in school.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$p$ &amp; $t$ values</td>
<td>&lt;0.001 (6.45)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cohen's $d$</td>
<td>0.744</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belief</td>
<td>2.83±0.70</td>
<td>3.85±0.46</td>
<td>I need lots of natural ability to learn math.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$p$ &amp; $t$ values</td>
<td>&lt;0.001 (5.90)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cohen's $d$</td>
<td>1.98</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Discussion

The overall findings indicated that for mathematics dispositions, the music group students statistically significantly improved from pretest to the posttest; while the non-music students did not show statistically significant improvement from pretest to the posttest. Moreover, the music group students’ mathematics dispositions in the posttest were statistically significantly higher than the non-music group students. These findings specified that throughout the 9-week intervention of participating music-mathematics integrated lessons, the music group students
positively changed their mathematics dispositions. In this study, aesthetics was explored by the teachers as a methodology to provide a rich and emotionally stimulating mathematical learning context, and the overall finding were consistent from previous findings that arts themes lesson can reduce students’ mathematics anxiety and engage students through creative and active involvement in mathematics learning (e.g. Eisner, 2002; Sylwester, 1995; Upitis & Smithrim, 2003; West, 2000; Witherell, 2000).

The overall findings were consistent with pervious findings on the positive impact of music integrated mathematics activities, lessons and curriculum on students’ mathematics dispositions (An, Kulm, & Ma, 2008; An, Ma, & Capraro, 2011; Benes-Laffety, 1995; Catterall & Waldorf, 1999), significant positive shifts in disposition through the intervention compared with their non-music group peers. In the current study, the music group students improved their confidence and motivation by having mathematics lessons within an enjoyable learning environment associated with music. In addition, the music group students developed a positive disposition about the usefulness and success of mathematics by exploring the relationships between music and mathematics along with completing various mathematics problems based on their own musical works. Several possible reasons will be proposed in the following paragraph to explain the findings in this study.

First of all, in the highly motivational learning environment created based on music activities, the music group students were aesthetically engaged. Throughout the intervention period, students’ development of engagement in mathematics demonstrated three distinct levels: (a) in the beginning, their original interests in and previous musical experiences along with their curiosity toward the relationship between music and mathematics engaged them to participate in the music-mathematics integrated lessons; (b) the pleasant musical composition experiences of using colorful cards and playing handbells and other musical instruments further engaged students to participate in mathematics activities; and then (c) through this engagement, students participated in closely related mathematical tasks throughout their music related experiences.

Secondly, during the same period of time that the music group students enhanced their engagement in mathematics, their confidence toward mathematics learning also improved. During the mathematics lesson, the music group students experienced the power of mathematics in an aesthetic creation process -- mathematics knowledge in various content areas can be used to create music as well as design musical instruments. As students experienced the beauty of both music and mathematics through their own musical compositions, playing and listening as well as the musical instrument designing processes, their perceived and excited feelings possibly motivated their learning behavior while participating in mathematics tasks by exploring and investigating mathematical concepts associated with music. Moreover, during the sharing of musical works while discussing mathematical tasks, classmates revealed and recognized each other’s potential capacities. A strong sense of participants’ personal discovery emerged as they constructed and explored meanings through their own works, thus their motivation and confidence in learning mathematics was further enhanced.

Moreover, throughout the whole process of using mathematics to create, play and listen to music, and using mathematics knowledge to answer mathematical tasks constructed from music of their own, participants in this study had multiple opportunities to experience the applications of mathematics in the real life situations such as using mathematical knowledge to compose music and design musical instruments. By completing different music related tasks and solving contextually meaningful mathematical problems in each music-mathematics integrated
activity, students had numerous chances to experience the success of accomplishing music-
mathematics related tasks, mathematics tasks embedded within real life context and pure
mathematical tasks.

Finally, the process of participating in music themed mathematics lessons not only
enriched students’ view of mathematics problem forms but also improved their basic
mathematical procedural fluency and strategic competence. Because all the music themed
activities were integrated as a part of students’ regular mathematics lessons for the music group,
in addition to receiving the regular lessons as the non-music group students, the music group
students also had opportunities to have mathematics lessons through a variety of non-routine
strategies. During the intervention, the music group students have more opportunities to solve a
variety of mathematics problems focused on different mathematical content that contextualized
in music themes, these individualized problems designed based on each student’s own music
compositional works or musical instrument designing further impacted their dispositions.

Conclusions

In this “standards-based” era—when arts are marginalized in the school curriculum,
because unlike mathematics and language arts, music and art are not officially assessed on a state
or national level—students and teachers tend to ignore the value of art (Oelkers & Klee, 2007).
This study provided evidence that music not only has an aesthetic value as a form of art, but also
can be used as an educational resource for teaching mathematics. The results 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 music-mathematics integrated instructional approach in the current study is
distinguished from many previous intervention studies in that they focused only on the effects of
music listening or music instrument learning on student’s mathematics disposition. Rather than
treating music and music related activities as an external stimulation for students’ learning of
mathematics, the current study combined music as a part of a mathematics teaching and learning
component. The music-mathematics integrated program emphasizes a profound association
between music and mathematics. Results suggest that music related activities may be particularly
valuable in mathematics education when teachers seek to provide more effective instructional
strategies. Mathematics teachers who desire to go beyond the traditional teaching approach may
be able to use various types of student-centered activities to facilitate students’ understanding of
mathematics concepts.

Before proceeding to an articulation of conclusions, some limitations to this study should
be noted. One of the possible threats to internal validity was the Hawthorne effect. Because the
teaching approaches were novel for most students in the music group, some improvement in
disposition might be accounted for in their initial interests about the non-traditional learning
experiences. To reduce the Hawthorne effect, 14 music-mathematics lessons were provided to
the music group students and thus most students may become familiar with this instructional
approach after the first few lessons. In addition, because the cluster sampling method was used to
randomly assign two classes of students in the third grade in an elementary school, the findings
may not generalize to other elementary school students who study in different schools and school
districts. However, even with all these limitations, this intervention study provides an
opportunity to observe the benefit of teaching mathematics integrated with music. It is not suggested that the intervention activities that integrated music into mathematics described in this study are a prototype for all classroom activities related to mathematics. The development of mathematical understanding and a positive disposition should not be expected to emanate from an isolationist curriculum, but instead should be designed to connect mathematics content with knowledge and skills from fields other than mathematics, such as music.

The findings obtained in the current study were limited to a curriculum unit of relatively short duration; a logical next step would be to expand to other mathematics content areas at other grade levels. Future work includes case studies in select classrooms, using music-mathematics integrated curriculum and instructional strategies to model the impact of background and implementation variables, analysis of interview data from teachers and students, analysis of the mathematics achievements tests’ particular items with specific content areas, and analysis of students’ behavior from lesson videos. Future studies will also include more students with different background (e.g., more African American and Hispanic students, more low-achieving students) and longitudinal studies with multiple years will also be implemented to investigate the effects of the music-mathematics integrated curriculum and instructional strategies on students’ future mathematics achievements and dispositions.

Educational Implications

With the publication of the *Principles and Standards for School Mathematics* (NCTM, 2000), mathematics educators pay greater attention to the mathematics processes of connection and representation, along with communication, reasoning and proof and problem solving proposed by NCTM. Mathematics learners can discover and understand mathematical ideas by experiencing different kinds of activities with connections made within and outside of mathematics. Music, with its unique features, can be used as a resource for students to make these connections and also as a way for students to represent mathematics in alternative ways. Teachers should take advantage of the opportunities that music offers to help all students learn mathematics in challenging and enjoyable ways (Johnson & Edelson, 2003). We believe that by connecting arts or music into mathematics teaching and learning, elementary students may have more opportunities to improve their mathematics dispositions towards mathematics.

This study is part of a line of research inquiry that appears to be gaining increasing empirical evidence (e.g., Kjellstrom, Tillman, and Cohen, 2012; Tillman, 2011; Tillman et al., 2012) that mathematics educators should adopt and develop a more comprehensive and connected curriculum. Due to a heavy focus on preparing students for high stakes, standards-based tests in K-12 schools, the arts have been increasingly marginalized in the school curriculum. Only those subjects like mathematics and language arts that are officially assessed on a state or national level are given priority in the curriculum (Oelkers & Klee, 2007). The current study provided evidence that music can be used as an educational resource and context for teaching mathematics to elementary students. The results of the current study provide some guidance for the potential scope of future educational research progressing this line of inquiry. First of all, there is a need for additional research studying efforts to enrich preservice teacher education programs, and the optimum supports for effective development of interdisciplinary teaching strategies using varying authentic contexts for mathematics pedagogy. Moreover, there is a need for research studying professional development for inservice teachers that will support
them in developing mathematics pedagogy that makes meaningful connections between mathematics and other subject areas.

It is not suggested that teachers should teach all mathematics content with connections, such as with music. Instead, the development mathematics dispositions should not emanate from a single curriculum or instrumental model, but rather should develop using multiple instructional strategies connected to content other than mathematics, such as music. Moreover, effective teachers should understand that mathematics is connected with other subjects outside of mathematics and can be taught by integrating other content. Thus, teachers’ pedagogical content knowledge of teaching students mathematics with sense-making, especially linked with the arts might provide an alternative way to design and teach an effective lesson. It is suggested that teacher professional development programs should familiarize teachers with various instructional approaches with connection within and outside of mathematics contexts.

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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## Appendix A
Math Content Foci with Corresponding Music Activities from Intervention Lessons

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Math Focus*</th>
<th>Music-Math Integrated Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lesson 1</strong> (week 1)</td>
<td>• NS 3.0  Concept of fraction  Part whole relationship</td>
<td>Music composition (Melody)  Handbell playing  Analysis of musical works</td>
</tr>
<tr>
<td><strong>Lesson 2</strong> (week 2)</td>
<td>• NS. 2.0  Basic fact</td>
<td>Singing  Handbell playing</td>
</tr>
<tr>
<td><strong>Lesson 3</strong> (week 3)</td>
<td>• SDAP 1.0  Statistical table  Statistical graphs</td>
<td>Music composition (Melody)  Handbell playing  Analysis of musical works</td>
</tr>
<tr>
<td><strong>Lesson 4</strong> (week 3)</td>
<td>• SDAP 1.1  Concept of probability</td>
<td>Music composition (Chords)  Handbell playing</td>
</tr>
<tr>
<td><strong>Lesson 5</strong> (week 4)</td>
<td>• NS 2.0  Number line</td>
<td>Piano keyboard playing (Intervals)  Piano keyboard investigation</td>
</tr>
<tr>
<td><strong>Lesson 6</strong> (week 4)</td>
<td>• MG 1.0  Measurement of time</td>
<td>Music composition (Rhythm)  Drums playing  Analysis of musical works</td>
</tr>
<tr>
<td><strong>Lesson 7</strong> (week 5)</td>
<td>• AF 2.2  Algebraic expressions  Concept of variables</td>
<td>Music composition (Rhythm)  Drums playing  Analysis of musical works</td>
</tr>
<tr>
<td><strong>Lesson 8</strong> (week 5)</td>
<td>• SDAP 1.3  Bar graph &amp; circle graph  Pictograph</td>
<td>Music composition (Music Form)  Handbell playing  Analysis of musical works</td>
</tr>
<tr>
<td><strong>Lesson 9</strong> (week 6)</td>
<td>• AF 2.2  Function tables</td>
<td>Music listening  Analysis of musical works</td>
</tr>
<tr>
<td><strong>Lesson 10</strong> (week 7)</td>
<td>• NS 2.0  Problem posing</td>
<td>Music composition (Melody)  Handbell playing  Analysis of musical works</td>
</tr>
<tr>
<td><strong>Lesson 11</strong> (week 7)</td>
<td>• MG 1.0  Perimeter</td>
<td>Musical instrument designing  Investigation of musical instruments</td>
</tr>
<tr>
<td><strong>Lesson 12</strong> (week 8)</td>
<td>• NS 3.0  Equivalent fractions</td>
<td>Handbell playing  Drums playing  Analysis of musical works</td>
</tr>
<tr>
<td><strong>Lesson 13</strong> (week 8)</td>
<td>• AF 2.2  Algebraic expression</td>
<td>Music composition (Harmony)  Handbell playing  Analysis of musical works</td>
</tr>
<tr>
<td><strong>Lesson 14</strong> (week 9)</td>
<td>• MG 1.0  Area</td>
<td>Musical instrument designing  Investigation of musical instruments</td>
</tr>
</tbody>
</table>
Note: The mathematics content foci were based on California State Standards

Appendix B
Sample Music-Mathematics Integrated Lesson Plan (Lesson 13)
Designed by the teacher who volunteered to participate in the present study

Academic Learning Goal
- Students will explore and learn how to compose their own music by creating their own color, number, and letter patterns.

Instructional Materials and Special Setup
- Basic 8 music note color papers written musical names, letters, and numbers
- 6 sets of music composition color pattern packets
- Hand bells, overhead projector

I. Opening
- Use a visual music pocket chart to have students engage in the lesson activity to motivate their inquiry learning.
- Display the song color cards in the pocket chart and ask students to find the patterns in the song. I say to the students, “Today you are going to do a very exciting music integrated math lesson. You are going to create your own color or number patterns to compose your own music. First of all, who can find the patterns in the song in a pocket chart?” Students use their prior knowledge about patterns and find several patterns in a song with class together.
- Teacher explains the close relationship between math and music in a sense that they both consist of a variety of patterns.
- Discuss about more patterns in a song and how students use the color, number, or letter patterns to compose their own

II. Instruction Process

Input
- Review and preview the lesson vocabulary and introduce the lesson materials and activity
- Lesson Vocabulary: music composition

Model
- Explain to the students that they are now going to explore the pattern activities and create their own color patterns. (Cooperative and inquiry-based learning activity)
- The process of the experiment of creating patterns.
  - Pass out a set of color composition papers to each table.
  - Each table creates the color patterns.
  - Students work cooperatively inputting their pattern creation ideas.
  - During the experiment, I, as a teacher, act as a supervisor or a guide for the students to be able to perform the experiment smoothly and productively.

Check for Understanding and address misconceptions and/or the obstacles:
- Teacher walks around and asks students about their pattern creation activity and monitors the student group work smoothly.
- Also, teacher provides the extra support if the table needs help with creating their own patterns.

III. Guided Practice
**Guided Practice**
- Teacher chooses one table’s pattern and performs the color patterns in music using keyboard. Also, teacher uses overhead to show the patterns created by other table. The table members play their own music using hand bells to the class.
- Teacher provides students the feedback of the pattern creation they did and the outcome of their work as music.

**Discuss, Argue, or Proof**
- Discuss about the cooperative learning with kindness. Also, guide students to appreciate the music that is created by their classmates.
- Discuss about the fabulous activity of composing music using color patterns and playing their created music using hand bells.

**IV. Independent Practice**
- The tables who didn’t present show their color patterns to the class and play their patterns using hand bells.
- Teacher provides students the feedback of the pattern creation they did and the outcome of their work as music.

**V. Closure**

**Closure**
- Conclude the lesson by asking questions: “Who wants to share what you learned from today’s lesson?

**Assessment**
- Lesson participation of creating color, number, and letter patterns
- Presentation and performance skills of the composed music using hand bells
- Check with partners – cooperative learning and assessment

**Reflection**
- Based on the assessment results teacher finds out if the students achieved the lesson objectives/standards or not.
- Decide whether the extended activity or the re-teach activity is necessary to meet the students’ needs.

**VI. Differentiating Instruction**
- For ELL Students: Use visuals (color papers) and real life objects (hand bells) to guide them to have the concrete understanding of music composition using color patterns. Pair up with the student who uses the same language. When the class does the independent activities, teacher works with ELL students, using SDAEI strategies.
- For special Ed and low students: When the whole class works on the table activity, teacher works closely with them to provide the extra support to meet their specific needs. Also, always provides hands on materials to support their mathematical reasoning skills.
- For exceptional students: Have them create more complex color patterns and express those patterns into music.
- If time allowed, students might have had more opportunities to create more color patterns and play them into music using hand bells and other instruments.
- Also, students could have created their own word problems related to the pattern creation. (Ex. Alex created the patterns 5, 8, 3 two times and Riona created the pattern 5, 3, 1 three times. If they play music using those patterns they created and each number represents one beat, how many beats do they play altogether? 3x2=6 (Alex), 3x3=9 (Riona) So, 6+9=15 beats. They play 15 beats altogether.)