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The Effects of a Music Composition Activity on Chinese Students' Attitudes and Beliefs towards Mathematics: An Exploratory Study

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This article presents an exploratory research investigating the integration of pop music and statistics lesson as an intervention to promote students' attitudes and strengthen and extend their beliefs towards mathematics. Thirty-five students randomly selected from 189 students in 6th grade in a primary school in Southeast China were provided a 90-minute mathematics lesson integrated with music composition activity taught by the first author. Pre-and post-questionnaires with closed-ended and open-ended questions on evaluating students' attitude and belief toward mathematics were provided before and after the lesson. The results demonstrated the mathematics lesson integrated with music had a positive effect on students' attitude and beliefs toward mathematics learning.

Key words: mathematics- music-connection, attitude, belief, intervention, teaching and learning

Introduction

Both the National Council of Teachers of Mathematics [NCTM] (2000) and the National Arts Education Associations [NAEA] (1994) explicitly suggested in their standards that all students from K-12 should be able to recognize and apply knowledge connecting to other content areas. Research has consistently found the benefit of teaching with connection for understanding, and teaching by connection with science and literature has received much attention from researchers in recent years (i.e. Keen, 2003; Marrongelle, Black, & Meredith, 2003). This connection provides students with an opportunity to make sense of mathematics and easily remember and apply mathematics in meaningful ways when students connect new knowledge to existing knowledge (Schoenfeld, 1988).

One of the methods of connection is to integrate art into mathematics serves as a catalyst for discovering mathematics (Betts, 2005). The Equity Principle in NCTM (2000) requires teachers to develop effective methods for supporting the learning of mathematics for all students. Regardless of their personal characteristics, backgrounds, or physical challenges, all students must have opportunities and support to learn mathematics. The goal of success for all can be achieved by providing opportunities for students to experience the esthetics of arts in learning mathematics (Betts & McNaughton, 2003; Eisner, 2002).

As an essential part of arts, music, along with literature and visual arts, can rarely be found integrated into mathematics lessons (Johnson & Edelson, 2003; Rothenberg, 1996). Existing ways to teach mathematics through music are usually only superficially focused on the relationship between mathematics and music, such as counting rhythms or learning the fractional nature of note values; educators are called for design and implementation of more mathematical-based music activities (Rogers, 2004). Music relates internally and externally to mathematics from multiple perspectives: mathematics knowledge from the kindergarten to the university levels exist or are used from basic music elements to the whole works (Fauvel, Flood, & Wilson, 2003; Harkleroad, 2006; Loy, 2006). For example, notes, intervals, scales, harmony, tuning, and temperaments relate to proportions and numerical relations, integers, logarithms and arithmetical operations, trigonometry, and geometry (Beer, 1998; Harkleroad, 2006). Melody and rhythm can be represented mathematically and music forms can also be represented by mathematical patterns (Beer). The mathematical concepts of the *Fibonacci sequence* and the *Golden Section* theory also use by some music composers (Garland & Kahn, 1995; May, 1996). Fiske (1999) has summarized and demonstrated that teaching through arts can: (a) transform the environment for learning; (b) reach students who may not be easily reached otherwise; (c) connect students to themselves and to others; (d) provide new learning experiences for adults involved in students' lives; (e) open new challenges for successful students; and (f) connect learning experiences from school to the world. Arts integrated mathematics lessons can provide an alternative approach to students who have difficulty learning mathematics in traditional ways. Researchers have reported benefits from the arts not only for students with special characteristics, but to all students' learning integrated with arts: (a) effective motivation in students' engagement in mathematics (Fernandez, 1999; Hewitt, 1998; Pitman, 2006; Shilling, 2002); (b) remarkable improvement on understanding in mathematics (Autin, 2007; Catterall 2005; Shaffer, 1997); (c) development in cognitive ability (Eisner, 1985; Peterson, 2005); (d) improvement in critical thinking and problem solving skills (Wolf, 1999); (e) development of ability to work collaboratively in groups (MacDonald, 1992; Wolf, 1999); (f) enhancement in students' self confidence (MacDonald,1992); (g) improvement of empathy and tolerance in class (Hanna, 2000); and (h) considerable improvement in mathematics achievement (Harris, 2007; Upitis & Smithrin, 2003).

The present study investigated the effects of mathematics-music connection activities on Chinese students' attitudes and beliefs towards mathematics. It integrated pop music and statistics lessons as an intervention to promote students' positive attitudes and strengthen and expand their beliefs towards mathematics understanding.

Theoretical Framework

This study is grounded on theories and research that suggest (a) focusing on the individual abilities of students from multiple intelligences theory can enhance classroom learning (Gardner, 1993); (b) the use of the arts as a methodology providing a rich and emotionally stimulating mathematics learning context, reducing students' mathematics anxiety and engaging students through creative and active involvement based on different abilities (Eisner, 2002; Miller & Mitchell 1994; Sylwester, 1995; Upitis & Smithrim, 2003; West, 2000; Witherell, 2000).

Implications of Multiple Intelligences

Gardner (1983) argues that there are multiple intelligences among different learners, including linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, interpersonal, and intrapersonal intelligences. All intelligences can route individuals through complete development and communication. The differences in intelligences can serve both as the content of instruction and the means or medium for communicating the content. Based on multiple intelligences, if a student had difficulties understanding principles of content in mathematics, the teacher should provide an alternative route for him to understand the content (Kassell, 1998). Embedding music activities into mathematics not only can increase students' mathematical understanding, but also can provide them an enjoyable means to develop logical/mathematical intelligences along with their musical/rhythmic intelligences development (Shilling, 2002). Johnson and Edelson (2003) found teaching mathematics integrated with music could help children whose strengths lie in areas other than the logical-mathematical intelligence to learn mathematics easier. Gardner found that using music to enhance children's enjoyment and understanding of mathematical concepts and skills, could help children gain access to mathematics through new intelligences. Moreover, arts enabled students to use different learning styles and prior knowledge, pulling together diverse cognitive and affective experiences and organizing them to assist understanding (Selwyn, 1993).

Greene (2001) defined learning through aesthetics as an "initiation into new ways of seeing, hearing, feeling, moving, a reaching out for meanings, a learning to learn integral to the development of persons — to their cognitive, perceptual, emotional and imaginative development" (p.7). Learning through aesthetic perspectives allowed students to view the world from a different point of view and experience rewards from success in mathematics through the arts (Gamwell, 2005). Arts integration curricula afforded the greatest measures of transfer in learning, especially when higher order or critical thinking was the goal of instruction, the essence of mathematics education (Redfield, 1990; Trusty & Oliva, 1994).

Mathematics Engagement and Motivation in Aesthetic Environment

Emotion is essential in the students' learning, because it focuses attention on learning (Sylwester, 1995). Arts involve emotions, which are basic to individual development, enabling students to express themselves and communicate ideas (Stevens, 2002). Brewster and Fager (2000) defined motivation as students' willingness, need, desire and compulsion to participate in, and be successful in the learning process.

Many studies have shown that students' learning enthusiasm, engagement, and positive disposition can greatly improve their academic achievement in mathematics (Hannula, 2002; Koller, Baumert, & Schnabel, 2001; Orhun, 2007; Schiefele, 1991). However, disengagement and mathematics anxiety are prevalent among students, and researchers noted significant negative impacts on students' performance, avoidance of mathematics courses, and career choice decisions (Resnick, Viehe, & Segla, 1982; Satake & Amato, 1995), especially in Confucian Heritage Culture regions, such as China, (Morris, 1988). Studies argued that China's examination-driven-curriculum has shaped a lecture-oriented course mode, with an emphasis on memorization and test-preparation, which resulted in a degree of student disengagement under a forced learning environment (Kong, Wong, & Lam, 2003).

Researchers have identified two components that comprise math anxiety (Morris, Davis, & Hutchings, 1981): (a) cognitive—includes the worrisome thinking about personal performance and (b) potential negative consequences and emotions—includes nervousness, fear, and discomfort when doing math-related tasks (Vance & Watson, 1994). Teachers in arts enriched classrooms tended to engage students physically, cognitively, and emotionally in learning and problem solving (Smithrim, 2003; Sylwester, 1995; Upitis & Smithrim, 2003).

In order to reduce mathematics anxiety as well as increase motivation, Miller and Mitchell (1994) suggested teachers should create a positive learning environment, free from tension and possible causes of embarrassment or humiliation. Arts, with its aesthetical features, can provide students with an enjoyable environment, in which they can discover and think about mathematical concepts in various ways and build fundamental understandings and appreciation for both math and arts (Lawrence & Yamagata, 2007). Students also may feel more comfortable in taking risks with their thinking in an arts-enriched environment (Langer, 1997). Arts also can provide students a learning environment with less prejudice and violence, and helped them become better risk takers, become more sociable, and enhanced self-esteem (Trusty & Oliva, 1994).

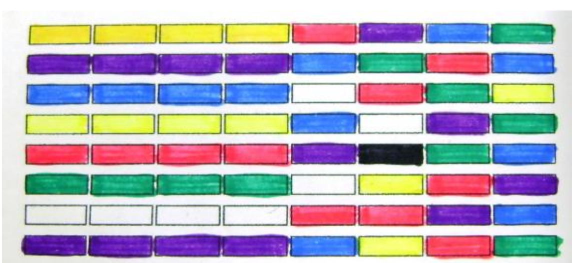
The goal of this study is to analyze the change of sixth grade Chinese students' mathematics attitudes and beliefs through the experience of composition and enjoying music in a music-enriched mathematic lesson. The research questions include: (a) Do students' attitudes and beliefs about mathematics and mathematics learning change as a result of a music activity? (b) What aspects of students' attitudes and beliefs towards mathematics and the connection between mathematics and music change as a result of a music activity?

Method

Participants and Intervention Lesson

The study is guided by first author's personal academic background of music and teaching experiences as a mathematics teacher. In this study, the first author played a dual role as researcher and pilot teacher for a music integrated mathematics activity. We carried out this study in a sixth grade class of an elementary school in Nanjing, a Southeast higher economic metropolis in China. Most students in this school came from low-come families. Thirty-five students were randomly selected from all 189 sixth grade students in the school. In designing this lesson, we (a) personalized the experiences of the students in the classroom (Gardner, 1993)— all students composed their own music and analyzed data based on their unique work; (b) provided opportunity for the students to become emotionally engaged with their work (Sylwester, 1995)—students' music works were played immediately by the piano; and (c) encouraged students to explore the aesthetic qualities associated with such engagement (Eisner, 2002)—students were encouraged to explore pattern in their music by using mathematics methods.

A 90-minute lesson with two sessions was provided to students between pre and post questionnaires. Two worksheets were handed out to students to compose their own music and draw statistical graphs. Color pens, rulers, compass, protractors and a digital piano were prepared for the class. In session one, students learned fundamental music composition skills and used graphic notation to compose music based on some simple mathematical rules. Students used seven different color bars to represent music scales and the numbers of bars to represent notes' durations. In this graphic notation system, we used red, white, yellow, blue, green, black and purple to represent C, D, E, F, G, A, B in music. Chords (three or more different notes that sound simultaneously) were represented by different combinations of color. Based on a typical pop music chord sequence (sequenced as I, V, VI, III, IV, I, II and V), students learned to compose their own music by choosing colors from specific chords to fill in the first four blanks and choosing any color to fill in the following blanks in each music sentence (see Figure 1). After students finished their work, the teacher played students' compositions on the piano (see Figure 2; the specific chord was played by left hand and students' melody was played by right hand). Students enjoyed the performance and shared their music with each other.



Yellow	Yellow	Yellow	Yellow	Red	Purple	Blue	Green
Purple	Purple	Purple	Purple	Blue	Green	Red	Blue
Blue	Blue	Blue	Blue	White	Red	Green	Yellow
Yellow	Yellow	Yellow	Yellow	Blue	White	Purple	Green
Red	Red	Red	Red	Purple	Black	Green	Blue
Green	Green	Green	Green	White	Yellow	Red	Purple
White	White	White	White	Red	Red	Purple	Blue
Purple	Purple	Purple	Purple	Blue	Yellow	Red	Green

Figure 1. **A sample of students' composition work *my wish* presented by graphic notation.**

Figure 2. **A sample of students' composition work *my wish* presented by grand staff.**

In session two, based on students' composition notes, students were assigned to complete statistics tables and draw statistics graphs. Teacher encouraged students to complete a bar graph that can show the number of each music note used in their composition works and a multiple line graph that can show the changes of three of their favorite notes in each music sentence (see Figure 3 of next page). For superior students, after they finished the first two tasks, the teacher recommended them to construct a circle graph to represent the number of three of their favorite notes.

Instruments and Data Collection

Before the lesson, all students completed a questionnaire on attitude and belief towards mathematics. The questionnaire consists of nine close-ended Likert items with five levels ranging from strongly disagree to strongly agree and two open-ended items. The nine close-ended items were designed to assess students' confidence, success, and anxiety in mathematics. Two open-ended questions were designed to assess students' belief toward mathematics and the relationship between music and mathematics. After the intervention lesson, the same questionnaire was given as a posttest.

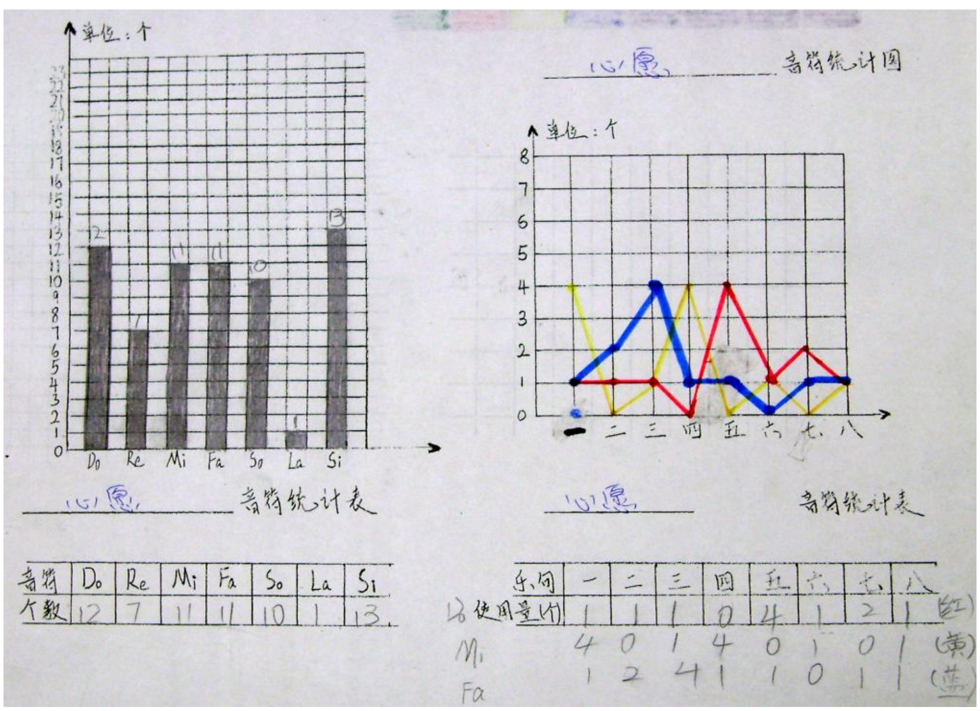


Figure 3. **A sample of students' worksheets (the statistics graphs of music notes used in *My Wish*).**

Data Analysis

Both quantitative and qualitative methods were applied in analyzing data. A paired-samples t-test was used to determine statistical significant differences in mean score, standard deviation between pretest and posttest close-ended questions. Effect sizes were calculated and expressed in Cohen's d to determine the whether or not that difference was important in educational terms. For the open-ended questions, we coded, categorized, and compared students' responses (Lincoln & Guba, 1985) to analyze how students' views on mathematics and the relationship between music and mathematics changed from pretest to posttest.

Results

The results of paired-samples *t*-test (See Table 1) showed that the means on all items in the pretest were improved in the posttest. Item 1 (interest in mathematics), item 3 (confidence in mathematics) and item 4 (success in mathematics) were indentified statistical significance. The effect sizes for these items with significance fell in the moderate range, indicating that the lesson had some educational impacts on the students.

Table 1

***T*-test Results on Close-ended Questions of Students' Pretest and Posttest**

Item	Pretest Mean ± SD	Posttest Mean ± SD	*t*-value	Effect size *Cohen's d*
1	4.47 ± 0.83	4.79 ± 0.41	-2.149*	0.5
2	4.53 ± 0.71	4.76 ± 0.43	-1.852	0.4
3	3.82 ± 0.80	4.15 ± 0.82	-2.069*	0.4
4	4.06 ± 0.65	4.35 ± 0.69	-2.147*	0.4
5	4.74 ± 0.57	4.82 ± 0.46	-0.649	0.2
6	4.35 ± 0.60	4.47 ± 0.75	-0.751	0.2
7	4.21 ± 0.64	4.24 ± 0.82	-0.206	0.0
8	4.21 ± 0.88	4.47 ± 0.71	-1.272	0.3
9	4.62 ± 0.55	4.65 ± 0.65	-0.239	0.1

Note. N=35; *$p < .05$; all the items are available at the appendix.

The results of qualitative data analysis showed that student's belief towards mathematics and the relationship between mathematics and music experienced considerable changes. In terms of the open-ended question one "what is mathematics" (see Table 2), ***passive*** or ***traditional*** words which described mathematics as "difficulty", "memory" or "single approach" decreased in the posttest. For example, response rate of students' regard mathematics as "difficulty" decreased from 36% in the pretest to 15% in the posttest, and the responses such as "memory" or "single approach" and "drilling" that appeared in the pretest diminished in the posttest. Instead, ***active*** or ***sense-making*** words were more expansively used in the posttest than the pretest. For example, students' response regarding mathematics as "problem solving in real-life contexts" increased from 66% to 90%, and the words such as "effectiveness", "multiple approaches", "correlation with other subjects", "music", "effectiveness" and "creativity" that count zero in the pretest appeared to 33% in total in the response rate in the posttest. For the words categorized as nature in belief of mathematics by students such as "computation", "number", "dimensions" "data" and "formula application" were only slightly changed in the pretest and posttest.

Table 2

Responses on "What is Mathematics"

Category	Theme	Response Rate (*N*=35) Pre(%)	Post (%)
Active or sense-making	Problem solving in real-life contexts	66	90
	Language	3	6
	Ubiquity	15	12
	Multiple approaches	0	6
	Fun	3	8
	Music	0	6
	Game	9	9
	Correlation with other subjects	0	3
	Usefulness	0	6
	Effectiveness	0	6
	Creativity	0	6
	Easiness	3	3
Passive or Traditional	Difficulty	36	15
	Memory	6	0
	Drilling	6	0
	Single approach	3	0
Neutral	Computation	15	18
	Number	15	12
	Dimensions	3	0
	Data	0	3
	Formula application	0	3

The results from the open-ended question two indicated that students' understanding of the relationship between mathematics and music also were changed greatly. Table 3 showed that most students' answers based on their perceptual experiences in answering the relationship between music and mathematics in the pretest. However, in the posttest, most students could explain the relationship rationally or mathematically with a deeper understanding. On the posttest, the answers based on perceptual experiences decreased: 30% of students mentioned that "music makes me smarter on mathematics" and the response rate decreased to 9% in the posttest; the response such as "both music and mathematics require learning", "both enrich lives" and "music makes me feel less anxiety in mathematics" decreased from 21% to 0%. Interestingly, the response rate of one item based on perceptual experiences, "both mathematics and music are fun", increased from 15% in the pretest to 24% in the posttest.

The answers based on rational understanding largely increased from pretest to posttest: on the pretest, only 15% students claimed that mathematics and music were highly correlated or supplemented to each other; however, the percentage increased to 72% on the posttest; and in the pretest 9% students mentioned that "music can be presented mathematically", the response rate increased to 33% in the posttest; and in the pretest no student mentioned that "both music and mathematics are arts and languages", "we can learn both in one class"; "both are functional"; "both can be represented by symbols" and "we can use mathematical methods to analyze music" , in the post test the sum of response rate of these topics increased to 42%.

Table 3

Students' Responses on "What is the Connection between Math and Music"

Category	Theme	Reponses Rate (*N*=35)	
		Pre(%)	Post (%)
Based on perceptual experien-ces	Music makes me smarter on mathematics.	30	9
	Both are connected with everyday life.	15	12
	Both require learning.	6	0
	Both are fun.	15	24
	Both enrich lives.	6	0
	Music makes me feel less anxiety in mathematics.	9	0
	Both are intuitive and emotional.	9	3
Based on rational unders-tanding	They supplement each other.	12	39
	They are highly correlated.	3	33
	We can express music in a mathematical way.	9	36
	We can use mathematical methods to analyze music.	0	18
	Both develop logical thinking.	3	6
	Both are arts and languages.	0	6
	We can learn music and mathematics in one class.	0	9
	Both are functional.	0	6
	Both can be represented by symbols.	0	3

Discussion

The improved scores in all items in the close-ended questionnaire indicated that the mathematics activity which integrated music improved students' attitudes and engagement in learning mathematics. Such changes can be explained by the intervention lesson, which catered for students' interests in pop songs in their everyday life and aroused students' enthusiasm to learn how to compose pop music. Gadamer (1998) suggested that there exists a cognitive element to aesthetic experience, in which the observer's interaction with a work of art is "playful" and the observer's joy resulting from knowing something more about the world and about ourselves. The underlying mathematics task in students' music composition activities allowed students to easily accomplish the mathematics goals in a joyful learning environment filled with music. The increase in the response rate in the posttest of the second open-ended item "both mathematics and music are fun" also confirmed the positive change in attitude. In this carefully designed joyful learning environment, students did mathematics happily and their interests towards mathematics increased in the light of their original interests in pop music. The pleasant feeling in mathematics learning integrated with music can be counted as one of the factors that decrease students' anxiety towards mathematics: student feel delighted in using their mathematics knowledge to solve problems by analyzing data from their own piece of work.

The statistically significant improvement on the two survey questions (a) *do you think that you have enough self-confidence in learning mathematics*; (b) *are you good* *at mathematics* confirmed that students' confidence in mathematics was improved as a result of the intervention activity. This might be explained by the fact that students' achievements were highly rewarded and they were worked individually. When completing the activities in the intervention lesson students not only feel a cheerful sense of accomplishment in the mathematical tasks, but also get an extra reward by enjoying their own compositions works accompanied with piano. The experience of personal choice in students' sense making, students felt more confident about themselves; classmates revealed and recognized each other's potential abilities by and through different music piece composed. A strong sense of students' personal discovery emerges as they constructed and explored meanings through their works. As a consequence of music rewarding as well as students' interests to music, their attitudes and beliefs about success in mathematics were improved, and they started looking forward to solving more challenging mathematics tasks, and hence improved their confidence. The significant increase of students attitude on mathematics can be explained as when students develop conceptual understanding of mathematics integrated with arts, the learning is individualized, thus each student was motivated to learn (Autin, 2007).

The results of the open-ended question one "what is mathematics" showed that in students' posttest, passive or traditional words in describing mathematics decreased largely and active or sense-making words increased largely when compared with the pretest. Spangler (1992) argued that those kinds of passive or traditional wording in portraying mathematics such as *mathematics is computation*, *single approach or answer* are *unhealthy* beliefs toward mathematics. The decrease of passive or traditional words as well as the increase in using active or sense-making words showed students' beliefs toward mathematics became more *healthy* as a result of this intervention music integrated activity. When students use sense-making words, it is virtually impossible for them to learn as passive observers (Van de Walle, 2004). These changes indicated that the intervention lesson has provided an environment for students to learn mathematics with more sense making. When mathematical patterns or processes automatically generate art, a surprising reverse effect can occur: the art often illuminates the mathematics (Autin, 2007). This activity provided students a good example of how mathematics can be used in creating and analyzing music. Their experience let them know the process of music creation does not only depend on intuition; mathematics also functions importantly in the composition process. Students experienced the power of mathematics esthetics: organized and arranged patterns mathematically, the music elements such as pitches and rhythms got harmonic and powerful sound effects. This finding also confirmed Driscoll's suggestion (1999) that students can understand mathematics deeper when learning mathematics in new ways and in unexpected settings. The increase in response that mathematics is *problem solving in real-life contexts* and *correlation with other subjects* can be explained by the fact that this activity provided students chances to apply mathematics to some situations outside of mathematics class and mathematics is related with real life. As Noble and his colleagues (2001) argued, learning mathematics in multiple environments could connect students' experiences in different mathematical environments. The response rate of stating mathematics is *creativity* increased because students can use mathematical rules to create their own pieces of music; the increasing response rate of "multiple approaches" and decreasing "single approach" stated in the posttest because students proved in their composition that everyone can have a unique piece of music. Moreover, when students analyzed data based on their music works they had different statistical tables or graph. As Friel, Curcio and Bright (2001) asserted, graph instruction within a context of data analysis may promote a high level of graph comprehension which includes flexible, fluid, and generalized understanding of graphs and their uses. The increased response rate in those who mentioned *effectiveness* and *usefulness* in describing mathematics resulted from the experience of students on how powerful mathematics as a tool is: based on the mathematics rule to make music, students can create high quality music easily and efficiently. The decrease or elimination of such words as *difficulty*, *memory* and *drilling* might be explained as when students' confidence in mathematics increased, they did not feel mathematics as difficult as before and in this activity, solving mathematics problems and accomplishing mathematics tasks did not need much *memory* or *drilling* process.

The results of the open-ended question *what is the connection between math and music* showed in students' posttest, the description based on students' perceptual experiences in describing mathematics decreased largely and the description based on rational understanding increased largely than in the pretest. This result implied that students' belief toward the relationship between mathematics and music changed notably, and this activity helped these students gain special knowledge and skills they are less likely to gain from their everyday experience. When students are motivated through the creativity of art, a springboard for connections can be provided for mathematical learning (Martin, 2005). The increase in students' response pointed out mathematics and music *supplement each other* and *is highly correlated* since students had understood some relationships between the two subjects from the mathematical perspective and acknowledged the existence of these relationships. The increase in students' response in stating that *we can express music in a mathematical way* and *we can use mathematical methods to analyze music* is because in session one of this activity students created their music mathematically and in session two students made statistical tables and graphs based on their own pieces of music. The increase in students' response of *we can learn music and mathematics in one class* can be explained that students believed they had acquired knowledge both in mathematics and music in the intervention activity. Students' response that *both mathematics and music can be represented by symbols* increased because during the intervention lesson, students gained experiences about how to use mathematical symbols to present music, and also experienced how the teacher transferred their graphic notation back into music played on the digital piano. We also gladly noticed from the posttest that some students went further than our expectations: some answers argued that both music and mathematics are *arts and languages*, both can *develop logical thinking* and both are *functional*. When students recognized the connection between aesthetics and mathematics, they acknowledged the possibility of a bridge between mathematics and everyday life and remove the mystery in mathematics (Betts & McNaughton, 2003). In a word, the increase of the results demonstrated students effectively constructed a connection between mathematics and music.

Conclusion and Educational Significance

In this article we have presented the effects of a mathematics activity integrated with pop music composition. This study, from the perspective of music, verified that students benefited from arts-integrated environment to learn mathematics. According to the results, this explorative study demonstrated mathematics lesson integrated with music had a positive effect on students' attitude and belief toward mathematics learning. We can conclude that bringing music into mathematics classes provided a joyful environment for students. As a consequence, students engaged and effectively strengthened confidence in learning mathematics. Students improved in both areas with links that connect mathematics with other subjects (NCTM, 2000): "Students ... should have frequent experiences with problems that connected to the real-world experiences, that interest, challenge, and engage them in thinking about important mathematics" (NCTM 2000, p. 182). And Bosse (2006) claimed that as the beauty and power of mathematics was personalized to students, students came to recognize that they can manipulate and make decisions about their world and they believed that would be less possible to live without mathematics in the future.

The results found that students enjoyed learning mathematics in this activity. The implication of this study showed music integrated mathematics lessons gave students a chance to learn mathematics actively with sense making. In our view, the positive results can be attributed to a combination of closely linked factors: (a) used suitable mathematics –music links to arouse students' interest in pop music and mathematics learning; (b) used graphic notation to create music based on mathematical rules that allowed a deep but perceivable connection between music and mathematics; (c) rewarded students' achievements highly by sense of achievement in mathematics, the pleasure of enjoying their own music played by piano and the recognition of peers; (d) deigned and provided mathematics tasks based on students' unique music works. The powerful influence of music on past and present lives was seen more holistically when students discovered coherence with other aspects in their school experience (Barrett, 2001).

A key strength of this study is that it provided a unique window into the world of students' exploring learning through arts experiences. Through the voices of the students, we learned how the arts activities provided a vehicle for them to become actively engaged in the construction in their own learning. Students explored their sense-making in a various ways and came to see and appreciate each other's abilities and characteristics that were not previously apparent to them. The social aspect of the sense-making contributed to the development of a supportive, open learning environment and a true sense of community (Eisner, 1992).

Limitations were also noted in this study. First, few teachers are adequate to replicate this activity in their everyday teaching. Second, the sample size is small and the topic of the lesson is limited to statistics due to a short intervention period. Also, biases might be produced from researcher as teacher. However, even with all these limitations, this exploratory study provided an opportunity to get a look into the connection between music and mathematics. We do not suggest that the intervention activities that integrated music into mathematics described in this study are a prototype for all classroom activities related to mathematics; we argue that the development of mathematical understanding, beliefs, and attitudes should not emanate from a single curriculum but should permeate the curricula wit subjects other than mathematics, such as music.

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 do believe that by connecting some arts or music elements into mathematics teaching and learning, students may have more opportunity to change their beliefs about, and attitudes toward mathematics. By designing appropriate music integrated into mathematics lessons, students can understand, analyze, and interpret mathematics in different routes. Teaching students to interpret critically the reality they live in and understand its codes and messages so as not to be excluded or misled should be an important goal for elementary education (Bonotto, 2005). Thoughtful integration helps remove mathematics from the realm of tedious practice and place it in the realm of essential and dynamic tools (Hotaling-Bollinger, 2003). Students have opportunities to present and understand mathematics in alternative ways, especially for students who have a high level of musical-rhythmic intelligence. To achieve this goal, lessons or curriculum tailored to the needs of specific children may be designed and employed (Gardner, 1983). This exploration study, in turn, would serve to broaden and deepen educators' understanding of different ways students experience their learning and contribute to the creation of successful learning environments where more students can engage in. The findings from this study invite further longitudinal research on other types of mathematics lessons using different links from music and mathematics and focusing on different mathematics content areas at various grade levels, concentrating on not only attitude and belief toward mathematics, but also students' mathematics achievement. Also, the technology support also needs to be involved in this kind of integration so that every mathematics teacher can teach similar music-mathematics-integration lessons without intensive learning of music knowledge and skill.

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Appendix

The Questionnaire of Attitudes and Beliefs towards Mathematics

Close-ended questions:

1. Are you interested in mathematics?
2. Do you like attending mathematics class?
3. Do you think that you have enough self-confidence in learning mathematics?
4. Are you good at mathematics?
5. Is mathematics useful in everyday life?
6. Do you think that you have enough self-confidence in learning statistics?
7. Are you good at statistics?
8. Are you interested in statistics?
9. Is statistics useful in everyday life?

Open-ended questions:

Could you explain to your younger sisters or brothers?

1. What is mathematics?
2. What is the connection between math and music?

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