THE EFFECTS OF MUSIC-MATHEMATICS INTEGRATED CURRICULUM AND INSTRUCTION ON ELEMENTARY STUDENTS' MATHEMATICS ACHIEVEMENT AND DISPOSITIONS

A Dissertation

by

SONG AN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2012

Major Subject: Curriculum and Instruction

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Approved by:

Chair of Committee,	Gerald Kulm
Committee Members,	Mary Margaret Capraro
	Patrick Slattery
	Laura Stough
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ABSTRACT

The Effects of Music-Mathematics Integrated Curriculum and Instruction on Elementary Students' Mathematics Achievement and Dispositions. (May 2012)

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Chair of Advisory Committee: Dr. Gerald Kulm

The purpose of the current research was to examine the effects of a sequence of classroom activities that integrated mathematics content with music elements aimed at providing teachers an alternative approach for teaching mathematics. Two classes of third grade students (*n*=56) from an elementary school in Southern California participated in the research. A random assignment pretest-posttest control group design was used to examine students' changes in mathematics content achievement and the disposition between the two groups. The students in the music group received music-mathematics integrated lessons. A quasi-experiment time series design with multiple pretests, mid-tests and posttests was utilized for investigating the effects of music-mathematics integrated lessons on students' mathematics process ability levels. The results demonstrated that the intervention of a series of music-mathematics integrated lessons had positive effects on the music group students. The findings showed that the music group students had statistically significantly higher scores on mathematics achievement, and mathematics dispositions after the intervention. Moreover, the music group students also showed statistically significant improvement on scores in the mathematics process abilities from pretests to posttests. The study results suggested that 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. The findings suggest that teachers should take advantage of the opportunities that music offers to help all students learn mathematics in challenging and enjoyable ways developing students' mathematics achievement, mathematical process ability, and mathematics dispositions.

DEDICATION

To my grandparents

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I appreciate my professors' help in building my research knowledge and teaching skills during my Ph.D studies in mathematics education — Dr. Gerald Kulm, Dr. Dianne Goldsby, Dr. Yeping Li, Dr. Robert Capraro, and Dr. Trina Davis. I also thank my Ph.D committee members Dr. Kulm, Dr. Mary M. Capraro, Dr. Patrick Slattery, and Dr. Laura Stough for allowing me to design a research by using music-mathematics integrated activities for elementary students as my dissertation study. Special thanks to Dr. Mary M. Capraro, for her patient consulting, editing, and proof reading of my dissertation.

Special thanks to Ms. Min Young and her students as well as her colleagues in the Leal Elementary School in ABC Unified School District in California who field tested the activities and provided important feedback throughout my research. I also would like to express my appreciation to Dr. Shuhua An, California State University at Long Beach and Dr. Zhonghe Wu, National University, who provided constant help on the development of my dissertation research.

NOMENCLATURE

NCTM	National Council of Teachers of Mathematics
MSA	Model–Strategy-Application
NS	Number Sense
AF	Algebra and Functions
MG	Measurement and Geometry
SDAP	Statistics, Data Analysis, and Probability
MR	Mathematical Reasoning

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CHAPTER I

INTRODUCTION

Researchers during recent decades have identified numerous drawbacks in using traditional mathematics curriculum and instructional methods to teach students. Traditional methods of instruction may be ineffective, because they are unable to reach all students and meet their needs. Thus traditional instruction has prevented some students from reaching their learning capacities in the area of mathematics skills and abilities (Scott, 2005). Traditional mathematics instruction consisting of assigning the same problem to every student, lecturing from the textbook, insisting on one way to solve problems, and neglecting conceptual understanding has not only been accused of being the cause for low mathematics achievement, but also as the origin of mathematics anxiety (Furner & Berman, 2005; TIMSS, 2003). The Equity Principle (NCTM, 2000) explicitly indicated that teachers should develop effective methods for supporting the learning of mathematics for all students regardless of their personal characteristics, backgrounds, or physical challenges Teaching mathematics using effective didactic strategies (Vinner, 1997) with the goal of developing students' conceptual understanding through the use of problem-solving activities, models, simulations, discoveries, challenges, and games has the potential to close the achievement gap and reduce mathematical anxiety (NCTM, 2006;Tobias, 1998). Music-mathematics integrated

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This dissertation follows the style of *Journal for Research in Mathematics Education*.

curriculum and instructional approaches, with its unique feature of providing opportunities for students to understand and apply mathematical knowledge in meaningful ways in an enjoyable environment, can facilitate students' learning of mathematics in effective ways (An & Capraro, 2011).

Various types of studies have investigated ways of associating music with mathematics instruction for improving K-16 students' achievement and attitude toward mathematics in the past few decades (e.g. An, Kulm, & Ma, 2008; An, Ma, & Capraro, 2011; Bilhartz, Bruhn, & Olson, 2000; Benes-Laffety, 1995; Costa-Giomi, 2004; Omniewski, 1999), and findings from these studies indicated that music has a positive impact on students' mathematics achievement and attitudes. As many researchers have proven, music can serve as an external stimulation on students' mathematics learning such as exploring how music learning impacts mathematics learning (e.g. Costa-Giomi, 1999; Cox & Stephens, 2006) including the most influential cases of Mozart Effects (e.g. Hallam, Price, & Katsarou, 2002; Rauscher et al., 1993, 1995, 1997). A limited number of research focused on investigating combining music as a part of mathematics teaching and learning components through mathematics instruction. The current study seeks to investigate the effects of integrating music activities as an integral part of regular mathematics lessons with a group of third grade students' mathematics achievement and their disposition toward mathematics learning.

The goal of the current research is to examine the effects of a sequence of classroom activities integrating mathematics content with music elements aimed at providing teachers an alternative approach for teaching mathematics. Two classes of

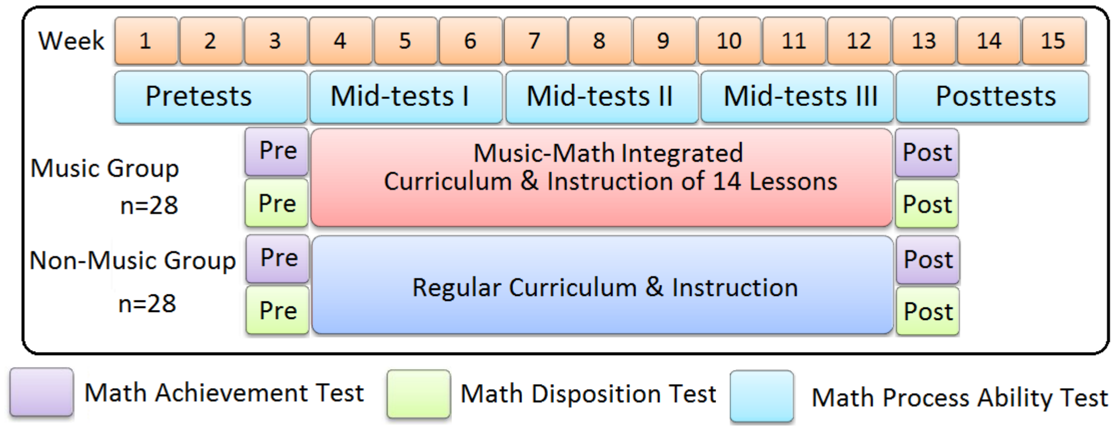

Figure 1. General research design of intervention and tests between music group and non-music group students.

third grade students (*n*=56) from an elementary school in Southern California participated in the research study. One class of students (*n*=28) was assigned as the music group and they were involved in a series of 14 mathematics-music integrated activities associated with regular mathematics lessons throughout a nine week interval. Another class of students (*n*=28) was assigned as the non-music group and received only regular mathematics lessons (see Figure 1). A random assignment pretest-posttest control group design (Shadish, Cook, & Campbell, 2002) was used to examine students' changes in mathematics content achievement and their dispositions. As the students in the music group were assigned to receive music-mathematics integrated lessons, a quasi-experiment time series design with multiple pretests, mid-tests and posttests was utilized to investigate the effects of music-mathematics interdisciplinary lessons on students' mathematics process ability levels. Pre and posttests measuring mathematics content achievement and students' mathematics dispositions were administered to both groups of students. Moreover, within the treatment (music) group, mathematics process ability tests were administered to students to assess their improvement in mathematics abilities throughout the intervention.

Problem Statement

In recent decades, researchers have conducted much research on the field of using arts to promote education. Although these studies have various foci and utilized the arts differently, the general results indicated there was a positive correlation between arts involvement and student development (e.g. Deasy, 2002; Fiske, 1999). One of the theoretical explanations for the benefits of learning through or in arts has accounted for the transfer of learning in the arts to non-arts content (Catterall, 2002, 2005). Through arts engagement, students can complete the process of autonomous cognitive change, and their non-arts abilities were improved.

Evidence clearly indicates that traditional mathematics curriculum and instructional methods are not serving our students well (Hiebert, 1999). Researchers have advocated that teachers should change their role from procedural demonstrations to facilitating students' mathematical thinking building by adopting various problem-solving situations to engage students and to encourage students sharing their mathematical thinking (Fennema et al., 1996). Teaching mathematics integrated with contents out of mathematics is proposed as an effective method for students to learn mathematics with more sense making and in a better attitude. One of the methods in teaching mathematics was to integrate arts as a catalyst for mathematical learning (Betts, 2005). Research has consistently found benefits for teaching mathematics connected with science and language arts in recent years (i.e., Keen, 2003; Marrongelle, Black, & Meredith, 2003). These connections provided opportunities for students to make sense of mathematics and apply mathematical knowledge in meaningful ways when connecting new knowledge to existing knowledge (Schoenfeld, 1988).

Recent research has reported beneficial results not only for students with special characteristics, but for all students learning mathematics and other subjects when integrating topics with arts: (a) significant enhancement in students' attitude and beliefs towards learning mathematics (An, Kulm, & Ma, 2008); (b) effective motivation in students' engagement in mathematics (Shilling, 2002); (c) remarkable improvement in understanding mathematics (Autin, 2007; Catterall 2005; Peterson, 2005); (d) improvement of motivation for learning (Csikszentmihalyi, 1997); (e) 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); (g) improvement of empathy and tolerance in class (Hanna, 2000); (h) improvement in mathematics achievement (Harris, 2007); (i) development of the imagination (Greene, 2001); and (j) increase in students' creativity, and social skills and decrease in dropout rates (Catterall, 2005).

The links between music and mathematics are very rich and include melody, rhythm, intervals, scales, harmony, tuning, and temperaments that are related to proportions and numerical relations, integers, logarithms and arithmetical operations, trigonometry, and geometry (Beer, 1998; Harkleroad, 2006). Unfortunately, these links are rarely explored and utilized by mathematics educators. As an essential part of arts, music, along with literature and visual arts, was rarely found integrated into mathematics lessons (Johnson & Edelson, 2003; Rothenberg, 1996). However, existing research of teaching mathematics through music were usually only superficially focused on the relationship between mathematics and music such as counting rhythms or learning the fractional nature of note values (Rogers, 2004). Most mathematics-music-integrated designed and adopted by teachers were generally based on the obvious relations that based on teachers' perceptual experience while more connection based on rational understanding need to be explored (An et al., 2008). More research needs to be done about the effect of math-music-integrated curriculum on students' mathematics achievement and attitude.

Purpose of the Study

Teaching mathematics integrated with music not only can improve students' attitudes toward learning mathematics but also can increase students' mathematics achievement. On the one hand, music can be used as a motivator to engage students in learning mathematics in an enjoyable but sense making way; on the other hand, music can be used as a resource for teachers to present and design mathematical problems in non-routine ways as well as for students to apply mathematical knowledge in meaningful ways and connect new mathematical knowledge to existing knowledge. The current study was characterized by a sequence of classroom activities aimed at providing teachers an alternative method for teaching mathematics integrated with music. The overarching goal of the current study was to examine the effects of the music-mathematics integrated instruction and curriculum as intervention with elementary students using mathematics achievement, process ability and dispositions towards mathematics learning as the variables.

Research Questions

The three questions of this research are:

(1) Does the music group have a statistically significantly higher mathematics disposition mean score than the non-music group after the intervention of using music-mathematics integrated curriculum and instruction?

(2) Does the music group have a statistically significantly higher mathematics content achievement mean score than the non-music group after the intervention of using music-mathematics integrated curriculum and instruction?

(3) Do the mathematics-music lessons statistically significant improve the music group mathematics process mean achievement scores across the intervention period of using music-mathematics integrated curriculum and instruction?

Theoretical Framework

In general, my dissertation research was built on theories and research that suggest (a) focusing on the individual abilities of students from multiple intelligences theory to enhance classroom learning by (Gardner, 1993); (b) the implication of motivation theories by using aesthetics as a methodology to provide a rich and emotionally stimulating mathematical learning context, reducing students' mathematics anxiety and engaging students through creative and active involvement in mathematics learning (Eisner, 2002; Sylwester, 1995; Upitis & Smithrim, 2003; West, 2000; Witherell, 2000). The theoratical framework for the current study is domostrated in the following figure (see Figure 2).

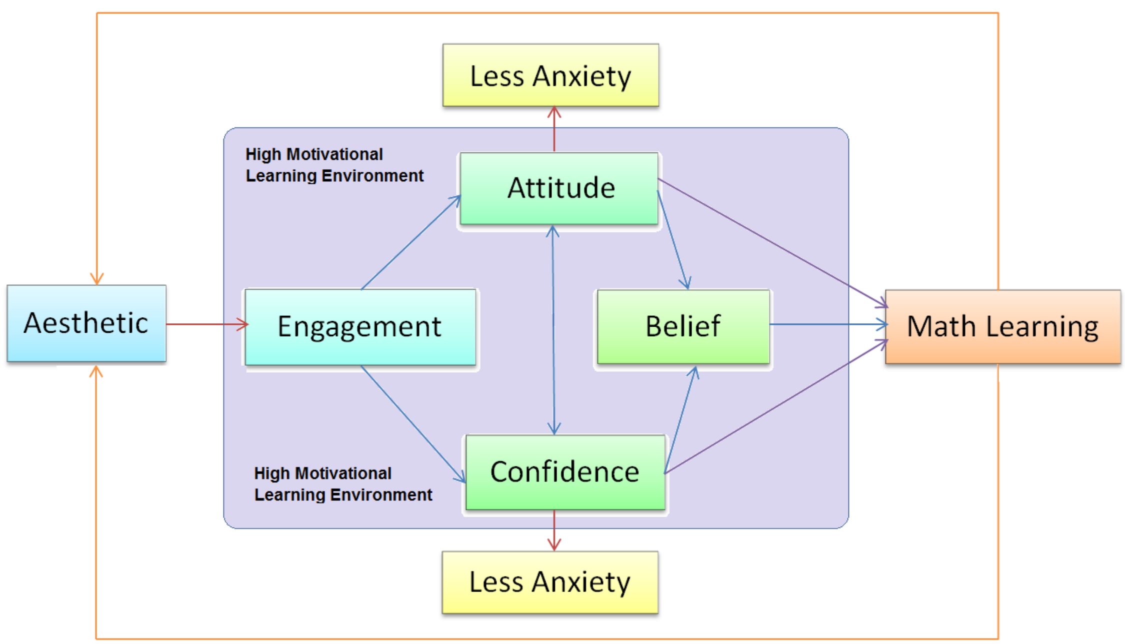

*Figure 2***.** Theoretical framework of the current study.

Implications of Multiple Intelligences

Gardner (1983) argued 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 development and communication. The differences in intelligences can serve both as the content of instruction and the means for communicating the content. Based on multiple intelligences, if a student has difficulties understanding principles of content in mathematics, the teacher should provide an alternative route to develop conceptual understanding (Kassell, 1998). Embedding music activities into mathematics can not only increase students' mathematical understanding, but also provide them an enjoyable means for developing logical/mathematical intelligences along with their musical/rhythmic intelligences (Shilling, 2002).

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 music allows students to view the world from different perspectives and experience rewards from success in mathematics through the arts (Gamwell, 2005). Gardner (1993) found that using music to enhance children's enjoyment and understanding of mathematical concepts and skills could help students gain access to mathematics through new intelligences. Music, as an important form of arts, can enable students to use different learning styles and prior knowledge, pulling together diverse cognitive and affective experiences and organizing them to assist understanding (Selwyn, 1993). As an application of multiple intelligence theory, teaching mathematics integrated with music facilitates students to complete the process of knowledge transferring which may facilitate students whose strengths lie in areas other than the logical-mathematical intelligence to learn mathematics more easily (Johnson & Edelson, 2003).

Implication of Motivation Theories

Motivation is an important factor in students' mathematics learning, because it not only associates with students' emotion, interest and enjoyment in learning mathematics but also relates to students' engagement and mathematics achievement (Martin, 2003). Emotion is essential in students' learning, because positive emotions may lead to a high level of motivation facilitating students focusing attention on learning (Sylwester, 1995). As an application of motivational theories, Miller and Mitchell (1994) suggested teachers should create a high motivating environment for learning, free from tension and other possible causes of embarrassment or humiliation. Music, with its aesthetical features, has the potential of providing students a highly positive motivating environment, in which students can discover and think about mathematical concepts in various ways and build fundamental understandings and appreciation for both mathematics and the arts (Lawrence & Yamagata, 2007). Additionally, music can provide students a highly motivating environment with less prejudice and violence, helping them becomes better risk takers and communicators (Langer, 1997; Trusty & Oliva, 1994).

According to motivational theory, students who are motivated intrinsically are more likely to exhibit initiative, independence, sense making and enjoyment in learning mathematics (Csikszentmihalyi, 1996). Teaching mathematics integrated with music can effectively increase students' intrinsic motivation, because in an enjoyable learning environment integrated with music, students might be aesthetically engaged. When students were motivated intrinsically, they not only tend to pursue more advanced mathematical knowledge based on their own initiative as well as accept more challenging tasks during learning. Additionally, they may have opportunities to show creativity in the mathematics learning process (Glastra, Hake, & Schedler, 2004). Moreover, music also can motivate students to learn mathematics extrinsically (Bronson, 2000). When students are learning mathematics integrated with music, they may not only feel a cheerful sense of accomplishment when completing mathematical tasks, but also receive an extra reward by enjoying their own music works. Such external rewarding might further increase students' engagement in learning mathematics concepts and doing mathematics problems.

Variables and Operational Definitions

In the current study, the independent variable was the Mathematics-Music-Integrated Lessons; the dependent variables were (a) Students' Mathematics Attitude, and (b) Students' Mathematics Achievement. Specifically, the three variables were defined as follows:

Mathematics-Music-Integrated Lessons: A series of activities with a goal of understanding, applying and practicing mathematics knowledge based on music related contents such as designing musical instruments and composing music.

Students' Mathematics Dispositions**:** Students' mental and emotional dispositions to mathematics including mathematics success, mathematics anxiety, mathematics confidence, mathematics motivation, and mathematics usefulness.

Students' Mathematics Achievement**:** Students' performance levels of mathematics related to the ability of using the mathematical content knowledge they learned to solve mathematics questions including number operation, algebra, measurement, geometry, and data analysis.

Students' Mathematics Process Ability Level**:** Students' performance levels of mathematics related to the ability of using the mathematical process knowledge they learned to solve mathematics questions including problem solving, reasoning & proof, communication, connection, and representations.

Limitations of the Study

Several limitations can be noted in the current study. First, the intervention period was only one semester and the Hawthorne effect might impact the study results, thus further changes in students' attitude and achievements in their later elementary school years as well as their future learning of mathematics is unknown. Second, because the convenient sampling method was used by asking volunteer teachers as well as their students from a limited number of schools to participate in the study, the findings may not generalize to other elementary school students with different backgrounds. However, even with both of these limitations, the current study differs from other one-shot studies that focused on one lesson's effects on students from one class. The current study will provide an opportunity to observe the effects of a three-month-long music intervention on improving students' mathematics learning compared with control group students. Moreover, different from previous research in which integrated lessons were taught by the researcher not teacher, which may cause researcher effect, in the current study, the mathematics-music-integrated lessons was taught as an integrated part of participating teachers' regular lessons throughout the intervention period, the exterior influences on students was maximally reduced.

Educational Significance

Based on the results of my dissertation study, more research was designed and conducted to assess additional students and teachers with different backgrounds on different perspectives. Additional books and professional development programs were written and provided for teachers to learn how to teach mathematics effectively and meaningfully integrated with music. In this "standards-based" era—when arts are marginalized in the school curriculum, because unlike mathematics and language arts, music and art are unusually not officially assessed on a state or national level—students and teachers tend to ignore the value of art (Oelkers & Klee, 2007). This study will provide evidence that music not only has an aesthetical value as a form of art, but also can be used as an educational resource for teaching mathematics. The results will 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.

Teaching mathematics integrated with other subjects can improve students' knowledge in both areas (NCTM, 2000): "In effective teaching, worthwhile mathematical tasks are used to introduce important mathematical ideas and to engage and challenge students intellectually…. the tasks may be connected to the real-world experiences of students." (p. 17). Teachers should take advantage of the opportunities that music offers to help all students learn mathematics in challenging and enjoyable ways (Johnson & Edelson, 2003). By connecting music into mathematics teaching and learning, students may have more opportunities to learn and understand mathematics from various lenses. By designing appropriate music integrated into mathematics lessons, students can understand, analyze, and interpret mathematics through different routes. This strategy allows students to present and understand mathematics in alternative ways, especially for those who have a high level of musical-rhythmic intelligence. This study could inspire educators to develop and adopt more flexible interdisciplinary curriculum that can provide enough opportunities for students to have intellectual communication and enhance their basic intellectual and theoretical knowledge of each individual subject.

The current study, in turn, could 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 be engaged and motivated. As a limited number of existing empirical studies focused on music integration into classroom teaching, the current study will try to fill this research gap by demonstrating that music is an important educational resource that has the potential to explore and develop mathematics lessons which may facilitate students tin their learning of mathematics. The results of the current study will also contribute to a better understanding of a new way of mathematics teaching in real world application, which help students better understand mathematics in an enjoyable environment with lower anxiety to learn mathematics. Such implications will not only direct future educational practices to enrich teacher education programs by integrating effective integrated teaching strategies into mathematics education courses for teachers, but also can help classroom teachers to develop more mathematics lessons in multiple ways by making connections not only within mathematics curriculum but also making meaningful connection between mathematics and other school curriculum.

CHAPTER II

LITERATURE REVIEW

In this chapter, literature related to research in music-mathematics integrated curriculum and instruction will be reviewed. This chapter is divided into four sections. In the first section, arts integration curriculum including its historical and philosophical roots, and different perspectives about arts integrated curriculum will be reviewed. In the second section, motivation theories including extrinsic and intrinsic motivation, affect and motivation and creating a highly motivating environment through music will be reviewed. In the third section, intelligence theories including multiple intelligences including the Mozart effects will be reviewed. In the fourth section, empirical studies of teaching mathematics integrated with arts including research reports of large scale and small-scale studies of music and mathematics learning will be reviewed.

Arts Integration Curriculum

Historical and Philosophical Roots

Using interdisciplinary curriculum in education is not a new concept. The earliest curriculum integrations between arts and other school subjects could be traced back to ancient Greece when Plato mentioned arts integration in his works (Kridel, 2010). Since the end of nineteenth century, educators such as Francis Parker and John Dewey had already tried to construct a connected comprehensive approach in school education.

Dewey conducted a series of exploratory studies on curriculum integration and reported his findings concerning students' developments from such curriculum. After Dewey's publication, his educational philosophy has been fundamentally connected with the progressive education movement, which leaded the first era of curriculum integration, and from the late of 1980s, with the influence of constructivism, the second era of curriculum integration was started (Gehrke, 1998).

Dewey's pragmatism and progressivism. Peirce, James and Dewey developed the Pragmatism in the twentieth century. As a representative of Pragmatist, Dewey rejected Aristotle's dualism in philosophy which divided the reality into ideational dimension and material dimension. Dewey believed human experiences of solving problems in real life are ways to build knowledge. Dewey's key educational philosophy components are that: (a) the learners are living organisms that drive a sustaining of life; (b) the learners live in a natural and social environment; the learners actively interacted with the environment and they may meet problems through the interactions; and (c) the learning process is the process of solving these problems they meet in the environment. Dewey's epistemology is to use scientific method to solve personal and social problems. Dewey believed that Idealism and Realism's epistemology isolated mind from social realities, in contrast, he proposed that human intelligence could actively and dynamically affected the society.

Dewey's philosophy on aesthetics is to value the art from people's everyday experiences. Aesthetics and well as its' concrete appearance—art, in Dewey's view, is a public media for artists and arts perceivers to communicate with each other. For Dewey, the aesthetic values coming from human experience: art exhibited a common association between the person and society and shared the common aim of achieving unity in the world. The value of art is art gives credit for all the elements of experience that may contribute meaning. Dewey rejected Realism's dualism which divided arts into fine arts and applied arts; in Dewey's view, fine arts and applied arts could be combined by integrating beauty and function together. By rejecting traditional value systems that based on universal hierarchies of tradition, Dewey tried to unify aims, means and the ends in the aesthetic experiences. Dewey also believes that people can solve aesthetic problems by using shared scientific intelligence.

From 1920s to 1930s, Dewey and other educators proposed three progressive approaches including the project method, the experience curriculum, and activity movement. From Dewey's perspective, schools should pay more attention to the aesthetic experience, and arts educators are encouraged to explore interrelations with other subject areas (Bresler, 2003). In Dewey and other Pragmatists' view, the separation of knowledge into isolated compartments as independent curriculum formed a learning environment that was unfamiliar to students' everyday experiences which may prove harmful for education (Beane, 1997; Dewey, 1938). Progressivism, rooted in Pragmatism and Liberalism, has a goal of educating students based on their own interests and needs. Progressivism educators such as Kilpatrick believe that process oriented learning process can benefit children the most. They tend to use activity and project based curriculum, and teach with an emphasis on problem solving and cooperation. For aesthetics, Progressivism educators may integrate the aesthetics across the curriculum. Progressivism educators encourage creativity in art, and tend to provide adequate opportunities for students to enjoy art works in order to improve their aesthetic appreciation ability. For example, Progressivism teachers may integrate music and visual arts with other school subjects, and they try to offer a free environment for students to explore aesthetics in various ways. However, during the post-Sputnik era until the end of the Cold War, integrated curriculum approaches were mainly forgotten by educators, during which time, the educational field was plunged into a rigid, discipline-based approach paying special attention to mathematics and science education (Beane, 1997; Henson 2003).

Constructivism. The past two decades can be considered as the second era of curriculum integration, which influenced by the constructivism. Constructivism is a series of related theories and philosophies about learning. In general, constructivists believe that learners construct their own knowledge based on own experiences (English & Halford, 1995; Yager, 1996). The "constructivism" is an umbrella term because it could be either considered as a methodological perspective or treated as a cognitive position (Noddings, 1973). As a methodological perspective, constructivism acknowledges human beings cognitive ability and argues that human organisms have an advanced capacity for organizing information (Magoon, 1977). As a cognitive position, it believes construction is the only way to build knowledge, however, some constructivists insist that the construction mechanisms consist of cognitive structures that are innate (Chomsky, 1968; 1971) while other constructivists hold the construction mechanisms are themselves products of developmental construction (Piaget, 1975).

Constructivism is not a theory of instruction; rather it is a theory of knowledge and of learning (Fosnot, 1996). As a theory concerned with mathematics education, Noddings (1990) argued that the constructivist position is really postepistemological which has weaknesses as epistemology however has great strengths as pedagogy.

Although there are many perspectives on constructivism with different explanations, constructivism could be categorized into two folds—(a) radical constructivism which maintain that students gain knowledge through from their personal experiences within their environment (Prawat & Floden, 1994); and (b) social constructivism, which maintain that students build their knowledge as a culture product through information sharing and interactions (Derry, 1999; Heylighen, 1997; McMahon, 1997). Vygotsky is one of key important theories who founded the social constructivism, and he contributed the theory of Zone of Proximal Development (ZPD) to the education field. ZPD suggested educators paying more attention on the difference between what learners can learn from themselves and what they can learn from the assistance of more knowledgeable persons, and the idea of ZPD has been applied in many mathematics education projects (e.g., Murata & Fuson, 2006; Steele, 2001; Tharp & Gallimore, 1988).

By the late 1980s, with the publication of *Caught in the Middle* (California State Department of Education, 1987) and *Turning Points* (Carnegie Council on Adolescent Development, 1989), a new call for curriculum reform was raised. Researchers proposed that schools as well as schools of education should be relevant for students, and the integrated curriculum—using arts to connect all subjects - was once again a hot topic among educators. Moreover, with the publication of *The Curriculum and Evaluation*

Standards for School Mathematics wrote by the National Council of Teachers of Mathematics [NCTM] in 1989, this first contemporary set of subject matter national standard with a goal of promote mathematics concept understanding which pointed out the importance of making connections within and out of mathematics curriculum. Many national level standards documents adopted constructivist teaching approaches by paying specific attention on the curriculum integration (Gehrke, 1998). For example, both the National Arts Education Associations [NAEA] (1994) and National Science Teachers' Association [NSTA] (1998) in their standards explicitly documented that all students from K-12 should be able to recognize and apply knowledge to other content areas (e.g., making connections between mathematics and arts, science and the arts).

Against Arts Integrated Curriculum

Researchers with concerns about the arts-integrated curriculum have expressed their views about the integrated curriculum implementation. One of the key arguments they have made is that there did not exist enough evidence based on empirical research findings to support an arts-integrated curriculum. There were no statistically significant improvements in student academic achievement when compared with students who used traditional curriculum (Hetland & Winner, 2000). Other concerns about the advantage and efficiency of arts-integrated curriculum were in teachers' complaints that the integration curriculum made their job harder than their already overloaded curriculum. There was also a lack of support for teachers to teach based on such curriculum from researchers and teacher educators (Horowitz, 2004). Artists also expressed their warnings towards the integration of arts. Their worries included integrating the arts across the curriculum undermined and caused misunderstandings of the essential disciplinary arts knowledge, and this kind of curriculum may cause arts specialists to leave schools (Veblen & Elliott, 2000).

The finding of investigations conducted by Ellis and Fouts (2001) based on examination of the benefits and drawbacks to music integration suggested that interdisciplinary education with no scientific, research-based standards should really be called nondisciplinary. In further argumentation, they claimed that superior teachers will always find and use connections across different school subjects during the teaching process while preserving the separate subjects approach and that an integrated curriculum will remove the benefits that exist in traditional independent discipline delivery. Beside the argument of “interdisciplinary curriculum meaning nondisciplinary curriculum”, more weaknesses were identified by various researchers including the issue of support, research, time, money, patience, fear, training, and integrity (Mallery, 2000; Wood, 2001).

Eisner (1999) also expressed concerns about the current arts-integrated curriculum, claimed that these kinds of curriculum, in reality, was not as effective as many researchers argued. He found that although many articles claimed the arts can improve students’ academic achievement or that the arts courses “strengthen” academic performance, the research did not provide enough data to support the argument. Winner (2001) proposed that in many areas between academic achievement and the arts, no reliable causal links were found. In their research, they argued that based on 31 published reports, there was only a small to medium correlation between studying the arts and academic achievement as measured primarily by test scores. No evidence was found that arts learning could improve academic achievements. In Hetland and Winner's view (2000), some academic improvement issues of the arts-learning-students could be explained by non-causal mechanisms such as high achieving students (no matter their ethnic or racial group, or social class) may choose or be guided to study the arts. They suggested that the differences between achievement scores are probably caused by the students who take arts courses who are also high-achieving, high test-scoring students. They provided more evidence for their argument in 4 published reports showing no relationship between studying arts and verbal creativity test measures and 15 published reports showing there exist a small relationship between music/visual arts and reading/math. However, due to the limitation of these studies, these relationships could not be generalized to new studies.

For Arts Integrated Curriculum

Researchers who favor arts integration argued that integrated curriculum can assist students to develop holistic thinking skills; therefore, students' knowledge may be developed through interdisciplinary connections (Mason, 1996). With the development of cognitive science showing that evidence of learning is a situated, socially-constructed, and culturally intervening procedure, educational researchers further argued that integrated curriculum can facilitate students in increasing their creativity because arts integration provides opportunities for learners to fulfill these requirements (Marshall, 2005). The supporters of the integration of arts into curriculum also maintain that the arts can provide students and teachers learning experiences that can intellectually and emotionally motivate understanding (Chrysostomou, 2004; Deasey, 2002; Mansilla, 2005). Based on the connections among integration, arts-integrated curricula can improve socially relevant democratic education by involving transcend disciplinary boundaries and engaging learners through self-reflection and active inquiry (Parsons, 2004).

Fiske (1999) and Erickson (2001) summarized and demonstrated that teaching through arts can: (a) transform learning environments; (b) reach students who may not be easily reached; (c) promote communication among students; (d) provide opportunities for adults' involvement; (e) offer new challenges for successful students; (f) address important problems, issues, concepts; (g) decrease auricular fragmentation; (h) allow teachers and students to explore knowledge deeper; (i) challenge higher levels of thinking; helps students connect knowledge; (j) forces an answer to the relevancy question; and (k) connect learning experiences from school to the world. Hargreaves and Moore (2000) also noted that the integrated curriculum not only provides teachers chances to address important issues which may have difficult to investigated in individual subjects, but also allows students to develop a wider view of curriculum, which can reduces redundancy of content. Another key reason that the supporters argue is that arts integrated curriculum provides students with a learning environment that enables them to have a better social relationship with their everyday experiences since the interaction among disciplinary boundaries engages students through a reflection and inquiry process (Parsons, 2004). Ellis and Fouts (2001) advocated that interdisciplinary education can not only improve students' higher-order thinking skills and motivation for learning but also provide opportunities to understand knowledge from multiple perspectives as well as transfer of learning (Erickson, 1998; Scripp, 2002).

Motivation Theories and Learning

Motivation is defined as "a potential to direct behavior that is built into the system that controls emotion which may be manifested in cognition, emotion and behavior" (Hannula, 2004, p. 166). Motivation is an important factor in students' mathematics learning, because it not only associates with students' interest and enjoyment in learning mathematics but also relates to students' engagement and mathematics achievement (Martin, 2003).

Motivation affects students learning and performance in several aspects. First of all, motivation increases students' energy and activity level (Maehr & Meyer, 1997; Pintrich, Marx, & Boyle, 1993). In mathematics instruction processes, for example, motivation relates to whether a student will engage in certain mathematics activities vigorously or lackadaisically. In addition, motivation directs students to certain goals (Dweck & Elliott, 1983; Maehr & Meyer, 1997). In mathematics education, for example, motivation influences students' choices such as whether to try their best in solving problems based the different reinforcements they may earn afterward. Moreover, motivation promotes initiation as well as persistence in certain activities (Pintrich et al.

1993). Mathematics education is a long-term process, which requires students to persist throughout the mathematics learning process by repeatedly build on mathematics knowledge based on existing knowledge, and motivation will impact such process in learning mathematics. Finally, motivation affects students' learning strategies and cognitive processes (Dweck & Elliott, 1983). In mathematics lessons, for example, students with a high level of motivation may be benefited from their cognitive engagement to understand mathematics knowledge effectively.

Extrinsic Motivation and Intrinsic Motivation

In general, there exists two types of motivation—extrinsic motivation and intrinsic motivation. Extrinsic motivation refers to the motivation which lies outside of the individual as well as the task being performed, and the intrinsic motivation refers to the motivation which lies with the individual and the task that the individual involved (Csikszentmihalyi, 1996). For example, when students are extrinsically motivated in mathematics tasks, some of them may work for finish the task with the pressure to pass the test or get rewards from their parents. Extrinsically motivated students tend to seek approval and external signs of worth to finish the mathematics task and they prefer to ask procedural questions rather than content-enhancing questions; In contrast, when students are intrinsically motivated in mathematics tasks, they may find the mathematics tasks are enjoyable and worthwhile to do for themselves, and they tend to demonstrate autonomy and use self-initiated exploratory strategies (Sansone & Smith, 2000).

Although both kinds of motivation could facilitate students to obtain success on mathematics learning, extrinsic motivation has drawbacks. Studies found that extrinsic motivated students may exert only the minimal behavior and cognitive effort they need to execute a task successfully, and they may stop their effort as soon as no more reinforcement is provided (Maehr & Meyer, 1997). Compared with extrinsic motivation, research findings found many benefits from intrinsic motivation. For example, researchers found that intrinsic motivated students tend to (a) pursue knowledge based on their own initiative; (b) be cognitively engaged in the learning process; (c) accept more challenging task during learning; (d) learning with an orientation of understanding; (e) show creativity in the knowledge building process; (f) experience pleasure in the study; (g) evaluate their own progress regularly; (h) have higher achievement (Csikszentmihalyi, 1990, 1996; Glastra, Hake, & Schedler, 2004; Hennessey, 1995). As there are many advantages related to intrinsic motivation, many educators attempt to keep and develop students' high level of intrinsic motivation throughout the learning process, however, studies showed that many students gradually lost their intrinsic motivation as they move from low grade to high grade levels, especially in mathematics (Eccles & Midgley, 1989).

Affect and Motivation

Affect refer to the feelings, emotions, and general moods of the learners during their learning process. Pleasure, anxiety, excitement, anger and so forth are different forms of affect. Affect is closely related with motivation because different degree of motivation may cause different kind of affects, for example, too much motivation for students may lead to anxiety.

Interest and motivation. Interest is defined as human's most basic and common motivating emotions (Izard, 1993). High levels of interest are the foundation to initiate and maintain a high level of intrinsic motivation for learning (Hidi, 2000). Researchers has also identified that students' interest and enjoyment in a particular learning task are their most important components of motivation for them to persist in learning (Sansone & Smith, 2000). Students who are interested in a specific topic may not only concentrate more and became more cognitive engaged but also tend to learn the knowledge in a meaningful and organized way such as linking the existing knowledge to the new knowledge (Scheaw & Lehman, 2001).

There are two kinds of interests that corresponding with two kind of motivation. Specifically, personal interest, which is relatively stable over time related with intrinsic motivation; and situational interest, which is evoked by temporarily goal serving related with extrinsic motivation. Research suggested that personal interest has more benefits than situational interest because personal interest is the ultimate force to sustain students in an activity while situational interest only temporarily captures students' attention (Alexander, Kulikowich, & Schulze, 1994). Students' situational interest usually is generated by the things that are new, different, or unexpected; while students' personal interest unusually is inspired from their previous experiences (Schraw & Lehman, 2001).

Mathematics Anxiety

Anxiety, which closely related to motivation, is a feeling of nervousness and apprehension about an uncertain situation (May, 1977). Researchers found that mathematics anxiety commonly exists among school students in all grade levels, and it has become a concern for the education community (Endler & Edwards, 1982). In the United States there are about two thirds of people has the emotion if fear and loathe to mathematics (Burns, 1998). Moreover, more than 93% of students in the United States from K-16 do not have positive experiences with mathematics (Jackson & Leffingwell, 1999). Researchers (Morris, Davis, & Hutchings, 1981): have identified two components that comprised mathematics anxiety (a) cognitive—including the worrisome thinking about personal performance and (b) potential negative consequences and emotions—including nervousness, fear, and discomfort when involved in mathematical-related tasks (Vance & Watson, 1994). Among all the negative influences that associated with mathematics anxiety, one of the most universally discussed factors is the negative relationship between mathematics anxiety and mathematics achievement. Many researchers in various studies consistently found that students with a higher level of mathematics anxiety perform at a lower level of mathematics achievement (e.g. Ho et al., 2000; Lee, 1992; Satake & Amato, 1995).

Traditional ways of mathematics instruction was considered as one of the key factors that caused the mathematics anxiety: Assign the same problem to every student, teaching by lecturing the textbook, insisting on only one way to solve problem, neglecting conceptual understanding and so forth were argued as the origins of mathematics anxiety (Furner & Berman, 2005). Teaching mathematics in non-traditional ways such as using problem solving activities, simulations, discoveries, challenges, and games was proposed the effective methods to reduce students' mathematics anxiety (Tobias, 1998). Researchers suggested that in order to reduce students' mathematics anxiety as well as develop a positive attitude toward mathematics, teachers should demonstrate various ways of mathematics instruction to students with emphasis on teaching through manipulatives and real life activities which focus on conceptual understanding (Bursal & Paznokas, 2006).

Create a High Motivating Environment through Music

Emotion is essential in students' learning, because a good emotion may lead to a high level of motivation to facilitate students focusing attention on learning (Sylwester, 1995). As an application of motivation theories, Miller and Mitchell (1994) suggested teachers should create a high motivating environment for learning, free from tension and other possible causes of embarrassment or humiliation. Music, with its aesthetical features, have potential to create a high motivating environment for students, in which students can discover and think about mathematics concepts in various ways and build fundamental understandings and appreciation for both mathematics and the arts (Lawrence & Yamagata, 2007). What is more, music can provide students a high motivating environment with less prejudice and violence, helping them becomes better risk takers and communicators (Langer, 1997; Trusty & Oliva, 1994).

Because of the abstract property of mathematics, many concepts are very difficult for students to make connections with their life experiences which they are familiar with. Thus students' understanding as well as memorization was limited (Sweller, 1999). When students feel troubled about making sense of new knowledge and making connection with the existing knowledge, they may not complete the learning task. When this happens, students' motivation and engagement was reduced, and their attitude together with confidence may also be negatively influenced, which may impede students' learning of mathematics. As previous research has shown with implications for motivation theory, teaching mathematics integrated with music can effectively engage students in learning mathematics. By creating a high motivating learning environment (see figure below), music was used as a sugarcoating for learning particular concepts in mathematics. Students' attitude and confidence toward mathematics can be increased while their anxiety toward mathematics can be reduced (An, Kulm & Ma, 2008; An, Ma & Capraro, 2011).

Intelligence Theories and Learning

Multiple intelligences theory (Gardner, 1983) and the Mozart effect theory (Rauscher, Shaw, & Ky, 1993) are two theories that related with learning of music and mathematics, which heavily impacted on the education field. Both theories not only have been recommended for improving classroom learning (Gardner, 2004; Rettig, 2005), but also have been applied in classroom activities (Elksnin & Elksnin, 2003; Hoerr, 2003). However, both two theories has serious problems in empirical support— multiple intelligences theory has limited validating evidence to support while the Mozart effect theory has more negative than positive findings across many studies (Waterhouse, 2006). The development of both theories was reviewed as follows.

Multiple Intelligences

Published in 1983, Gardner in his book *Frames of Mind: The Theory of Multiple Intelligences* systematically introduced a new way of defining intelligence. In the book, Gardner proposed the existence of seven distinct intelligences including linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, intrapersonal, and interpersonal intelligence. In 1999 Gardner revised his model by adding the naturalistic intelligence as the eighth intelligence. More recently, two more intelligences—mental searchlight intelligence and laser intelligence were also added into the intelligence category (Gardner, 2004).

Specifically, based on Gardner (1983, 1999)'s definition, linguistic Intelligence refers to the ability of effectiveness in language using, which include reading, writing, listening and talking. Logical-mathematical intelligence refers to the gift of effectiveness in using numbers and reasoning, which include problem solving, deriving proofs, and computation. Spatial intelligence refers to the talent of recognizing form, space, color, line, and shape and representing visual and spatial ideas. Bodily-kinesthetic intelligence refers to the capacity of performing skillful and meaningful movements to express ideas and feelings as well as solve problems. Musical intelligence refers to the ability of recognizing rhythm, pitch, and melody, which include music playing, composing, singing and conducting. Interpersonal and intrapersonal intelligences respectively indicate the capability of understanding oneself and the capability of understanding of others. Naturalistic intelligence involves the talent to understand and work effectively in the natural world, including the ability of recognizing and classifying plants, minerals, and animals. Mental searchlight intelligence, as Gardner (2004) proposed, relates with the ability to scan wide spaces in an efficient way thus permitting individuals to run society smoothly while laser intelligence associated with the ability which generating "the advances (as well as the catastrophes) of society" (p. 217). Unlike the first eight kinds of intelligences which have connections to each other, Gardner failed to integrated mental searchlight intelligence and laser intelligence with other intelligences—because both two new intelligences used standard IQ as basis, however, Gardner proposed the original multiple intelligences theory with a goal of rejecting the standard IQ measurement (Waterhouse, 2006).

According to the multiple intelligences theory, each individual has different degrees of strengths as well as weaknesses in these intelligence domains (Hirata, 2004). As some educators criticized the traditional school curricula that focused too much attention on develop students' linguistic intelligence and logical/mathematical intelligence than other type of intelligences, students who are not strength in linguistic or logical/mathematical intelligences usually have a disadvantaged position in the school than their peers (Goodnough, 2001). By noticing this unbalances condition on single intelligences among learners, educators proposed that teachers need to foster students' natural intellectual strengths as well as personal interests by broadening instructional and assessment repertoires to cover various intelligential domains (Center for Educator

Development in Fine Arts, 2004). As multiple intelligences theory advocated some students may have lower logical/mathematical intelligence than others, and these students who have higher intelligences other than mathematics might experiencing difficulties in learning mathematics through traditional instructions. Multiple intelligences theorists suggested teacher to revise their instruction methods through diversity ways by facilitates students to make full use of their favorable intelligences to maximally develop and complement their other intelligences.

Musical intelligence was treated as important as all other kinds of intelligences such as logical/mathematical intelligence in the multiple intelligences theory. Gardner (1993) proposed that music can promote the development of other intellectual domains which involved with organizational capabilities. Gardner (1993) found that using music to enhance children's enjoyment and understanding of mathematical concepts and skills, could help students gain access to mathematics through new intelligences. Music, as an important form of arts, can enable students to use different learning styles and prior knowledge, pulling together diverse cognitive and affective experiences and organizing them to assist understanding (Selwyn, 1993). As an application of multiple intelligence theory, teaching mathematics integrated with music facilitates students to complete the process of knowledge transferring, as a result, the students whose strengths lie in areas other than the logical-mathematical intelligence to learn mathematics more easily (Johnson & Edelson, 2003).

Mozart Effects

Rauscher and his colleagues (1993) published their groundbreaking article about Mozart effects entitled Music and Spatial Task Performance. In the article, they reported an experiment that assigned three groups of 36 college students into three conditions—the first group was assigned to listen to ten minutes of Mozart's sonata for two pianos in D Major, (K448); the second group was assigned to listen to ten minutes of relaxing music; and the third group was exposed to silence for ten minutes. After the treatment of receiving music or silence, participants were assigned three spatial-reasoning skills sub-tests from the Stanford-Binet Intelligence Scale. The results of the tests showed that the group of participants who listened to the Mozart music demonstrated significantly higher IQ scores than the participants in the other two groups (119 for group of Mozart music, 111 for group of relaxing music and 110 for group of silence), although such advantage of IQ only lasted about 10 to 15 munities after the treatment.

After the initial publication of the Mozart effects, Rauscher and his colleagues conducted a series of follow-up studies. Rauscher et al. (1995) found that listening to the same Mozart music piece of K488 can improve college student’s ability to mentally unfold a folded abstract figure. Moreover, Rauscher et al. (1997) further found that the preschool children who received a six-month period of piano training demonstrated enhanced students’ spatial-temporal reasoning abilities in solving spatial tasks. More than positive influences on human intelligence, Rauscher, Robinson, and Jens (1998) reported that rats, when exposed to the Mozart sonata, also demonstrated an improvement in the spatial-temporal ability in doing maze tasks.

Many researchers in the recent two decades conducted many kinds of research to replicate the Mozart effects by recruiting participants in various ages and backgrounds. For example, Rideout and Laubach (1996, 1997, 1998) conducted a series of experiments on the effects of the same Mozart music and relaxing music pieces on participants' scores of paper folding and cutting test, and the results consistently supported evidence for the existence of Mozart effect. Nantais and Schellenberg (1999) also conducted an experiment to investigate the Mozart. In their research, two 17-item paper folding and cutting tasks were assigned to the participants after the treatment of music and they found that participants in both Mozart and Schubert's music significantly improved students' test scores compared with the silence group. Wilson and Brown (1997) also examined the Mozart effects by assigning maze tests for participants and their results showed that the participants of Mozart music group had significant higher scores than the relaxing music group and the silence group.

Rauscher et al. (1995) theorized possible explanations for the Mozart's sonata's effects on improvement of spatial-temporal reasoning. In their perspective, the Mozart's sonata stimulates neuron's activity in certain areas of the brain that are also responsible for spatial-temporal reasoning. The Mozart effect is a theory that provided measurable connections between music and mathematics, which stimulate the spatial and temporal areas of the brain based on human cognition (Shaw, 2004). Shaw pointed out that there are two kinds of mathematics reasoning which include spatial-temporal reasoning and language-analytic reasoning: The language-analytic approach expects students to receive necessary information with a goal of answering questions, while the spatial-temporal reasoning involves the mental rotation of objects in space and time, searching sequences and patterns, and thinking in advance. The traditional approach in education focused on more on the language- analytic reasoning by providing a lecture type of environment for students where information and solutions are of a quantitative nature which might neglect the mental visualization process in conceptual understanding of mathematics. Cheek and Smith (1999) suggested that improving the spatial/temporal cognitive abilities of the brain may cause an unintended improvement in visually dependent mathematics content such as geometry.

Empirical Studies of Teaching Mathematics Integrated with Arts

Research Reports of Large Scale Projects

In this section, six large-scale projects that related arts are briefly reviewed. Specifically, these projects include: Chicago Arts Partnerships in Education, North Carolina and Oklahoma A+ Schools, Arts for Academic Achievement, ArtsConnection, Empire State Partnerships, and Transforming Education through the Arts Challenge.

Chicago Arts Partnerships in Education (CAPE) is a program that formed in formed in the early 1990s with a goal to integrate the arts across the school curriculum. CAPE tried to promote classroom teachers and arts teachers work together by designing arts integrated lessons. Catterall and Waldorf (1999) found that students had positive attitudes toward attending the arts-integrated lessons and the CAPE students had higher achievement than their non-CAPE peers in all Chicago public schools on the standardized reading and mathematics test which included 52 comparisons. DeMoss and Morris (2002) investigated the effects of CAPE instruction on students by collecting data through surveys, observations and interviews, focus groups, and student writing, and they found that arts-integrated environments broadened learning communities, enhanced students' learning motivation and engagement in subject contents, and improved students' analytic interpretations and affective connections ability in writing.

The A+ schools program, initiated in 1993 in North Carolina, is a school reform model that treats the arts as fundamental element across all school subjects. Based on the multiple intelligences as the theoretical framework, the A+ schools program the arts-specific lessons including visual arts, music, drama, and dance were provided to students at least once a week. Nelson (2001) in the executive summary of the four-year (1995-1999) evaluation of the A+ schools program noted that the arts integration in the A+ schools program offered students opportunities to encounter the fundamental ideas of the curriculum more frequently and more diversely which facilitated students' opportunities to better understand specific content knowledge. Moreover, Corbett and his colleagues (2001) also reported five effects of the A+ schools on students, schools, communities, teachers, and students, which included (a) legitimized the arts as an important school subjects for promoting students learning; (b) pushed schools to make new networks among teachers from various subjects who teaches in different schools as well as their communities; (c) enhanced administrative ability to leverage internal structures and manage external environments; (d) constructed a key principle to organize a coherent arts-based curriculum; (e) offered students' enriched academic learning opportunities through good environments.

Arts for Academic Achievement (AAA), supported by the Perpich Center for Arts Education and executed in the Minneapolis Public Schools, is a program aimed at using arts to promote students' learning in subjects other than arts, such as reading and science. Ingram and Seashore (2003) indicated that there is a statistically significant correlation between arts integrated instruction and third and fourth grade students' achievement of reading and mathematics—such relationship is even stronger for disadvantaged students. More than the improvement of achievement, Ingram and Seashore also found the positive changes in student-student interactions. Specifically, they noted students' increased their interactions in areas: (a) improvement of group communication, (b) the emergence of unlikely leaders, (c) more communication between children with special needs and their peers, and (d) working in teams to accomplish a goal.

Founded in 1979, the ArtsConnection project involved more than 120 public schools in New York City by inviting teaching artists working with classroom teachers at various grade to provide opportunities of arts learning experiences and offer various instructional methods for students. The goal of the project is to investigate the effects of using diverse teaching methodologies involved with arts on students' cognitive, social, and personal development as well as the academic growth. Hefferen (2005) reported that in the research from 2000 to 2004, which focused on developing connections between dance, drama, and literacy instruction. The report showed that the experiences of arts enhanced student's confidence as well as cognitive skills including creativity, elaboration, originality, and the ability of comprehending multiple ways of problem representation.

Funded by the New York State Council for the Arts (NYSCA) and the New York State Education Department, the Empire State Partnerships (ESP) collaborated with 56 cultural organization partnerships with 84 organizations and 113 schools. The goal of EPS was to design and implement integrated curriculum by integrating arts into other school subjects across various grade levels. Researchers (e.g. Baker, Bevan, Admon, Clements, Erickson, & Adams, 2004) investigated ESP the impact and thematic development of arts teaching and learning in ESP through various research methods, and they found that learning through the arts not only allows learners with different background to learn school subjects in diverse ways by providing more avenues into the specific content areas for students to understand, but also provides students to encounter a specific subject knowledge repeatedly through a variety of ways connected with different art forms.

Supported by the National Arts Education Consortium, Transforming Education through the Arts Challenge (TETAC) is a project which involved 35 schools cooperated with six regional arts education institutes in California, Florida, Nebraska, Ohio, Tennessee, and Texas. The goal of this project is to promote students' inquiry during learning process and improve students' achievement. In order to accomplish this goal, the project facilitated school teachers became artist-teachers, by directing teachers to develop integrated lessons. Hutchens and Pankratz (2000) in their project report noted that TETAC provided an adaptable model or integrated arts instruction, in which students could gain knowledge in an arts incorporated environment.

Discrete, Small-Scale Studies on Music and Mathematics Learning

In this section, empirical studies related to using music as a medium to promote mathematics learning are briefly reviewed. Specifically, there are two type of research: (a) music and mathematics were taught as two independent subjects, and the effects of learning music on mathematics capacity were assessed (e.g. Bilhartz, Bruhn, & Olson, 2000; Costa-Giomi, 2004) and (b) music and mathematics were taught as an interdisciplinary curriculum, and the effects of such interdisciplinary curriculum on students' mathematics attitude or achievement were assessed (e.g. Benes-Laffety, 1995; Omniewski, 1999).

Bilhartz, Bruhn, and Olson (2000) conducted a study on the effect of music training on children's cognitive development, specifically, spatial-temporal reasoning. In their study, 71 preschool students were randomly block assignment by class assigned into experimental and control groups. The 36 students who assigned into the experimental group were received a 30-week music program including singing, instruments playing, and composing, while students in the control group received no special musical related interventions. Pre and posttest on six subtests of the Stanford Binet were provided to students in both groups. The results showed that one of the six subtests (on visual memory), the experimental group students has statistically significant higher score than the control group students. This study provides additional evidence of a link between

Costa-Giomi (1999, 2004) also reported studies on investigating the effect of three years of piano instruction on children's spatial, verbal, and quantitative skills. Costa-Giomi compared 43 fourth-grade students who received three years of private traditional piano instruction and 35 students who did not receive any piano lessons on their scores of verbal, quantitative, and spatial ability test, musical ability test, and fine motor ability test. The results showed that the students who received three years of piano instruction have statistically significant higher score on the control group students on spatial test. Moreover, in the experimental group, students' spatial test score increases as the years of piano learning increases, while score of the students in the control group remain the same.

Rauscher and his colleagues (1997) randomly assigned 78 preschool children into four groups to receive different treatments—children in different groups received six or eight consecutive months' keyboard lessons, singing lessons, computer lessons and no lessons. Children from all groups were provided pre and posttests for assess their spatial reasoning by using the instrument of the Wechsler Preschool and Primary Scale of Intelligence-Revised. One-way ANOVA and multiple t tests of children's test score showed that children in the keyboard group improved significantly on one of the spatial-temporal reasoning tests, while children in the other three groups did not. Moreover, students from the keyboard group have significantly higher score than the other three groups on the posttest.

Jordan-Decarbo and Galliford (2001) investigated the effects of music instruction on cognitive, social/emotional, and musical movement capabilities of preschool disadvantaged children. In their study, 106 young children were assigned into two groups—music group students received a 10-week intervention by having a music lesson every week; control group students received no specific music lessons in the curriculum. The Preschool Evaluation and musical movement test were used as pre and posttest before and after the intervention. Results showed that the music group students had significantly higher scores on the tasks of motor, cognitive, expressive language, and social/emotional abilities than the students from control group. In addition, music group students also had significantly higher scores on the overall musical ability.

Zafranas (2004) investigated the relationship between keyboard learning and students' spatial-temporal reasoning. In the study, 61 children with a age from five to six years were assigned to receive a 30-minute piano lesson once a week for six months. The Kaufman Assessment Battery' six subtests including the hand movement task, the gestalt closure task, the triangles task, the spatial memory task, the arithmetic task, and the matrix analogies task were used as pre- and post-tested for all the participants. The results showed there was statistically significant improvement on Hand Movements (visual-motor sequencing tasks), Gestalt Closure (visual-vocal communication tasks), Triangles (spatial-visualization tasks), Spatial Memory (spatial-localization tasks), and Arithmetic (mathematical concept and computational skill tasks) but not in Matrix Analogies (analogical thinking tasks).

Omniewski and Habursky (1998) conducted a study on the effects of teaching school core curriculum integrated with various arts forms including music. In their study, four classes of 75 students were randomly assigned into four groups as the Solomon design: 30 students were assigned into treatment group and 35 students were assigned into control group, half students in each group received pretest and after one month intervention all the students revived the posttest. The results indicated that the treatment students who received education from the arts integrated curriculum have statistically significant higher score on mathematics test than their peers who assigned into the control group. Omniewski (1999) further reported a study of the effects of an arts infusion program on students' achievement. In this study, 49 students from three entire classes were assigned as three different conditions—students in three classes respectively received six-week interventions by using the arts infusion approach, innovative manipulative approach and traditional textbook approach. Pre and posttests were assigned for all three classes, and the arts infusion approach group students had significantly higher score on the posttest than the students from the other two groups.

Benes-Laffety (1995) conducted a study focused on the integration of using musical activities including sinning, chants, cheers and rhythm movement into the traditional mathematics lessons. In Benes-Laffety's study, 44 students from two classes were selected to participate the research—one class of students were assigned as the experiment group and the other class of students were assigned as the control group. Mathematics content test which covered geometry, measurement and money concepts and the *Aiken Mathematics Attitude Scale* were used as the instrument to assess students' changes in mathematics achievement and attitude. The results showed that there is no significant difference on students' attitude between the music group and control group students, while music group students have significantly high score on the mathematics content test.

CHAPTER III

METHODLOGY

Participants

Student Participants Background

The current study was conducted in an elementary school is located in a city in Southern California. This school served 699 students in grades kindergarten to six on a traditional calendar system. The demographic percentage within school population were: 6.61% - Caucasian, 60.06% - Asian, 11.93% - Filipino, 9.34% - Hispanic, and 7.04% - Others. Most students in this school were from families whose socio-economic status was in the medium-to-medium high range and only 3% of the students at the school were receiving free or reduced meals. Among all students in this elementary school, 95% of them achieved higher than basic proficiency on the California Mathematics Standards Test in 2010-2011.

A total of 56 third grade students with an age range of seven to eight participated in the current study. The two classes with 28 students in each were randomly assigned to the two teachers in the beginning of 2011-2012 school year before the study. Specifically, 28 students (n=15_{boys} and n=13_{girls}) from class A was randomly assigned in the music group (treatment group). The ethnicity background of the music group consisted of 19 Asians, 2 African Americans, 2 Caucasians, and 5 Hispanics. Among all the students in class A, 14 were English language learners at the intermediate, early advanced or advanced language levels. Parallel to the music group, there were 28 student participants from class B (n=14$_{boys}$ and n=14$_{girls}$). These students were randomly assigned in the non-music group (control group). Their ethnic backgrounds were 14 Asians, 3 African Americans, 2 Caucasians, 4 Filipinos, and 5 Hispanics. Among all the students in class B, 12 were English language learners at the intermediate, early advanced or advanced language levels.

Teacher Participants Background

Two female elementary school teachers who teach in the target school participated into the present study. Both teachers had multiple years of teaching experience at the third grade level: teacher A had 11 years of teaching experiences while the teacher B had 9 years of teaching experiences. Evidences such as previous California State Test score and sample video lessons showed that the two teachers participants had equivalent teaching abilities with third grade mathematics. Before the study, two classes of 28 students were randomly assigned to the two teachers. Teacher A was assigned to class A teaching 14 music-mathematics integrated lessons to her students; teacher B was assigned to class B teaching regular mathematics lessons to her students.

Before the study, the teacher who was assigned to teach the music group students attended a series of professional development seminars (total of 10 hours) on music-mathematics integrated instruction. The professional development seminars were led by the author and college professors. Additionally, the music group teacher had multiple interactions with the author throughout the intervention period discussing the lesson plan and the instructional strategies. Prior to the dissertation study, the music group teacher had taught 15 pilot lessons teaching mathematics integrated with music over the previous two years, and received feedback on these lessons from professional development facilitators. The music group teacher was exposed to the pedagogical skills needed to teach mathematics lessons with music. The non-music group teacher attended regular professional development programs focused on various topics about effective teaching strategies offered by the school and workshops offered from other professional organizations such as California Mathematics Council (CMC) and the National Council of Teachers of Mathematics (NCTM).

Research Design

For between group investigations, a random assignment pretest-posttest control group design (Shadish, Cook, & Campbell, 2002) was used to examine students' changes in mathematics content achievement and their dispositions between the two groups (see Figure 3). Before the study, the two classes of students were randomly assigned as the two units to the two teachers. Among the two classes, one class was assigned to the music group teacher to receive music-mathematics integrated lessons; the other class was assigned to the non-music group teacher to receive standard mathematics lessons. As Shadish and his colleagues indicated, the randomized experiment is the most preferred design for having a precise and unbiased estimate of the effect of intervention. The random assignment in the current study equalizes the two groups on expectations of all dependent variables before the intervention began; and reduces the alternative causes that confounded the music-mathematics intervention conditions. Before the intervention, a pretest was administered to students in both groups to assess their mathematics content achievement and mathematics disposition. The aim of the pretest was to investigate how the two groups being compared initially differed from each other and to identify whether there was a pretest difference possibly suggesting a selection bias (Shadish et al., 2002).

Music Group (n=28)	R	O	X	O
Non-Music Group (n=28)	R	O		O

Figure 3. Diagram for the between group design.

For the within group investigation, the students in the music group were involved in 14 music-mathematics integrated lessons throughout the intervention period. This quasi-experiment time series design employed multiple pretests, mid-tests and posttests (Shadish et al., 2002) for investigating the effects of music-mathematics interdisciplinary lessons on students' mathematics process ability levels (see Figure 4). This design allows researchers to diminish the internal validity threats such as maturation and testing. Specifically, there were 15 tests including 3 pretests, 3 stage one mid-tests, 3 stage two mid-tests, 3 stage three mid-tests 3 stage four mid-tests and 3 posttests. Additionally, a focus group interview with 10 students (5 boys & 5 boys, 3 high achieving, 4 middle achieving and 3 low achieving students) was conducted as follow-up to interpret the students' changes in attitude and achievement.

O O O	X O_1 X O_2 X O_3	X O_4 X O_5 X O_6	X O_7 X O_8 X O_9	O O O
	Week 1-3	Week 4-6	Week 7-9	
	Intervention of 14 Music-Math Integrated Lessons			
Pretests	Mid-tests I	Mid-tests II	Mid-tests III	Pretests

Figure 4. Diagram for the within group design.

Music Intervention Procedure

Intervention Curriculum and Instruction Model

An and his colleagues developed a music-mathematics integrated curriculum (An & Capraro, 2011), and an alternative model of mathematics instruction by integrating music into mathematics lessons (An, in press). Multiple intelligence theories and motivation theories contributed to the theoretical framework to determine the effectiveness of mathematics-music interdisciplinary curriculum and the instructional model.

In the intervention curriculum, An and Capraro, (2011) provide a series of music-mathematics integrated activities. In the music-mathematics interdisciplinary curriculum, there are two types of music-mathematics integrated frameworks for teachers to design and teach their own lessons based on specific mathematical content: (a) the framework of musical instrument designing activities, and (b) the framework of music composition activities. Specifically, in the framework of musical instrument designing activities section, teachers are provided with historical and cultural information about the origin, development and the characteristics for each of the target musical instruments. The curriculum also contains two great masters' musical pieces and one contemporary musician as a reference for teachers to share with students. The recommended music pieces are uploaded on a video-sharing website for students to listen to and view. After students understand what the target instrument looks like and how it sounds, students are assigned to a musical instrument designing activity project and one or two discussion questions. Students learn and practice various mathematics concepts and skills in each activity and have opportunities to share their ideas with classmates during each activity. For example, in the above type of lessons *My Classical Guitar*, we provided the following background information about a classical guitar for students:

> Many people consider the classical guitar as a traditional Hispanic instrument. However, this type of instrument was played by people in many Asian and European countries throughout history. Classical guitars usually have six nylon strings and are plucked with the fingers. This instrument belongs to the chordophone family, because one can play up to six different tunes together. The

> tone of a classical guitar is made by the vibration of the strings; the sound is further transmitted and amplified through the bridge and saddle via the sound board which is located in its hollow body (An & Capraro, 2011, p 24).

Then, we will introduce two composers as well as their representative works for students to listen: *Sonata Mexicana* composed by Manuel Ponce (1882-1948) and *Guitar Concerto in A, op. 30* composed by Mauro Giuliani (1781-1829). After the musical instrument introduction and music listening, we provided the following mathematics project and discussion questions for students (see Figure 5):

Use circles to design a classical guitar.

1. Make four congruent circles tangent to each other (see step 1 below);
2. Outline the edges of the two middle circles and the spaces as shown in figures
3. Then cut out the middle section as shown in step 3;
4. Split the new figure in half and paste it leaving a uneven, nonparallel space between the two pieces as shown in step 4;
5. Redraw the outline of the new figure constructed in Figure 4 (see step 5)
6. Construct a small circle inside the new figure as shown in step 6.
7. Paste the new figure in step 6 on your worksheet below the finger board.
8. Use colored pens to decorate the guitar.

> What is the area and the perimeter of your guitar's sound box? Discuss your method with your classmates (An & Capraro, 2011, p 24).

In the framework of the music composition and playing activities, teachers were provided with an introduction to one music composition theory to share with students at the beginning of each activity. After students have a basic understanding of the target composition method, students are assigned music composition activity projects and one or two discussion questions. Students compose, play and share their own music works and then are assigned several mathematics problems based on their own music works. For example, in one of the music composition activity, we provided the following information about music composition for students:

> Texture deals with how you will decorate your melody. You can choose not to decorate your music; in this case, your music will be monophonic music. Monophonic music means only one note will be played at each moment. One can create monophonic music if one plays a piece of music with the saxophone by himself or sings a song alone. However, monophonic music is difficult to satisfy many people's hearing requirements because it is too simplistic. Composers need to add more related but different notes to the melody in order to beautify the music. One can use chords as accompaniment for a melody—in this case you may have homophonic music. One can also use one or more melodies to decorate another melody—this ancient technique is called "counterpoint", and in this case polyphonic music will be created (An & Capraro, 2011, p.139).

Then, students are asked to compose their own music on the worksheet by using seven different colored squares (red, white, yellow, blue, green, black, and purple) to represent the musical scale of C(Do), D(Re), E(Mi), F(Fa), G(So), A(La), and B(Ti), and play music when they finished their composing of *Twinkle Twinkle Little Star* (see Figure 6). After that, we will ask students to find the number of composition squares of each color they used in the *Twinkle Twinkle Little Star* to explore the concept of number, fraction, decimal, percentage and ratios (see Figure7). Finally, students are guided to construct a bar graph and a circle graph of the colors in the *Twinkle Twinkle Little Star* (see Figure8).

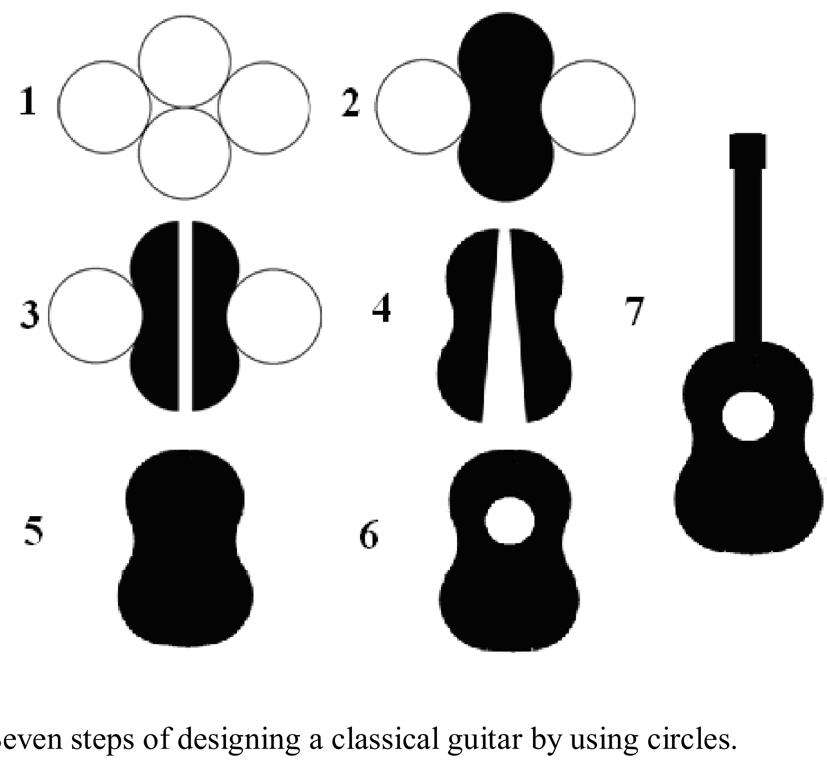

Figure 5. Seven steps of designing a classical guitar by using circles.

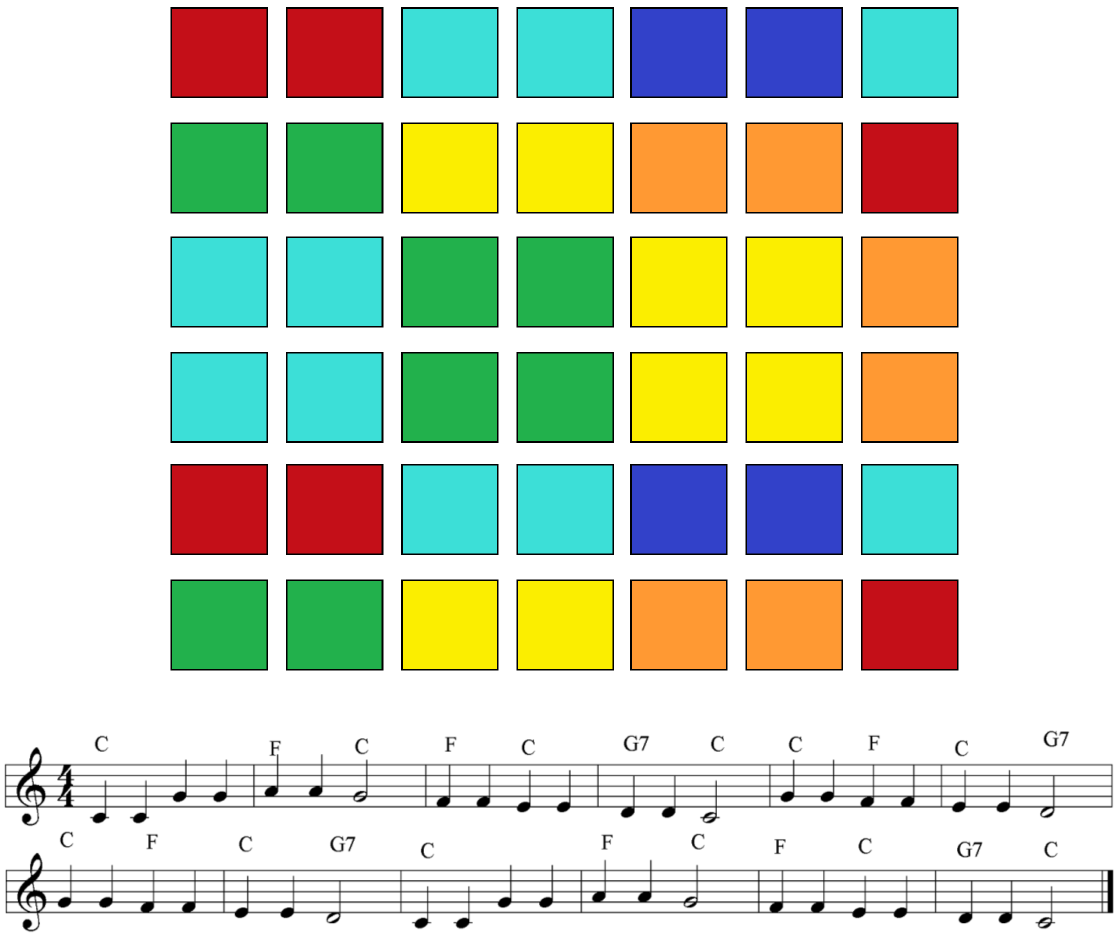

Figure 6. Graphical notation and staff notation of the *Twinkle Twinkle Little Star*.

Squares of which color represent the **Most** places in my melody?							
Squares of which color represent the **Least** places in my melody?							
How many squares in my work are **Red** and **Yellow**?							
How many squares in my melody are ( ) and ( )?							
How many squares in my melody are ( ), ( ) and ( )?							
What are the differences between squares of **Green** and **Blue** in my melody?							
What are the difference between the ( ) and the ( ) in my melody?							
	Red	**Orange**	**Yellow**	**Green**	**Blue**	**Indigo**	**Violet**
Number of squares							
Fraction	$\frac{}{42}$	$\frac{}{42}$	$\frac{}{42}$	$\frac{}{42}$	$\frac{}{42}$	$\frac{}{42}$	$\frac{}{42}$
Simplified fraction							
Percentage							
Decimal							
What is ratio between squares of **Indigo** and **Green** in my melody?							
What is ratio between squares of ( ) and ( ) in my melody?							
What is ratio between squares of ( ) and ( ) in my melody?							

Figure 7. Sample mathematics problems based on the *Twinkle Twinkle Little Star*.

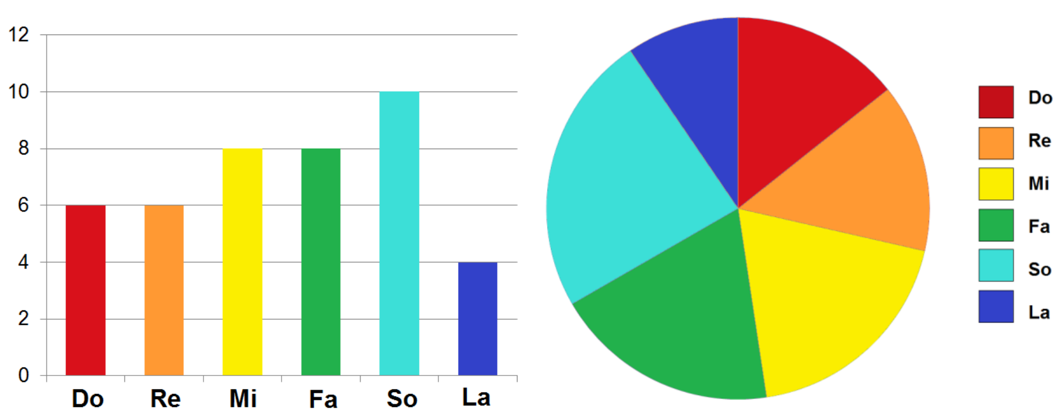

Figure 8. Statistical graphs constructed based on the *Twinkle Twinkle Little Star*.

An (in press) proposed an instructional model for each music-mathematics integrated lesson. The model has five phases for each lesson, with each phase containing varying levels of focus on music and mathematics. The suggested percentage of time spent on each phase is about 5% in phase one, 5% in phase two, 30% in phase three, 30% in phase four and 30% in phase five (see Figure 9). Based on different mathematics contents, the proportion of each phase may vary. In phase one, teachers introduce music knowledge using musical composition theories or musical instrument background. Music is the foci in the instruction in phase one. In phase two, teachers introduce the connection between the target music activity and the related mathematical objectives. Both music and mathematics is the focus in phase two, however music will still retain more of a focus than mathematics. In phase three, teachers facilitate student engagement in the music activities by (1) directing students to participate in the activity through a correct process, (2) encouraging students to think and asking questions to help students identify the key mathematical ideas from the music experience. Music and mathematics have an equivalent focus in phase three. In phase four, teachers will use students' music activity products as a resource to (1) design mathematical concepts or process examples, and (2) assign mathematics tasks based on students' own music activity outcomes. Both music and mathematics are focused on in phase four, but a greater emphasis was placed on mathematics. In phase five, teachers will focus only on mathematics topics and help students improve their understanding of mathematical content from unsophisticated to rigorous levels, and music will not be included in phase five.

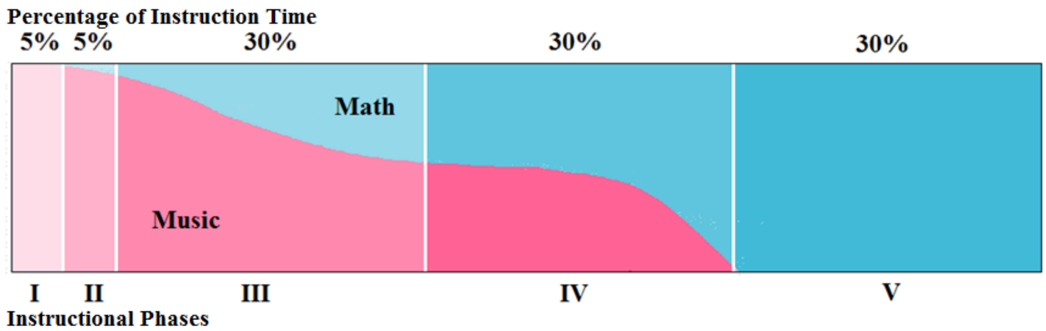

Figure 9. Percentage of time spent on each instructional phase in the music-mathematics integrated lessons.

In our current curriculum and instructional model hypothesis, interactive music activities are used as a resource to create a highly motivational environment in which students are engaged in aesthetics through active participation. The key features of this model are that it allows students to make sense of mathematical concepts and processes through multiple pathways and to apply mathematics within real-world contexts (An, 2011).

Lesson Designs for the Music-Math Intervention

The participant teacher designed and implemented music activities as an integrated part of her regular mathematics lessons over a nine-week period (see table 1). During the intervention period, one 45-minute music-integrated mathematics lesson was introduced to the third grade student participants each week. Each music-mathematics integrated activity was focused on one or more major mathematics content areas (see table on page 69).

Table 1

Strategies of Teaching Mathematics Integrated with Music and the Math Content Focus of Each Intervention Lesson

Math Focus*	Strategies of Teaching Mathematics Integrated with Music
Lesson 1 (week 1) NS 3.0	• Play childrens' favorite pieces of music by using handbells (e.g. *London Bridge*) based on graphical notations • Teach the concept of fraction and one whole relationship
Lesson 2 (week 2) NS. 2.0	• Play children's favorite pieces of music by using handbells and other percussion instruments (e.g. *Twinkle, Twinkle Little Star*) based on graphical notations • Teach students reciting multiplication basic facts while singing songs and playing instrument
Lesson 3 (week 3) SDAP 1.0 SDAP 1.1	• Play children's favorite pieces of music by using handbells and other percussion instruments (e.g. *Row, Row, Row Your Boat*) based on graphical notations • Teach statistical graphs and tables based on graphical music notations
Lesson 4 (week 3) SDAP 1.0 SDAP 1.1	• Introduce music composition activities by using graphical notation cards and playing students' own music works • Teach the concept of probability (e.g. certain, likely, unlikely, and impossible) through draw-lots experiments
Lesson 5 (week 4) NS 2.0	• Play music with patterns on digital piano • Introduce the concept of number line based on the piano keyboard activity
Lesson 6 (week 4) NS 2.0 MG 1.0	• Play children's favorite pieces of music by using handbells and other percussion instruments (e.g. *Happy Birthday*) based on graphical notations • Teach method for measurement and geometry concepts based on different musical instruments.

Table 1 Continued

Lesson 7 (week 5) AF 2.2	• Guide student to compose music using color patterns and play students' music works by using handbells • Introduce function table using the music patterns and the basic concepts of algebra (e.g. algebraic expressions, variables)
Lesson 8 (week 5) SDAP 1.3 NS 2.0	• Guide student to compose music using graphical notation and play students' music works by using handbells • Introduce bar graph, circle graph, and pictograph to students and guide them to construct statistical graphs based on music works
Lesson 9 (week 6) NS 2.0 AF 2.2	• Play children's favorite pieces of piano music from CD player • Guide student to make data charts and function tables and analyze data; teach students how to create problems based on given data
Lesson 10 (week 7) NS 2.0	• Play music by using handbells and other percussion instruments based on mathematical patterns • Guide students to count music measures/values; teach students how to create problems based on given data
Lesson 11 (week 7) NS 2.0 MG 1.0	• Play students' music works by using handbells and other percussion instruments; teach students reciting volume facts while singing songs and playing instrument (e.g. *The Alien Gallon King*) • Teach students how to create problems based on given data
Lesson 12 (week 8) AF 2.2 NS 3.0	• Play children's favorite pieces of music by using handbells and other percussion instruments (e.g. *London Bridge*) based on graphical notations • Introduce the concept of equivalent fractions, ratio, function rule and algebraic expressions
Lesson 13 (week 8) AF 2.2	• Guide student to compose music using music composition color wheel and play students' music works by using handbells • Introduce the function rule and algebraic expressions; Teach students how to create problems based on given algebraic pattern
Lesson 14 (week 9) NS 2.0 MG 1.0	• Play child favorite pieces of music by using handbells and other percussion instruments (e.g. *Oh McDonald*) based on graphical notations • Introduce the concept of perimeter and area based on students' instruments; guide students to measure the perimeter and area

Note: The mathematics content foci were based California State Standards

Music composition and playing activities were the two primary music activities that the teacher participant incorporated into her mathematics lessons. In the music-mathematics - integrated lessons, students had opportunities to use graphic notation (e.g., music color cards) and a variety of musical instruments such as handbells, drums, music sticks, and keyboards as manipulatives to learn mathematics. Actual musical pieces provided to the students to apply basic music theories to mathematics learning. Students had opportunities to experiment, practice, and apply various mathematics concepts and skills through the series of music-mathematics integrated lessons. Additionally, students had multiple opportunities to share their knowledge of basic concepts in mathematics with their classmates during each music integrated math lesson. For example, during the mathematics lesson that incorporated a music composition activity, music composition color cards were provided to the students as their creative music composition tools. Students used color patterns, number patterns, and letter patterns written on the color cards to compose their own music. Students created music using patterns and played it using hand bells. Students also shared their musical works with the class. In addition, mathematics concepts were introduced and several mathematics word problems were provided based on the students' own musical works.

Instruments

Mathematics Disposition Test

This test was adapted from the *Fennema-Sherman Mathematics Attitude Scales* (Fennema & Sherman, 1976), was used to assess students' changes of disposition toward mathematics. As Fennema and Sherman's test is designed for high school students, the current attitude test simplified the vocabulary difficulty in the test in order to facilitate students to respond to the test in an unbiased way. This survey included 36 items which covered following themes: (1) mathematics success, (2) mathematics anxiety, (3) mathematics confidence, (4) mathematics motivation, (5) mathematics usefulness and (6) mathematics belief. Each theme has six items to strengthen the internal validity. A five-level Likert scale was used where participants choose from 1 to 5 for strongly agree to strongly disagree in response to each survey questions. Smiling and unhappy faces were used as symbols representing agree and disagree for facilitating students to provide their feedback on the test. The overall coefficient alpha reliability of the mathematics achievement test was 0.852, and the mathematics disposition test is displayed in Appendix C.

Mathematics Achievement Test

This test was designed by the author, adopted from *the California Standard Test* (Standardized Testing and Reporting [STAR], 2011), and was used in assessing students' mathematics content achievement between music group and non-music group students.

Two parallel versions of the tests were designed for pretest and the posttest. During the test development process, the test items were sent for review and revision to California school teachers, mathematics teacher supervisors, as well as mathematics education professors in order to strengthen the validity of the test. Specifically, this mathematics achievement test contained 28 questions items in total with 15 multiple choice questions and 5 open ended questions with multiple sub-questions.

This test covered all the five content areas that listed in the Mathematics Content Standards for California Public Schools [MCSCPS] (2009) including: seven items on number sense (NS), five items on algebra and functions (AF), six items on measurement and geometry (MG), three items on statistics, data analysis, and probability (SDAP), and five items on mathematical reasoning (MR). Each content area is tested with both multiple choice questions and one open ended question assessing students' mathematics content knowledge from different perspectives. Students' mathematics achievement score was computed by adding the number of items from their correct answers. The overall coefficient alpha reliability of the mathematics achievement test was 0.817. Specifically, the coefficient alpha reliability of the pretest was 0.801 and of the posttest was 0.832. The mathematics achievement test is displayed in Appendix D.

Mathematics Process Ability Test

Wu and An (2006 & 2007) developed the model–strategy-application (MSA) assessment as a method of determining students' mathematics process ability levels on three areas. This test was derived from the core strands of proficiency from NRC (2001) and RAND (2003), as well as the guiding principles of the California Mathematics Framework (2006). The mathematics process assessment includes three components: model, strategy, and application. Specifically, in the Model column students are asked to demonstrate their visual approach to solving a problem; in the Strategy (S) column students use mathematical terms and symbols to show the mathematical process to solve the problem; and in the Application (A) column students create their own word problems connecting and applying their learned knowledge to the real world.

A series of 15 MSA tests were assigned to the music group students in the pretests, mid-tests, and posttests. All the test items directly assessed the content that was taught in the lessons based on the music-mathematics activity lessons during the intervention period. Each specific ability area (model–strategy-application) was evaluated independently according to the four-point rubric. The overall coefficient alpha reliability of the mathematics process ability test was 0.922, and the sample of mathematics process ability tests as well as the rubrics is contained in Appendix E.

Data Analysis

For the quantitative analysis of between group assessment, students' pre and post mathematics content achievement test and the mathematics disposition test was analyzed using independent *t*-tests to determine statistically significant differences in mean scores between the treatment group students and control group students. Specifically, the descriptive information such as means and standard deviations in each comparison was analyzed; moreover the test of significances was analyzed to determine whether there existed any statistically significant differences between pretest and posttest or between the music group and the non-music group.

For the quantitative analysis of within group assessment, 15 of music group's mathematics process achievement tests (3 pretests, 3 stage one mid-tests, 3 stage two mid-tests, 3 stage three mid-tests 3 stage four mid-tests and 3 posttests) were analyzed by using repeated measurement ANOVA to determine statistically significant differences in mean scores and standard deviations of the 15 tests among pretest, stage one mid-tests, stage two mid-tests, stage three mid-tests and posttests throughout the intervention period. Post-hoc Scheffe tests were analyzed when significant differences were identified in order to find which means were significantly higher or lower than other means.

Effect sizes are used by researchers to assess practical significance concentrating on the how much difference there was between groups as a result of an intervention or how strong the relationship was among variables (Cohen, 1994; Vacha-Haase & Thompson, 2004). Specifically, Cohen's *d* was used to compare means between groups on all kinds of *t*-tests, and the η^2 (correlation ratio) was used to identify the effect sizes in ANOVA (Thompson, 2006).

CHAPTER IV

RESULTS

The findings of this study are organized into four sections, and the three research questions are addressed separately in each of the following three sections. In the first section, students' mathematics dispositions between the music group and non-music group students are compared. In the second and the third section, students' mathematics content achievement and process achievement between the music group and non-music group students are compared respectively. Finally, the findings of the study with regard to the three research questions were summarized.

Mathematics Disposition

Research Question 1

Does the music group have a statistically significantly higher mathematics disposition mean score than the non-music group after the intervention of using music-mathematics integrated curriculum and instruction?

In the current study, we used a pre-and-posttest design to assess both music group and non-music group students' mathematics dispositions. The original alpha value on the *t*-test was .05; after correcting the *t*-tests using the grouping items in each of the six disposition areas (mathematics success, mathematics anxiety, mathematics confidence, mathematics motivation, mathematics usefulness and mathematics belief). The new adjusted alpha for all tests was .0083 in order to reduce the probability of making a type I error (Thompson, 2006). The results showed that on the pretests, there were no statistically significant differences between the music group and non-music group students. The posttests revealed that the music group students had statistically significant higher scores in mathematics disposition than non-music group students.

The results of the independent *t*-test for the mathematics disposition showed that the pretest scores between the music group and non-music group were comparable on all the six aspects designed to measure, because no statistically significant differences existed on the results of each pretest. Specifically, the music group students' mean of mathematics disposition pretest was slightly higher than the non-music group students. The results of the *t*-tests demonstrated that after the intervention of a series of music-mathematics-integrated lessons the music group had a significantly higher score on mathematics disposition than the non-music group students who did not receive interventions (see Table 2).

Table 2

The Paired t-test Results on Mathematics Disposition

Paired t-test		Music Group		Non-Music Group	
		Pretest	Posttest	Pretest	Posttest
Overall	Mean ± SD	3.41±0.51	4.33±0.47	3.51±0.55	3.64±0.53
	p & t value	<0.001 (6.628)		0.341 (0.969)	
	Cohen's *d*	1.61		0.24	

Table 2 Continued

Confid-ence	Mean ± SD	3.61 ±1.01	4.39±0.65	3.60±0.92	3.66±0.79
	p & *t* values	<0.001 (3.87)		0.881 (0.228)	
	Cohen's *d*	0.94		0.06	
Anxiety	Mean ± SD	2.96±0.63	4.13±0.78	3.10±0.62	3.36±0.83
	p & *t* values	<0.001 (6.24)		0.17 (1.41)	
	Cohen's *d*	1.46		0.24	
Useful-ness	Mean ± SD	3.54±0.79	4.66±0.40	3.97±0.78	4.09±0.48
	p & *t* values	0.016 (4.45)		0.56 (0.58)	
	Cohen's *d*	1.88		0.13	
Success	Mean ± SD	3.92±0.74	4.66±0.52	3.89±0.74	4.18±0.81
	p & *t* values	0.004 (2.58)		0.065 (1.92)	
	Cohen's *d*	1.18		0.38	
Motiva-tion	Mean ± SD	3.58±0.96	4.27±0.90	3.67±0.96	3.86±0.77
	p & t value	<0.001 (6.45)		0.446 (0.78)	
	Cohen's *d*	0.744		0.22	
Belief	Mean ± SD	2.83±0.70	3.85±0.46	2.83±0.57	2.70±0.67
	p & t value	<0.001 (5.90)		0.439 (0.79)	
	Cohen's *d*	1.98		0.19	

Although the goal was to compare the differences between the music group and the non-music group students' mathematics dispositions by using the independent *t*-test, a series of paired *t*-test was also included as post-hoc tests to examine the disposition changes within each group of students. Because the independent *t*-test demonstrated that the music group had significantly higher score than the non-music group, this data does not indicate that the non-music group students failed to attain statistically significant improvements from pretest to posttest by participating in regular mathematics curriculum and instruction. Our rationale for including a paired *t*-test for both the music group and non-music group independently was to identify and eliminate the significant improvement of non-music group students' disposition score. Moreover, the paired *t*-test can also be used as supportive evidences to show the effects of music-mathematics integrated intervention lessons on facilitating music group students' improvement in their mathematics disposition scores.

The results of the paired *t*-test (see Table 3) on measuring the differences between pretest and posttest showed that there were statistically significant improvements in the music group students' mathematics disposition overall score on all 36 items among all six disposition areas ($p<0.001$; t=6.628). In the non-music group, there were no statistically significant changes among pre and posttest scores for the overall mathematics disposition scores ($p=0.341$; $t=0.969$). Moreover, the music group students showed statistically significant improvements from pretest to posttest on all specific disposition areas. In contrast, for every specific dispassion area, the non-music group students did not show statistically significant improvement.

Table 3

The Independent t-test Results on Mathematics Disposition

Independent t-test		Pretest		Posttest	
		Music Group	Non-Music Group	Music Group	Non-Music Group
Overall	Mean ± SD	3.41 ± 0.51	3.51 ± 0.55	4.33 ± 0.47	3.64 ± 0.53
	p & *t* values	0.65 (-0.22)		<0.001 (5.79)	
	Cohen's *d*	0.19		1.37	
Confid-ence	Mean ± SD	3.61 ± 1.01	3.60 ± 0.92	4.39 ± 0.65	3.66 ± 0.79
	p & *t* values	0.982 (-0.22)		<0.001 (3.71)	
	Cohen's *d*	0.01		1.01	
Anxiety	Mean ± SD	2.96 ± 0.63	3.10 ± 0.62	4.13 ± 0.78	3.66 ± 0.83
	p & *t* values	0.378 (-0.89)		<0.001 (3.55)	
	Cohen's *d*	-0.22		0.58	
Useful-ness	Mean ± SD	3.54 ± 0.79	3.97 ± 0.78	4.66 ± 0.40	4.09 ± 0.48
	p & *t* values	0.052 (-2.00)		<0.001 (4.814)	
	Cohen's *d*	-0.53		1.29	
Success	Mean ± SD	3.92 ± 0.74	3.89 ± 0.74	4.66 ± 0.52	4.18 ± 0.81
	p & *t*values	0.87 (-0.16)		0.001 (3.544)	
	Cohen's *d*	0.04		0.96	

Table 3 Continued

Motivation	Mean ± SD	3.58 ± 0.96	3.67 ± 0.96	4.27 ± 0.90	3.86 ± 0.77
	p &*t* values	0.76 (0.301)		0.067 (1.868)	
	Cohen's *d*	0.09		0.49	
Belief	Mean ± SD	2.83 ± 0.70	2.83 ± 0.57	3.85 ± 0.46	2.70 ± 0.67
	p &*t* values	1.000 (0.002)		<0.001 (7.472)	
	Cohen's *d*	0.00		2.00	

The results of the independent t-test on measuring the differences between music group students and non-music group students on the disposition test (see Table 2) showed that there were no statistically significant differences between the music group and the non-music group's overall scores on the pretest (p=0.65; t= −0.22), however, the music group students demonstrated statistically significant higher overall scores than the non-music group's overall scores on the posttest (p<0.001; t=5.79). For each specific disposition areas, on the pretest there were no statistically significant differences between the music group students and non-music group students. In the posttest, the music group students significantly outperformed the non-music group students on five out of six disposition areas including confidence, anxiety, usefulness, success, and belief.

Cohen's *d* test results between pretest and posttest within music group and within non-music group, showed large practical significance. Small practical significances were found between pretest and posttest within the non-music group. For example, large effect sizes were found not only between pretest and posttest within music group on the overall disposition scores (*d*=1.61) but also on all the six specific disposition areas with a range of effect sizes from 0.74 to 1.88 (see Table 1). In contrast, small effect sizes were found not only between pretest and posttest within non-music group on the overall disposition scores (*d*=0.24) but also on all the six specific disposition areas with a range of effect sizes from 0.06 to 0.38 (see Table 1). Moreover, with regard to practical significance tests, small effect sizes were found between the music group and non-music group within pretest, while large effect sizes were found between music group and non-music group within posttest. For example, 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 music group and non-music group within posttest not only on the overall disposition scores (*d*=0.1.37), but also on all specific disposition areas with a range of effect sizes from 0.49 to 2.00 (see Table 2).

In conclusion, the findings rejected the null hypothesis for research question one concluded that there was no statistically significant differences on the mathematics disposition mean score between the music group and the non-music group. The findings showed that music group students and non-music group students had similar scores on mathematics disposition on the pretest, however, after the intervention, the music group students displayed statistically significant higher scores in their disposition test than the non-music group students.

Mathematics Achievement

Research Question 2

Does the music group have a statistically significantly higher mathematics content achievement mean score than the non-music group after the intervention of using music-mathematics integrated curriculum and instruction??

In the current study, a pre-and-posttest design was used to assess both music group and non-music group students' mathematics achievement. The original alpha value on the *t*-test was .05. After correcting the *t*-tests for the grouping items in each of the five content areas (number sense, algebra and functions, measurement and geometry, statistics/data analysis/probability, and mathematical reasoning), the new adjusted alpha for all tests was .0012 in order to reduce the probability of making a type I error (Thompson, 2006). The results showed that on the pretests, there was no statistically significant differences on the pretests between the music group and non-music group students; whereas on the posttests, the music group students showed statistically significant higher scores in mathematics achievement than non-music group students (see Figure 10).

The results of the independent *t*-test for the mathematics achievement showed that the pretest scores between the music group and non-music group were comparable, because no statistically significant differences existed on the pretest. Specifically, the music group students' mean on mathematics achievement pretest was similar to the non-music group students ($Mean_{music}=3.46 \pm 4.90$; $Mean_{non\text{-}music}=3.46 \pm 3.17$), and there were no statistically significant differences between the music group and the non-music group's mathematics achievement on the pretest (p=0.68; t= 0.453). The results of the independent t-tests (see Table 4) demonstrated that after the intervention of a series of music-mathematics-integrated lessons, the music group (Mean $_{music}$=21.07 ± 3.71) had a significantly higher score on mathematics achievement than the non-music group students (Mean $_{non\text{-}music}$=10.67 ± 3.73) who did not receive interventions (p<0.001; t=10.53).

Table 4

The Independent t-test Results on Mathematics Achievement

Independent t-test n=56		Pretest Music Group	Pretest Non-Music Group	Posttest Music Group	Posttest Non-Music Group
Mathematics Achievement	Mean	9.96	9.46	21.07	10.67
	SD	4.90	3.16	3.71	3.73
	p-value	0.68		<0.001	
	t-value	0.453		10.53	
	Cohen's *d*	0.12		3.00	

Table 5

The Paired t-test Results on Mathematics Achievement

Paired *t*-test		Music Group n=28		Non-music Group n=28	
		Pretest	Posttest	Pretest	Posttest
Mathematics Achievement	Mean	9.96	21.07	9.46	10.61
	SD	4.90	3.71	3.16	3.73
	p-value	<0.001		0.031	
	t-value	10.53		2.271	
	Cohen's *d*	3.38		0.33	

As explained in the previous section (see page 69), the rationale for including a paired *t*-test for both music group and non-music group independently was to identify and eliminate the significant improvement of the non-music group students' mathematics achievement scores. Moreover, the paired *t*-test can also be used as supportive evidences to demonstrate the effects of music-mathematics integrated intervention lessons on facilitating music group students to improve their mathematics achievement scores. The paired *t*-test showed there were statistically significant improvements in the music group students' mathematics achievement score (p<0.001;

t=10.53). There were no statistically significant changes among pre and posttest scores for the mathematics achievement within the non-music group (*p*=0.031; *t*=2.271).

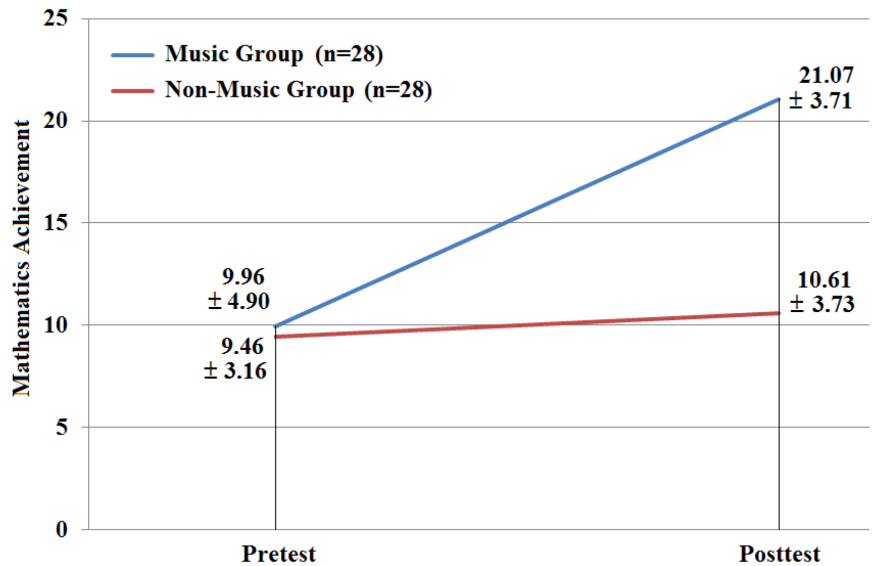

Figure 10. Average mathematics achievement assessment scores of pretest and posttest between music group and non-music group.

Similar to statistical significance test results between pretest and posttest within music group and within non-music group, large practical significances were found between pretest and posttest within music group and small practical significances were found between pretest and posttest within non-music group. For example, large effect size were found not only between pretest and posttest within music groups on the mathematics achievement (*d*=3.38) and small effect sizes were found between pretest and posttest within non-music group on the mathematics achievement (*d*=0.33) (see Table 1). Moreover, looking at the practical significance tests, small effect sizes were found between music group and non-music group within pretest while large effect sizes were found between music group and non-music group within posttest. For example, a small effect size was found between music group and non-music group within pretest on the mathematics achievement (*d*=0.12), while large effect sizes were found between music group and non-music group within posttest on the mathematics achievement (*d*=3.00) (see Table 2).

In conclusion, the findings rejected the null hypothesis for research question two indicating there was no statistically significant difference on the mathematics achievement test mean score between the music group and the non-music group. The findings showed that the music group students and non-music group students had similar scores on mathematics disposition on the pretest; however, after the intervention, the music group students displayed statistically significant higher scores on their mathematics achievement tests as compared to the non-music group students.

Mathematics Process Abilities

Research Question 3

Do the mathematics-music lessons improve the treatment group mathematics process mean achievement scores across the intervention period of using music-mathematics integrated curriculum and instruction?

In the current study, a time series design with multiple pretests, mid-tests and posttests was utilized for investigating the effects of music-mathematics integrated lessons on the music group students' mathematics process abilities. The original alpha value on the *t*-test was .05; after correcting the for 9 paired *t*-tests for the items in each of the three process ability areas (model, strategy and application) from three tests in each pretest, mid-test and posttest, the new adjusted alpha for all tests was .0056. The results showed that music group students' mathematics process abilities were statistically significantly improved from the pretests to the posttests. Within the three stages of the middle tests, statistically significant improvement was also identified. In general, the repeated ANOVA results indicated that for the music group students, mathematics process ability levels on all three mathematical areas were statistically significantly improved after the intervention (see Table 6) with p values on all three mathematics process ability areas being less than 0.0001. Large effect sizes were found in music group students before and after the intervention in all three mathematics process ability areas with η^2 from 0.57 to 0.68.

Table 6

The ANOVA of Mathematics Process Ability Levels among Pretests, Mid-tests and Posttests

Mathematics Processes n=28		Mean	*SD*	F value	*p* value	η^2	SS
Overall	Pretests	1.91a	0.46	72.73	<0.001	0.68	Between 64.77 Within 30.06
	Mid-tests I	2.59b	0.67				
	Mid-tests II	3.10c	0.50				
	Mid-tests III	3.61d	0.38				
	Posttests	3.76d	0.24				
Model	Pretests	1.98a	0.55	69.08	<0.001	0.67	Between 64.52 Within 31.52
	Mid-tests I	2.62b	0.63				
	Mid-tests II	3.10c	0.57				
	Mid-tests III	3.72d	0.27				
	Posttests	3.77d	0.27				
Strategy	Pretests	1.92a	0.56	44.99	<0.001	0.57	Between 67.03 Within 50.27
	Mid-tests I	2.26a	0.84				
	Mid-tests II	2.99b	0.60				
	Mid-tests III	3.48c	0.57				
	Posttests	3.73c	0.39				
Application	Pretests	1.83a	0.66	47.24	<0.001	0.58	Between 67.57 Within 48.17
	Mid-tests I	2.90b	0.77				
	Mid-tests II	3.24bc	0.65				
	Mid-tests III	3.63cd	0.47				
	Posttests	3.79d	0.31				

Table 7

The ANOVA of Mathematics Process Ability Levels among Each Process Ability

n=28	Test	Model Mean	Model SD	Strategy Mean	Strategy SD	Application Mean	Application SD	F	*p*	η^2
Pretest	1	1.86	0.97	1.36	0.62	1.71	0.97	2.44	.09	0.05
	2	2.11	0.83	2.39	0.78	2.14	0.93	.93	.39	0.02
	3	1.96	1.03	2.04	0.99	1.64	0.82	1.33	.26	0.03
Mid-test I	4	2.13	0.81	2.18	1.14	2.7	1.01	2.78	.06	0.06
	5	**2.77b**	1.05	**2.04a**	1.06	**3.21b**	0.91	9.62	**<.001**	0.19
	6	2.96	0.81	2.55	1.02	2.8	1.10	1.22	.29	0.03
Mid-test II	7	2.95	1.02	2.66	0.95	2.96	1.04	.80	.45	0.02
	8	3.04	0.55	3.34	0.59	3.46	0.74	3.34	.04	0.08
	9	3.3	0.94	2.95	1.10	3.29	0.95	1.11	.33	0.03
Mid-test III	10	3.71	0.59	3.23	0.91	3.64	0.63	3.54	.03	0.08
	11	3.71	0.51	3.59	0.59	3.73	0.64	.49	.61	0.01
	12	3.73	0.46	3.63	0.77	3.5	0.87	.71	.49	0.02
Posttest	13	3.64	0.46	3.77	0.39	3.89	0.31	2.75	.06	0.06
	14	3.86	0.44	3.7	0.71	3.73	0.51	.61	.54	0.04
	15	3.8	0.36	3.73	0.67	3.75	0.64	.11	.89	0.03

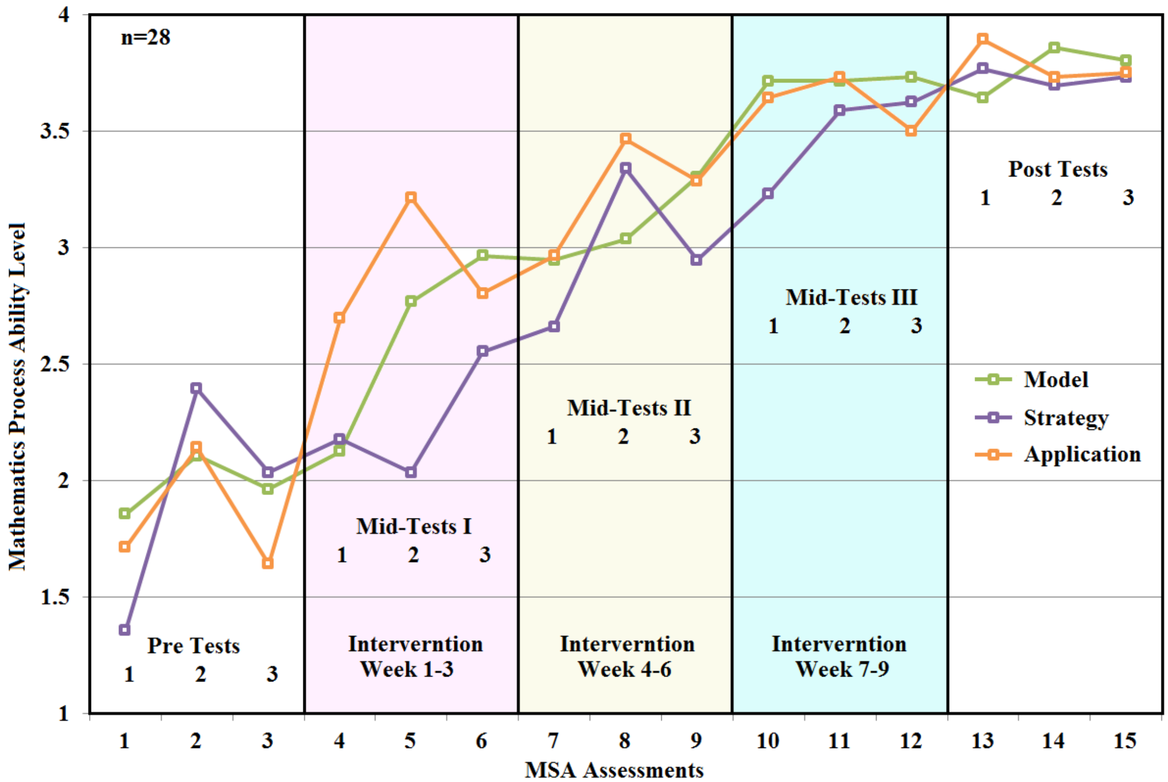

Figure 11. Average ability level of each mathematics process ability test through pretests to posttests.

In order to assess the mathematics process ability improvement, a total of 15 MSA tests were assigned to the music group students. As illustrated in Figure 11, the descriptive statistics analysis demonstrated a noticeable pattern of both improvements of means and reduction of standard divinations on all three mathematics process ability levels from the pretest to the posttest. This finding indicate that not only most students improved students' average mathematics process ability levels throughout the intervention of music-mathematics integrated curriculum and instruction but also the gap between high achieving and low achieving students was reduced. The test of significances showed that music group students' overall mathematical abilities were (a) statistically significantly improved from the pretest to the mid-test I; (b) statistically significantly improved from the mid-test I to the mid-test II; (c) statistically significantly improved from mid-test II to mid-test III; and (d) stable at a high level from the mid-test III to the posttest. Similar improvement patterns were also identified at each specific mathematics ability areas (model, strategy and application).

Specifically, the 9 sub-tests of the pretest of the three mathematical ability areas, the music group students showed an average ability level of lower than 2.0. On mid-test I, among the 9 sub-tests on the pretest of the three mathematical ability areas, the music group students had an average ability level higher than 2.0 including the 6 sub-tests which had levels higher than 2.5. On mid-test II, among the 9 sub-tests on the pretest of the three mathematical ability areas, the music group students demonstrated an average ability level of higher than 2.5 including 4 sub-tests which had levels higher than 3.0. On mid-test III, among the 9 sub-tests on the pretest of the three mathematical ability areas, the music group students displayed an average ability level of higher than 3.0 including 8 sub-tests which had levels higher than 3.0. On the posttest, among the 9 sub-tests on the pretest of the three mathematical ability areas, the music group students had an average ability level higher than 3.5 on all the 9 sub-tests' score higher than 3.5.

Although the goal was to compare the differences in students' mathematics process ability levels among each test from pretest to the posttest by adopting the repeated measure ANOVA, we also included a repeated measure ANOVA to examine students' mathematics process ability levels within each test among the specific ability areas of model, strategy and application to examine whether some ability areas many have statistically significant different from others. The original alpha value in the t-test was .05; after correcting the for the three process ability areas (model, strategy and application) within each pretest, mid-test and posttest, the new adjusted alpha for all tests was .0017. As noticeable differences among mathematics process ability levels were identified in the Figure 11 in few tests before the intervention and in the first stage of the intervention, the ANOVA indicated that only the second test in the mid-test I (test 5) have statistically significant different among the three process ability areas. A post-hoc Scheffe test was used to analyze the process ability strategy and results showed statistically significant lower scores than the model and application in test 5, and there were no statistically significant differences between the model and application (see Table 7). The repeated ANOVA showed that the music-mathematics integrated lessons had positive effects on all three kinds of process ability areas—some ability area (e.g. strategy) may have different improvement paces than others at the first stage of intervention; however, such differences in ability levels among different ability areas disappeared from intervention stage II and III as well as the posttest. Although statistically significant differences were found on a limited number of tests in mid-test I, the effect sizes indicators were expressed in η^2 showing only slight practical significances existed among the mathematics process ability areas on all tests.

In conclusion, the findings rejected the null hypothesis for research question three indicating there was no statistically significant differences on the mathematics process ability test mean score among the pretests, mid-tests and posttests. The findings showed that the music group's overall mathematics ability levels were statistically significantly improved from pretest to posttest; moreover, similar improvement were identified from the mid-test I, to mid-test II and to mid-test III during the intervention period.

CHAPTER V

DISCUSSION AND CONCLUSION

In the current study, music activities were used as curriculum resources to design and implement mathematics lessons in a nine-week intervention period. A series of 14 mathematics lessons using music activities associated with a variety of mathematics content areas were designed and implemented as an intervention for a group of elementary students. Based on multiple intelligences theory and motivation theories, we used aesthetics as a methodology to provide a rich and emotionally stimulating mathematical learning context, reducing students' mathematics anxiety and engaging students through creative and active involvement in mathematics learning (Eisner, 2002; Sylwester, 1995; Upitis & Smithrim, 2003; West, 2000; Witherell, 2000). Consistent with previous research on the impact of music-integrated activities on students' mathematics achievement and disposition (An, Kulm, & Ma, 2008; Benes-Laffety, 1995; Omniewski, 1999; Omniewski & Habursky, 1998), the present study's findings demonstrated that music-math integrated lessons have positive effects on not only mathematics achievement and process ability level but also mathematics dispositions.

Summary of Findings

The study focused on whether music-mathematics integrated activities were effective in serving as an instructional strategy for developing students' mathematics learning and/or an instructional aid for developing positive mathematics dispositions for elementary students.

Multiple quantitative methods and research designs were used to analyze the results including (a) paired sample *t*-tests by comparing the changes of mathematics achievement and disposition scores within the music group and within the non-music group students between each pretest and posttest; (b) independent *t*-test by comparing the mathematics achievement and disposition scores between the music group and non-music group students within each pretest and posttest; (c) one-way within-subjects (repeated measures) ANOVA by assessing the music group students' mathematics process ability score changes across the pretests, mid-tests and posttests. An independent *t*-test was used to compare the mathematics achievement and disposition scores between the music group and non-music group students within each pretest showing that the two groups of students were comparable as there were no statistically significant differences between the music group students and non-music group students on the pretest scores for both achievement and disposition test. The independent *t*-test compared the posttest in both achievement and disposition assessment showing the music group students had statistically significantly higher scores than the non-music group students on both assessments. Second, the paired sample *t*-test showed that within the music group there was a statistically significant improvement in mathematics achievement and disposition scores from pretest to posttest; while no significant differences were found between the pretest and the posttest within the non-music group students. Third, the repeated measures ANOVA, by comparing the music group students' mathematics process achievement across the pretests, mid-tests and posttests, showed that there were statistically significant differences between each tests across the intervention period. In short, the music group students displayed better mathematics achievement, higher process ability levels as well as more positive mathematical dispositions than their counterparts in the non-music (control) group.

The Changes in Mathematics Dispositions

The results indicated that throughout the 9-week intervention of participating ining music-mathematics integrated lessons, the music group students' mathematics dispositions were statistically significantly improved from pretest to the posttest; while the non-music students' mathematics dispositions did not show statistically significant improvement from pretest to the posttest. Consistent with previous research on the positive impact of music integrated mathematics activities, lessons and curriculum on students' mathematics attitude (An, Kulm, & Ma, 2008; An, Ma, & Capraro, 2011; Benes-Laffety, 1995; Catterall & Waldorf, 1999), the current study shows significant positive shifts throughout the intervention compared with their non-music group peers. We can reasonably exclude the possibility that some other variables caused the improvement in music group students' achievement.

Greene (2001) defined learning through aesthetics as a process of offering innovative resources of seeing, hearing, feeling, moving, reaching out for understanding along with students' development of cognitive, perceptual, emotional and imaginative learning. Learning through music allows students to view the world from different perspectives and experience rewards from success in mathematics through the arts (Gamwell, 2005). Based on the links between the academic subject and the arts, music-mathematics integrated curriculum and instructional approaches can improve socially relevant democratic education by transcending disciplinary boundaries and engaging learners through self-reflection and active inquiry (Parsons, 2004).

For each specific disposition areas including confidence, motivation, anxiety, usefulness, success, and belief, the music group students showed statistically significant improvement from pretest to posttest. This improvement can be explained showing that the music group students' dispositions toward mathematics were positively impacted by the music-mathematics integrated activities. These findings are consistent with the theoretical framework provided in Chapter II (see page 8)..

Motivation Through Engagement

The researcher attempted to use music related activities as an atheistic resource setting up a high motivational environment, within which students could participate in enjoyable and sense making mathematical activities.

In this high motivational learning environment, the music group students were aesthetically engaged. Throughout the nine-week intervention period, students' development of engagement in mathematics demonstrates 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 engages students to participate in mathematics activities; and then (c) through this engagement, students participate in closely related mathematical tasks throughout their music related experiences.

Confidence in Doing Mathematics

During the same period of time that the music group students enhance their engagement in mathematics, their confidence toward mathematics learning also improves. During the mathematics lesson, the music group students experiences 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 feeling possibly motivates their learning behavior while participating in mathematics related activities by exploring and investigating mathematical concepts associated with music. Moreover, during the sharing of musical works while discussing mathematical tasks, classmates reveal and recognize each other's potential abilities. A strong sense of participants' personal discovery emerges as they construct and explore meanings through their own works, thus their motivation and confidence in learning mathematics is further enhanced.

Reduced Anxiety

Students' anxiety of mathematics was reduced because they may have felt that mathematics was not as demanding in the music learning environment compared with the traditional mathematics learning environment. When students are learning mathematics integrated with music, they not only feel a cheerful sense of accomplishment when completing mathematical tasks, students may also receive an additional reward by enjoying their own music works. Such external rewards might further develop students' engagement in learning mathematical concepts and cause them to attempt more challenging mathematical problems (Bronson, 2000).

Usefulness of Mathematics

The music-mathematics integrated learning process also positively changes students' dispositions about success and usefulness. 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 (Fiske 1999; Erickson 2001). By completing different music related tasks and solving contextually meaningful mathematical problems in each music-mathematics integrated activities, students had numerous chances to experiences the success of accomplishing music-mathematics related tasks, mathematics tasks embedded within real life context and pure mathematical tasks.

Beliefs about Mathematics

The repeated successful experiences in learning mathematics strengthened students' beliefs about their success in learning mathematics. According to motivational theory, students who are motivated intrinsically are more likely to exhibit initiative, independence, sense making and enjoyment in learning mathematics (Csikszentmihalyi, 1996). Moreover, students were encouraged to share their successful experiences (e.g. play their music works to each other; and share their mathematics related tasks with each other) in an enjoyable learning environment. Such repeated reinforcement facilitated students to attempt more challengeable mathematics problems that relate to more profound mathematical content, Students' feeling of success in mathematics were further strengthened when finishing more and more complex mathematics tasks. Throughout the entire process from (1) using music activities to engage and motivate students to participate in mathematics activities; (2) facilitating students to participate in mathematics activities and identify the key mathematical ideas from the music experience within an enjoyable environment; and (3) using students' music activity products as resources to design mathematical concepts or process examples and assign math tasks based on students' own music activity outcomes, students' belief toward mathematics changed positively.

Teaching mathematics integrated with music can effectively increase students' intrinsic motivation, because in an enjoyable learning environment integrated with music, students might be aesthetically engaged. When students are motivated intrinsically, they not only tend to pursue more advanced mathematical knowledge based on their own initiative but they also accept more challenging tasks during learning. Additionally, they may have opportunities to show creativity in the mathematical learning process (Glastra, Hake, & Schedler, 2004). Students' own experiences of participating in music-mathematics integrated activities convinced them that in order to learn mathematics, a good class environment is important. A positive learning environment without anxiety may facilitate them to try more difficult mathematics tasks. Moreover, by exploring the connections between music and mathematics students understand there are multiple connections between mathematics and real life.

In conclusion, the music-mathematics lessons improved the music group students' mathematical dispositions in many ways. Music-mathematics integrated activities were recognized as the causes of students' changes in disposition. The music group students improved their confidence and motivation as well as reduced their anxiety 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 music works. Finally, they positively changed their belief toward mathematics.

The Improvement of Math Achievement

In the current study both the music group and the non-music group students completed a mathematics achievement test before the intervention. The results indicated that the students from both group had similar scores on the pretest. After a nine-week intervention of 14 music-mathematics integrated lessons, the music group students' mean score on the posttest of mathematics achievement test was significantly improved, while the non-music group students' score just slightly improved from their pretest. The findings are consistent with previous research on the positive impact of music integrated mathematics activities, lessons and curriculum on students' mathematics achievement (Omniewski & Habursky, 1998; Costa-Giomi, 2004). Multiple reasons could account for explaining this result. The most important reason for the music group students' improvement was that the students in the music group had numerous opportunities to learn, understand and practice mathematics knowledge in different contexts through various strategies.

Based on multiple intelligences theory, when students have difficulties understanding principles of a specific content, teachers should offer an alternative route to develop conceptual understanding (Kassell, 1998). Embedding music activities into mathematics can not only increase students' mathematical understanding, but also provide them an enjoyable means for developing logical/mathematical intelligences along with their musical/rhythmic intelligences (Shilling, 2002).

The 14 intervention lessons provided to the music group students content in all the mathematics areas listed on the Mathematics Content Standards for California Public Schools [MCSCPS] (2009) including: number sense (NS), algebra and functions (AF), measurement and geometry (MG), statistics, data analysis, and probability (SDAP), and mathematical reasoning (MR) (see Table 1 for detailed lesson topics and instructional strategies). Because all the music-mathematics integrated activates were integrated as a part of students' regular mathematics lessons for the music group, more than 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. The music group students were offered numerous mathematics problems focused on different mathematical content. All of the mathematics problems were connected with music, and these different mathematics problems were individualized based on each student's own music compositions works or musical instrument designing. Participation in music-math integrated activities not only enriched students' view of mathematics problem forms but also improved their basic mathematics skills by solving problems, which might have helped the music group students make significant improvements on the mathematics achievement posttest.

The design and of the mathematics lessons provided alternative strategies for doing mathematics and incorporated higher-order mathematics content to illustrate that music can be used to make connections to many mathematics content areas based on *California State Standards of Mathematics*. For example, in the content area of *number sense*, the music group students utilized songs such as *London Bridge* and *Twinkle Twinkle Little Star* to represent fraction concepts and facilitate students remembering the basic multiplication facts by using song singing activities. Students also could learn how to add and multiply by counting music notes and solving related word problems from music composition activities. In the content area of *algebra and function*, students recognized, described and extended linear patterns, algebraic expressions and equivalent fractions from various music compositions and playing activities; students also offered chances to learn key concepts of number line associated with piano keyboard playing. In the content area of *statistics, data analysis, and probability*, students have multiple opportunities to collected, sorted and displayed data based on the music that students composed by themselves by using graphical notations; students also can made and interpreted statistical graphs based on different music works. Moreover, for help students make sense of probability, students could be guided to conducted simple probability experiments by determining the number of possible outcomes and made simple predictions from music composition and playing activities. In *geometry and measurement*, student were offered multiple opportunities to recognize and understood key characteristics of geometric figures (e.g. circles, triangles) and measure the area, perimeter, and volumes of various geometric figures using appropriate measurement tools from music playing and musical instrument designing activities.

In conclusion, the music group students' mathematics achievement improved throughout the music-mathematics lesson interventions. By introducing different mathematical content knowledge to students in non-routine ways associated with music related activities, students could understand mathematics concepts with multiple connections not only within mathematics curriculum but also across the different school subjects.

The Improvement of Math Process Ability

The music group students' mathematics achievement showed statistically significant improvement from the pretest to the posttest as well as statistically significant improvements throughout the intervention period from the pretest to the posttest. The findings are consistent with previous research on the positive impact of music related activities on students' mathematics process abilities (Bilhartz, Bruhn, & Olson, 2000; Jordan-Decarbo & Galliford, 2001; Zafranas, 2004). The main reason for the music group students' improvement of mathematics process ability is that the students in the music group had various opportunities to focus on different mathematics processes throughout the intervention lessons.

The mathematics process ability tests were used to examine students' mathematical process abilities. Throughout the 15 tests, a pattern of improvement was identified on all three process abilities measured. The overall growth in mathematics ability from the pre to posttests demonstrated that through music-mathematics interdisciplinary experiences, students had multiple opportunities to improve their abilities with the mathematics processes. The significant improvement in students' Modeling levels indicates that their ability to draw pictures, tables, or charts to effectively solve mathematical word problems improved throughout the intervention. For example, the graphical notation with different geometrical shapes were used in almost all music-mathematics integrated lessons and students can experiences multiple ways of representing mathematics content with patterns. Also, in lessons 3, 5, 8 and 9, students have opportunities to make algebraic charts and statistical tables based on different music works.

Moreover, as demonstrated by the significant enhancement of students' Strategy levels, students' mathematical skills in using mathematical symbols, equations, and inequality to effectively show mathematical steps for solving mathematics word problems improved throughout the music implemented math instruction. For example, in lessons 1, 2, 5, 6, and 12, students were given various mathematics computation problems related to number sense strengthening their computational strategies. Finally, the significant development of students' Application levels showed improvement in students' ability to create their own word problems by applying mathematical reasoning to the real world. For example, in lessons 5, 7, 9, 13 and 14, students were assigned real world related mathematics problems to learn how to make connections with mathematics and real life scenarios, and in all lessons, students were encouraged to propose their own problems based on their music works.

Teaching specific content areas associated with elements of arts can assist students developing holistic thinking skills through interdisciplinary connections (Mason, 1996). Results showed that the music-mathematics integrated lessons positively impacted student gains in mathematics achievement throughout the nine-week intervention period. The students who learned through the various music-integrated instructional settings demonstrated increased mathematics ability levels over the intervention period. Other factors may have accounted for this improvement, because of the emphasis on mathematical processes in each music-mathematics integrated lessons.

By integrating music connections and representations in mathematics, teachers may have provided effective instruction for students to better understand mathematics from multiple approaches (Gardner, 1993; Fiske, 1999). Teaching when using any manipulative effectively or activities for students with representations and connections is crucial for providing students opportunities to create and explore by themselves (Clayden, Desforges, Mills, & Rawson, 1994). Music composition and playing instrument activities in mathematics instruction enables students to enjoy mathematics and make sense of important mathematical concepts.

The results showed that the music group students' mathematics process ability levels within each test among the specific ability areas of model, strategy and application showed considerable differences before the intervention and in the first stage of the intervention (e.g., the strategy ability level was statistically significantly lower than the model and application in the second test in mid-test I); however, such differences disappeared in the mid-test II and III as well as the posttest. This finding suggests that there exist slight differences in the rate of development of students' mathematics process abilities in different ability areas. Yet, by offering more music-mathematics integrated lessons to students for practicing mathematics processes, the students' overall higher mathematics ability levels might be improved, and the unbalanced development of mathematics abilities in different areas might be reduced.

In conclusion, the music group students' mathematics process ability levels improved throughout the music-mathematics lesson interventions. During the intervention period, the students were taught different mathematics process routes related to a variety of mathematics concepts. For example, students (a) communicated mathematical ideas with their peers during small group and large group discussions; (b) represented mathematics concepts with multiple forms including visual, words, symbol, number forms as well as other types of dynamic forms; (c) connected mathematics content within the mathematics curriculum and with different real life situations, (d) thought about mathematical meanings from reasonable and logical perspectives and (e) solved mathematics problems by using a variety of problem solving strategies.

Conclusion

The goal of the current research was to examine the effects of a sequence of classroom activities that integrated mathematics content with music elements aimed at providing teachers an alternative approach for teaching mathematics. Two classes of third grade students (n=56) from an elementary school in Southern California participated in the research. A random assignment pretest-posttest control group design was used to examine students' changes in mathematics content achievement and the disposition between the two groups. The students in the music group were assigned to receive music-mathematics integrated lessons. A quasi-experiment time series design with multiple pretests, mid-tests and posttests was utilized for investigating the effects of music-mathematics integrated lessons on students' mathematics process ability levels. The results demonstrated that the intervention of a series of music-mathematics integrated lessons had positive effects on the music group students. The music group students had statistically significant higher scores in the mathematics achievement, and mathematics dispositions on the posttest. Moreover, the music group students also have statistically significant higher scores in the mathematics process ability on the posttests as compared to the pretest. The findings are consistent with previous empirical studies' conclusions associating music with school subject curriculum and instruction promoting students' academic achievement and dispositions (e.g. An, Kulm, & Ma, 2008; An, Ma, & Capraro, 2011; Bilhartz, Bruhn, & Olson, 2000; Benes-Laffety, 1995; Costa-Giomi, 2004; Omniewski, 1999).

Positive changes of mathematics achievement and dispositions in this study reflect some distinctive features of the music-mathematics integrated curriculum and instructional methods. First, in this study, the music-mathematics integrated lessons were implemented as combined with the regular mathematics curriculum. Second, the effects of the music-mathematics curriculum were not only evaluated before and after the intervention but also across the intervention period. This research demonstrates the effects of the music-mathematics integrated lessons on mathematics achievement and dispositions for all children of mixed gender, ethnicity and socioeconomic backgrounds in both the music and non-music group students.

The music-mathematics integrated instructional approach in the current study is distinguished from many previous intervention studies that focused only on the effects of music listening or music instrument learning on student's academic achievement or attitudes. 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 mathematics teaching and learning components. 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 students' centered activities to facilitate students understanding of mathematics concepts.

A major strength of the current study is that it was conducted with a high degree of random assignment experimental control within a classroom setting. The external validity threats were reduced as the music group students received the interventions in their everyday classroom settings; and the internal validity threats were reduced by using the experimental design by having an experiment group and a control group with equivalent instructors, curricular, content coverage, and schedule of instruction. Moreover, the length of intervention is another feature in the current study. Unlike the study that had a short period intervention lasting several days with a limited number of music-mathematics integrated activities (e.g. An et al., 2008, 2010, 2011), the current study lasted nine weeks and contained 14 music-mathematics integrated lessons covering various mathematics content.

Limitations were also noted in this study. 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 disposition should not emanate from a single curriculum but should permeate the curricula with content other than mathematics, such as music.

The findings obtained in the current study were limited to a curriculum unit of limited 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. Teaching mathematics integrated with other subjects can improve students' knowledge in both areas (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" (p. 182). 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 achievement and dispositions towards mathematics.

Hargreaves and Moore (2000) noted that the integrated curriculum has the potential to provide teachers opportunities to focus on significant content areas which may be difficult to investigate in individual subjects; and students can develop a broader perspective of curriculum with less redundancy of content. Curriculum integrated with the arts also provides students with a learning environment that allows students to form a better social relationship with their real life experiences because of the interaction among disciplinary boundaries engaging students through the process of reflection and inquiry (Ellis & Fouts, 2001; Parsons, 2004). Moreover, teaching mathematics integrated with music can not only improve students' higher-order thinking skills and motivation for learning but also provide opportunities to understand knowledge from multiple perspectives as well as transfer of learning (Erickson, 1998; Scripp, 2002).

By designing appropriate music activities integrated into mathematics lessons, students can understand, analyze, and interpret mathematics through different routes. The music integrated mathematics instruction strategy allows students to present and understand mathematics in alternative ways, especially for those who do not have a high level of mathematical intelligence. To achieve this goal, lessons or curriculum tailored to the needs of specific children may be designed and employed (Gardner, 1983). This research serves 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 learning and understanding mathematics.

The students who learned through the various music-integrated instructional settings demonstrated increased mathematics ability levels over the intervention period. Other factors may account for this improvement, because of the emphasis on mathematics processes in each music-mathematics interdisciplinary lessons. By integrating music connections and representations in mathematics, teachers may have provided effective instruction for students to better understand mathematics from multiple approaches (Fiske, 1999; Gardner, 1993). Teaching when using any manipulative effectively or activities for students with representations and connections, is crucial to providing students opportunities to create and explore by themselves (Clayden, Desforges, Mills, & Rawson, 1994). Music composition and playing instrument activities in mathematics instruction enables students to enjoy mathematics and make sense of important mathematical concepts.

It is not suggested that teachers should teach all mathematics content with connections, such as with music. Instead, the development of mathematics achievement, mathematical process ability, and 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. Teachers should understand that in effective mathematics instruction, subjects are interconnected and these interdisciplinary connections can be used to design and teach effective lessons. 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.

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APPENDIX A

STUDENT DISPOSITION TEST

1 2 3 4 5

1.	( )	I am sure I can learn math
2.	( )	Math scares me sometimes
3.	( )	I need math for my future work
4.	( )	I feel proud to be the best student in math
5.	( )	I would like to do more math in school
6.	( )	I need lots of natural ability to learn math
7.	( )	I can do more difficult math
8.	( )	I like to go to math classes
9.	( )	Math is meaningful to my life
10.	( )	I am happy to get high scores in math
11.	( )	Math is enjoyable to me
12.	( )	I need work hard at home to learn math well
13.	( )	Math is harder for me than for many of my classmates
14.	( )	I am never worried about solving math problems
15.	( )	I use math in my daily life
16.	( )	I like to tell my friends if I get a good score in math
17.	( )	Once I am working on a math problem I find it hard to stop

18.	( )	To learn math well a good class environment is important
19.	( )	Math is an easy subject
20.	( )	I get nervous during a math test
21.	( )	Math will help me earn a living
22.	( )	I like people to think I am smart in math
23.	( )	I like to try difficult math problems
24.	( )	I need to memorize the textbook to learn math well
25.	( )	I usually do well in mathematics
26.	( )	Math makes me feel good
27.	( )	I often use math out of the school
28.	( )	To be the best student in math makes me happy
29.	( )	I would like to try more difficult math problems
30.	( )	Understanding math is more important than getting the answers
31.	( )	Math is one of my strengths
32.	( )	I feel uneasy in math class
33.	( )	Math has many connections to other school subjects
34.	( )	I would like to be a successful student in math
35.	( )	I enjoy solving math questions
36.	( )	Practicing math over and over is very important in learning math

APPENDIX B

MATHEMATICS PROCESS ASSESSMENT (5 SAMPLES OF MSA PROBLEMS)

Draw a Picture or Chart to show your understanding and solving of the problem	Solve the problem by showing procedures/steps or strategies	Create real-world related word problem for the given problem above

1. A pie was divided into fifths. Emily ate 1/5 of the pie. Tony ate 2/5 of the pie. Jenny ate 1/5 of the pie. How much of the pie was left? (Standard: Number Sense 3.2)

2. One stamp costs 34 cents. Two stamps cost 68 cents. Three stamps cost $1.02. If the cost of each stamp remains the same, how much would 4 stamps cost? (Standard: Algebra and Function 2.1)

3. Jenny walks her dog 10 min. everyday. If she continues this activity for 100 days, what is the total amount of minutes she does this activity for her dog? Draw a function table and find out the function rule to solve the problem. (Standard: Algebra and Functions 2.0)

4. An isosceles triangle must have 2 sides that are the same length. If the perimeter of the isosceles triangle is 20 inches and the length of the 2 equal sides are 14 inches, what is the length of the 3rd side of the isosceles triangle?(Standard: Measurement and Geometry 2.2, 2.3)

5. Miriam put 10 marbles in a paper sack. Six of the marbles were black, three were gray, and one was white. Miriam closed her eyes and took one marble out of the sack. Is it certain, likely, unlikely, or impossible that the marble she picked was white? (Standard: Possibility 1.1)

MSA ASSESSMENT RUBRICS FOR STUDENTS' ABILITY LEVEL OF EACH AREA

Level	Modeling	Strategies	Application
Level 1	Either no model or model completely inappropriate	Either missing computation or many computational errors	Problem either missing or impossible to follow
Level 2	Appropriate model used, but either not fully demonstrated, or possibly based on operation only, did not show the process of conceptual developing	Only few computational errors, but followed rules and formulas on computations (routine way), or only by trial and error	Problem attempted, but difficult to understand
Level 3	Appropriate model used, and the process of modeling demonstrated	No computational errors, but solved problem by routine way or only by trial and error	Problem fairly clear, but not appropriate or connected to real

			life application
Level 4	Model used highly efficient and meaningful, revealing comprehensive understanding	No computational errors and used a flexible or creative strategy in computation, revealing complete understanding of solving	Problem very clear, appropriate, and connected to real life application

APPENDIX C

MATHEMATICS ACHIEVEMENT ASSESSMENT I (PRETEST)

1. Which of following numbers is eight thousand six hundred:

   A. 8060 B. 8600 C. 8006 D. 860

2. 2,000 + _______ + 30 + 9 = 2,739; the number that goes in the blank is

   A. 700 B, 70 C. 730 D. 273

3. 6 × 6 equals which of the following?

   A. 5 × 7 B. 4 × 9 C. 8 × 3 D. 4 × 8

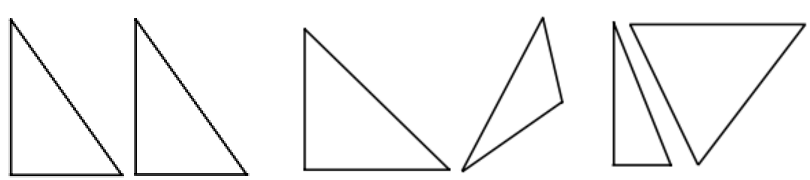
4. Mary had 22 pieces of candy. She gave two pieces each to three of her sisters. How many candies
   did she have left?
   A. 28 B. 26 C. 16 D. 14

5. 546 ÷ 6 equals what number?
   A. 91 B. 90 C. 11 D. 540

6. Please find the correct sequence of the following fractions from largest to smallest:
   A. 2/4, 1/3, 1/5 B. 1/5, 2/4, 1/3 C. 1/3, 1/5, 2/4 D. C. 2/4, 1/5, 1/3

7. Tom had a party. Seven children were at the party. If each one got three balloons and one cookie,
   how many items did the children have altogether?
   A. 21+7 B. 21 C. 21+7+7 D. 21−7

8. Which two triangles can be put together to form a rectangle?
   A. B. C. D. None of them is correct



9. A bag has 5 red balls and 1 yellow ball, which term is suitable for describe the chance of get a red ball from the bag?
   A. likely B. certain C. Unlikely D. impossible

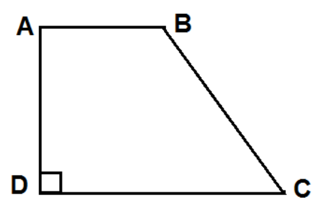
10. How many faces on a cube?
    A. 4 B. 8 C. 10 D. 6

11. What is the easiest way to find 19 + 53 + 1 ? _______
    A. Add 19 and 1 first, then add 53 to the sum.
    B. Add 53 and 1 first, then add 19 to the sum.
    C. Add 19 and 53 first, then add 1 to the sum.
    D. I have no idea.

12. About how long is a pencil and how tall is an adult man?
    A. 5 feet & 1.8mm B. 5 inch & 1.8m C. 5 yard & 1.8cm D. 5 inch & 1.8km

13. If 5 + N > 11, which group of numbers has all the possible numbers that N could be:
    A. 7, 9, 10 B. 4, 5, 6 C. 1, 7, 4 D. 3, 12, 19

14. Which two line segments are parallel in the following trapezoid:



A. AB & DC B. AD & DC C. AD & BC D. BC & DC

15. Do following computations and put the correct number in the blank:

(a) 67 + (   ) = 121   (b) 17 + 8 = (   ) + 9   (c) 12 = (   ) ÷ 4

(d)
$$\begin{array}{r} 15 \\ \underline{\times\,(\quad)} \\ 45 \end{array}$$

(e)
$$\begin{array}{r} 127 \\ \underline{+\ \ 13} \\ (\qquad) \end{array}$$

(f)
$$\begin{array}{r} 302 \\ \underline{-\ \ 114} \\ (\qquad) \end{array}$$

(g)
$$8\,\overline{)\,721}$$

17. On Friday, 302 people visited the museum. Four times as many people visited on Saturday than on Friday. On Sunday, 730 people visited the museum. How many people in total visited the museum from Friday to Sunday? (Show your process)

18. Find the answers to the following questions using the following table:

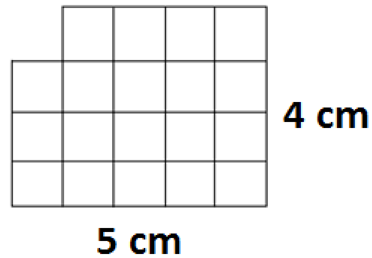
	Take bus	Walk to school
Boys	33	41
Girls	27	44

What is the total number of boys who take bus and girls who walk to school? (Show your process)

19. What is the perimeter and the area of the figure on the right?

(Show your process)

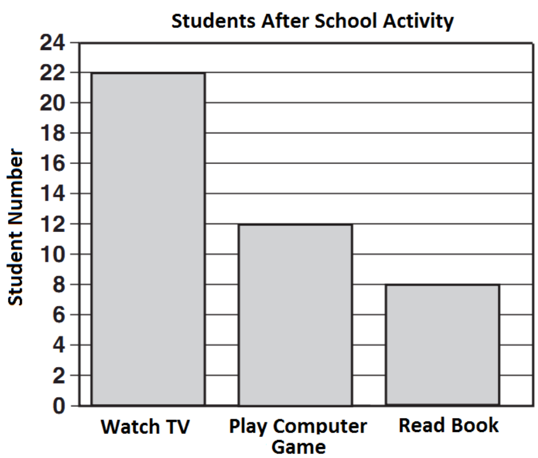
(1) Perimeter



(2) Area

21. Find the answers to the following questions using the graph on the left:

(1) How many more children watch TV than read book?
(Show you process)



(2) What is the total number of students who play computer game and read book? (Show you process)

(3) List at least one more information that you can find from the graph.

THE STUDENTS MATHEMATICS ASSESSMENT II (POSTTEST)

1. Which of following numbers is four thousand five hundred:
   B. 4050　　B. 4500　　C. 4005　　D. 450

2. 3,000 + ______ + 40 + 6 = 3,246; the number that goes in the blank is
   B. 200　　B, 20　　C. 240　　D. 246

3. 7 × 5 equals which of the following?
   A. 6 × 6　　B. 4 × 9　　C. 8 × 3　　D. 5 × 7

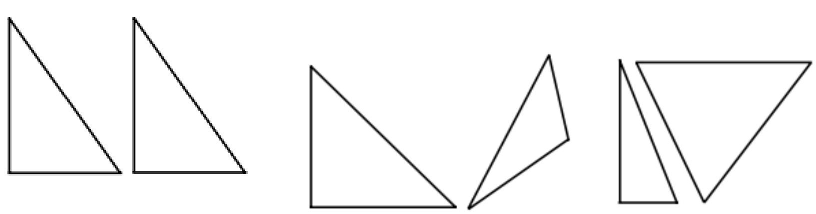
4. Mary had 31 pieces of candy. She gave three pieces each to three of her sisters. How many candies
   did she have left?
   A. 28　　B. 29　　C. 34　　D. 27

5. 497 ÷ 7 equals what number?
   A. 71　　B. 70　　C. 11　　D. 490

6. Please find the correct sequence of the following fractions from largest to smallest:
   A. 2/4, 1/3, 1/5　　B. 1/5, 2/4, 1/3　　C. 1/3, 1/5, 2/4　　D. C. 2/4, 1/5, 1/3

7. Tom had a party. Eight children were at the party. If each one got two balloons and two cookie,
   how many items did the children have altogether?
   B. 8×2+8×2　　B. 8+2+2　　C. 8×2+2　　D. 8×2

8. Which two triangles can be put together to form a rectangle?
   A.　　B.　　C.　　D. None of them is correct



9. A bag has 6 red balls and 1 yellow ball, which term is suitable for describe the chance of get a red ball from the bag?
   A. likely　　B. certain　　C. Unlikely　　D. impossible

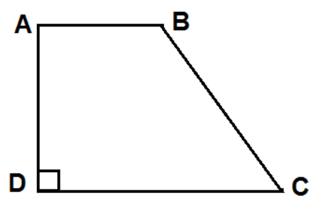
10. How many faces on a cube?
    A. 4   B. 8   C. 10   D. 6

11. What is the easiest way to find 19 + 12 + 1 ? _______
    A. Add 19 and 1 first, then add 12 to the sum.
    B. Add 12 and 1 first, then add 19 to the sum.
    C. Add 19 and 12 first, then add 1 to the sum.
    D. I have no idea.

12. About how long is a pencil and how long is a study desk?
    A. 5 feet & 1mm   B. 5 inch & 1 m   C. 5 yard & 1 cm   D. 5 inch & 1 km

13. If 5 + N > 11, which group of numbers has all the possible numbers that N could be:
    A. 7, 9, 10   B. 4, 5, 6   C. 1, 7, 4   D. 3, 12, 19

14. Which two line segments are parallel in the following trapezoid:



B. AB & DC   B. AD & DC   C. AD & BC   D. BC & DC

15. Do following computations and put the correct number in the blank:

(a) 66 + (   ) = 122   (b) 17 + 8 = (   ) + 7   (c) 12 = (   ) ÷ 3

(d) $\begin{array}{r} 15 \\ \times\,(\quad) \\ \hline 45 \end{array}$ (e) $\begin{array}{r} 138 \\ +\ 12 \\ \hline (\quad\quad) \end{array}$ (f) $\begin{array}{r} 302 \\ -\ 114 \\ \hline (\quad\quad) \end{array}$ (g) $8\overline{)\,721}$

16. On Friday, 411 people visited the museum. Four times as many people visited on Saturday than on Friday. On Sunday, 700 people visited the museum. How many people in total visited the museum from Friday to Sunday? (Show your process)

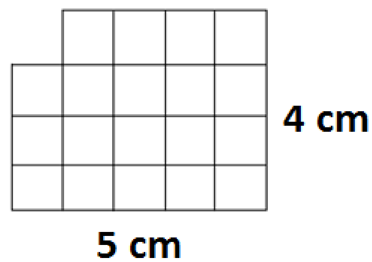
17. Find the answers to the following questions using the following table:

	Take bus	Walk to school
Boys	41	33
Girls	27	44

What is the total number of boys who take bus and girls who walk to school? (Show your process)

18. What is the perimeter and the area of the figure on the right?
(Show your process)

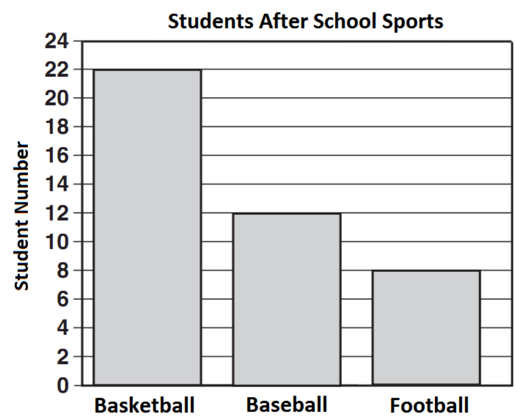
(4) Perimeter



(5) Area

19. Find the answers to the following questions using the graph on the right:

(1) How many more children playing basketball than football?
(Show you process)



(2) What is the total number of students who play baseball and basketball? (Show you process)

(3) List at least one more information that you can find from the graph.

APPENDIX D

SAMPLE LESSON DESIGN

Teaching the Concept of Fraction Using the Measures of Music

Key Content Standard(s) Addressed:

Number Sense

- Students understand the relationship between whole number and simple fractions.

Instructional Materials and Special Setup

Materials/Resources Needed

- Basic 8 music note color papers written musical names, letters, and numbers
- "London Bridge," "Row, Row, Row Your Boat," & "Twinkle, Twinkle Little Star" color cards in a pocket chart
- Hand bells, mini-white boards
- Overhead projector

I. Opening

How will you introduce the new learning (including vocabulary) and link it to the students' prior knowledge and to the new knowledge?

- Teacher sings a song "London Bridge" with numbers while playing drum to have students engage in the lesson activity to motivate their learning.

- (Display the song “London Bridge” color cards in the pocket chart. Teacher sings a song with numbers plying drum. Teacher asks students to figure out the title of the song and the number of measures played. Teacher says to the students, “Today you are going to learn about fraction using music. First of all, I will sing a song while playing drum. Please figure out what song I play and listen to my song to find out how many measures I play.” Students use their prior knowledge to figure out the title of the song and find out the numbers of measures played.

How will you assist students in seeing how the new learning is applicable to their lives?

- Discuss about how music can be used to learn about the concept of fraction and how the knowledge of fraction can be used to understand music.

II. Instruction Process

Input

- Review and preview the lesson vocabulary and introduce the lesson materials and activity
- Lesson Vocabulary: fraction (part of a whole), one whole (8/8, 12/12, 16/16 - when the top part and the bottom part are the same, when the numerator and the denominator are the same)

Model

- Demonstrate how to connect the concept of fraction and music.

  - Boys and girls, who can tell me what song I played?
  - If you listened carefully, I think you answer for this question.
  - "How many measures did I play?"
  - "You are right! I played 8 measures. That means there are 8 measures in a song London Bridge."
- Display the actual sheet music of "London Bridge."
  - Count the measures together by singing the song with numbers.
  - Then explain about the meaning of "one whole" –there are 8 measures in the song "London Bridge" and I sang 8 measures to sing the one whole song. (8/8: one whole)
  - When the top part and the bottom part are the same, the fraction is called "one whole."
  - Then play a part (5measures) of the song "London Bridge" and explain about
  - the definition of "fraction." – 5/8
  - Fraction means "Part of a whole."
- Have kids play the song using hand bells. Repeat the same process to model how to relate the measures of the song and the concept of fraction.
- Use another song "Row, Row, Row Your Boat" and repeat the same to reinforce the student learning of the concept of fraction and one whole.

Check for Understanding and address misconceptions and/or the obstacles:

- Teacher asks many questions regarding the concept of one whole and fraction while modeling, using songs and instruments. Students answers for the questions using their mini-white boards.

III. Guided Practice

Guided Practice

- Teacher uses another song “Twinkle, Twinkle Little Star” to provide students with more opportunity to clearly understand about the concept of fraction. Also, teacher provides more problem solving questions related fraction to improve students’ mathematical reasoning skills.
- Students practice how to add and subtract simple fractions while solving the fraction word problems provided by teachers.
- Have kids take out **their mini-white boards** and solve the word problems. Teacher checks the student answers.

Discuss, Argue, or Proof

- Discuss about the concept of fraction and one whole by asking and solving the word problems together.
  - "If Sarah played 3/8 of the song, how of the song does she need to play more to complete the whole song?"
  - Robert played 3/8 of the music and Angela played 4/8 of the music. How much of the music did they play in all?
  - How much of the music do they need to play more to complete the music?
  - Morgan played 3/5 of the music and Steve played 2/5 of the music. How much more music did Morgan play than Steve?

IV. Independent Practice

- Teacher provides more word problems to the students for them to independently practice the addition and subtraction of fraction with logical understanding of "one whole" and "fraction."
  - Janelle sang 4/9 of the song and Angela sang 2/9 of the song. How much of the song did they sing in all?
  - How much of the song do they need to sing more to complete the song?
  - Cecilia played 5/8 of the music and Rachel played 3/8 of the music. How much more music did Cecilia play than Rachel?
- Students answer for the questions on their mini-white boards and practice more the word problems independently. Teacher checks the student answers.

V. Closure

Closure

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

Assessment

- Lesson participation of answering for the questions throughout the lesson using white boards
- Performing music using hand bells with logical understanding of “one whole” and “fraction.”

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

Modifying Instruction for Exceptional Student Needs (Special Ed and ELL Students)

- For ELL Students: Use visuals (music 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 and solve more complex fraction word problems using music.

What might go differently than planned? (Common errors)

- If time allowed, students might have had an opportunity to do cooperative learning activities – playing music in a group and create more word problems such as multi-step problem solving questions by themselves. (Ex. *Kids are playing a song that has 9measures. How much of the song do they play if they sang 2 measures?9/2
  - Kids deleted the last 2 measure to make the music simpler, and then they played 3 measures. How much of the song did play? 9-2=7, 3/7
  - To be more creative, kids added 5 measures, and then they played 9 measures.
  - How much of the song did play? How much of the song do they need to play more to complete the song? 7+5=12, 9/12, 3/12

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