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SCHOOL OF MUSIC

THE EFFECT OF MUSIC INSTRUCTION ON SPATIAL AND MATHEMATICAL ACHIEVEMENT: A CASE STUDY

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ABSTRACT

When an elementary aged student is succeeding in all areas of academics except for mathematics, various strategies can be applied to assist the student’s mathematical achievement. Based on previous research suggesting that mathematics and music share many similarities in the way in which the brain processes the material, perhaps mathematical achievement can be enhanced through music instruction. The purpose of this study was to explore the effect of basic lessons in musicianship, vocal technique, and keyboarding technique on a specific student’s fundamental mathematical and spatial achievement. One third-grade student, having difficulty with math, was selected for this case study. To measure mathematical and spatial achievement, before and after eight music lessons, the student was given a test that included all the concepts she was expected to know during her third grade year. Her posttest demonstrated a much higher score than the pretest with fewer simple mathematical errors. This study also aimed to investigate the speed at which the participant was able to recall and process mathematics, however due to unexpected circumstances, this produced invalid and skewed results. The participant’s math grade in school was greatly improved over the course of the music instruction, showing that the music instruction may have been effective in increasing her mathematical achievement and it was certainly not detrimental.
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Chapter 1

THE PROBLEM

Claire’s Story

Claire is a seemingly ordinary third grader who is doing reasonably well in her classes at school. She has many interests and excels in reading and writing, geography, art, and music. She even partakes in a community choir in order to spend more of her time singing. Yet there is one subject that Claire does not grasp as easily. Her third grade math curriculum is exceedingly difficult and she cannot keep up with her classmates. Even though her parents are spending time working with her each day to improve her skills, her teachers have decided that she still needs a separate curriculum because she has fallen so far behind. According to her math teacher, Claire is eager to learn. She does well when participating in class on all subjects, including mathematics. However, when she takes her tests, she consistently scores below average in mathematics. She cannot seem to work through some part of the terminology or the math itself on her own (L. Lutz, Personal Communication, February 6, 2012). How can this student who enjoys learning and seems to try her hardest in everything she does already be falling behind with third grade math?

General Mathematical Disabilities

Some students have mathematical disabilities that prohibit their brains from processing spatial and logical information in the same manner as everyone else (Butterworth et al., 2011). For these students, simple number questions, such as
“which number is larger 6 or 2,” seem impossible. Even when a child understands what each number represents, or has a picture of 6 apples next to 2 apples, it can be difficult for that child to determine which group of apples is greater. There is a disconnect in the brain’s manner of processing information—concepts that are second nature to most children can be challenging for others (Butterworth et al., 2011). There must be a way to bypass this unconventional processing system and instead use another area of the brain to process this information. For instance, since Claire loves music, her parents have begun teaching her simple songs about the number patterns she is expected to understand in her classes. In this way she has been able to memorize basic mathematical skills.

Upon hearing that Claire’s love for singing is aiding in her daily mathematics lessons I began to wonder if memorizing multiplication tables through familiar melodies may be only the beginning. Many use song to memorize the alphabet and the 50 states, but music is more than a tool for memorizing information (Hetland, 2000). The study of music itself is capable of building spatial and logical achievement (Rauscher et al., 1997). Perhaps I might be able to help Claire with her math skills by giving her lessons in her favorite subject, music.

Some persons, perhaps including Claire, suffer from mathematical disabilities (Butterworth, 2011). For instance, dyscalculia, a disability similar to dyslexia, in which improper functioning of certain areas of the brain prohibit logical and spatial reasoning, is present in 5-7% of all people (Butterworth, 2011). It is in fact quite common for a person to have both the reading and language disability of dyslexia and the mathematical disability of dyscalculia (Montis, 2000). Also, people who have
a lack of numerical understanding “earn less, spend less, are more likely to be sick, are more likely to be in trouble with the law, and need more help in school” (Butterworth, 2011, p. 1049). This disability is highly understudied and under-accepted in our school system and it is assumed that many students have a simple lack of mathematical ability instead of an actual disability (Butterworth, 2011; Montis, 2000).

Music and Mathematics

The study of music and the study of mathematics use similar parts of the brain; they just stimulate the brain in slightly different ways (Hetland, 2011). In fact, when it comes to higher brain functions, the brain consistently uses similar firing-patterns (Boettcher et al., 1994). Based on the Montecastle method of organizing the firing-patterns of the brain, the cortical column, or the “basic processing unit,” is separated into trions (Boettcher et al., 1994, p. 54). These trions have a large variety of reoccurring spatio-temporal firing-patterns that are used in higher levels of thinking (Boettcher et al., 1994). Due to this overlap in brain function, teaching music can exercise the areas of the brain needed for mathematics (Hetland, 2011).

In addition, intelligence can be separated into at least seven different areas as classified by Howard Gardner in his initial theory of multiple intelligences (1989). He defined intelligence as the ability to solve an issue or create an object that is of value in at least one cultural setting (Gardner, 1989). Based on this theory, mathematical-logical intelligence, spatial intelligence, and musical intelligence are all separate (Gardner, 1989). Musical intelligence is the ability “to produce and
appreciate rhythm, pitch, and timbre,” i.e. the “appreciation of the forms of musical expressiveness” (Gardner, 1989, p. 6). Logical-mathematical intelligence is the “sensitivity to, and capacity to discern, logical or numerical patterns, and the ability to handle long chains of reasoning” (Gardner, 1989, p. 6). And spatial intelligence is the capacity “to perceive the visual-spatial world accurately and to perform transformations on one’s initial perceptions” (Gardner, 1989, p. 6). Gardner claimed that these intelligences are psychologically and socially unrelated yet many tasks involve multiple intelligences, for instance, a surgeon uses spatial intelligence to know how to aim his scalpel and kinesthetic intelligence to have the physical ability for the intricate movement of his scalpel (Gardner, 1989).

Research indicates that music can be used to increase spatial and mathematical-logical achievement (Hetland, 2000). This is because many tasks that are within music use a combination of intelligences, not only musical intelligences (Gardner, 1989). Rauscher et al. (1997) conducted a study with 73 preschool children, providing music lessons and routinely testing spatial-temporal reasoning. Their results demonstrated the possibility of basic education through music. They found that "all higher cognitive abilities draw upon a wide range of cortical areas” and music alone can enhance the “cortical firing patterns used in spatial temporal reasoning”(p. 2). Their specific strategies were greatly effective. Perhaps some of these strategies may help Claire.

Graziano, Peterson, and Shaw (1999) conducted a study to further explore the effect of music on spatial and mathematical achievement. They found that students who received basic piano lessons and musical notation lessons in addition
to their other lessons averaged 15% higher on their spatial skill examination than those who did not receive music lessons (Graziano et al., 1999). This demonstrates that it is possible to develop a child’s mathematical achievement by teaching the child music (Graziano et al., 1999).

**Purpose and Questions**

The purpose of this study was to explore the effect of basic lessons in musicianship, vocal technique, and keyboarding technique on a specific student’s fundamental mathematical and spatial achievement. Through this exploration of teaching techniques outside of mathematical instruction, the end goal was to aid Claire’s mathematical growth and to help her bridge this deficiency in logical capabilities. This study explored the capability of music instruction to help increase Claire’s mathematical and spatial achievement.

The questions pursued through this study are the following:

1. Does music instruction increase Claire’s mathematical and spatial achievement?
2. Does music instruction increase Claire’s speed at recalling and processing mathematics?
3. Does music instruction increase Claire’s achievement in her third grade math classes?
Chapter 2

REVIEW OF RELATED LITERATURE

Introduction

Through the present study, the effect of music lessons on a ten-year-old girl’s mathematical and spatial achievement was explored. It was hypothesized that through basic piano and musicianship lessons, Claire would better understand mathematics. Literature on the following topics was reviewed before beginning this study: mathematical disabilities and educational techniques, the effect of music instruction on overall academic achievement, and music to enhance mathematical achievement. These topics frame the discussion in this chapter. For each, several studies are reviewed and then summaries provided.

Mathematic Disabilities and Educational Techniques


The way in which one learns math is similar to the way in which one learns to read. Consequently, the learning disorders associated with mathematics are very similar to the learning disabilities associated with reading, however the mathematic disabilities are recognized less often. Both math and reading use significant amounts of long-term memory. One must have the words and the numbers stored in his or her memory in order to process. Also, simultaneous processing is used for both reading and math. For example, when reading, one does not always need to sound
out the entire word; instead the word is viewed and recognized as a whole instead of as individual letters. Similarly, when looking at a group of a few objects, one often can tell how many objects are present without actually counting each object. The pattern or grouping is recognizable.

Mathematical learning can be divided into two fundamental concepts – magnitude and value. Whether working with numbers or objects, everything has size and value. Further, two basic processes used in math are “procedure, which is a step-by-step thinking out of an arithmetic problem (e.g., divide 26 by 3) and conceptualizing or comprehending the problem” (p. 194). In other words, it is necessary to understand the question in an abstract way and to further be able to carry out that procedure. This means that one must comprehend both the magnitude and value by using working memory as well as long-term memory.

Chunking is often used to help students who are struggling in math. This is the process of splitting numbers or objects into patterns, for instance 112112112112 into 112/112/112/112. Another example is when a student writes the steps when doing long division instead of trying to keep the calculations straight in his or her head. This strategy allows the working memory to do less overall tracking the larger chunks of information instead of each individual piece. If the students write out each step they have less to remember during the process, just like grouping the math into sections is easier than working with each part individually. Some children learn math more quickly just like some students learn to read more quickly than others in the same class. These students are the ones who begin to chunk the information, putting together letter combinations instead of
sounding out each letter and recognizing a number without having to stop and think to determine its value.

Children learn to differentiate the sizes of objects on their own. However, an object’s value must be taught. For instance, a child who does not understand math can see that the number 100000 is larger in size on paper than 5 due to their number of digits. Yet a child must be taught that 89 is larger in value than 12 even though they can be viewed as the same size. A crucial part to teaching math, in fact generally the first step in the process, should be estimation. Estimation is more important than learning to actually solve problems in the early stages. Understanding that 69 plus 79 is not going to be 89 but instead it is going to be greater than 100 is where addition begins.

Das and Janzen separated mathematical learning disabilities into three groups: “Students with difficulties in learning basic multiplication facts, students with difficulties in reaching automated master of basic facts, and students with difficulties in learning to solve math word-problems but no difficulties with basic multiplication facts” (p. 200). In this specific study they focused on multiplication although the same three groups of learning disabilities holds true for nearly all levels of math. In other words, the three groups are students who struggle with mathematical procedures, students with difficulties in long-term memory, and students with difficulties in conceptualizing the math. Understanding which group the students fall into will help a teacher understand what needs to be done in order to help.

Dyscalculia is a specific mathematical disability, the mathematical equivalent to dyslexia, where numbers are confused and difficult to determine. Dyscalculia includes numerous mathematical inadequacies. For example, an inability to determine the larger of two groups of objects or an inability to look at a small number of objects and *know* how many there are without counting each individually, a skill about which most people would not think twice. Still, dyscalculia has not yet been specifically defined and therefore is difficult to diagnose. Butterworth, et al. focused on how the brain of a person with dyscalculia functions.

Normally, when the brain is attacking a mathematical activity, it uses the parietal lobes, the foundation of all spatial-logical intelligence. For more complex activities, the brain begins its functioning in the parietal lobes and then moves on to include the left frontal lobe. Mathematical tasks use symbolic notation in order to heighten the complexity, and it is taken for granted that the brain will immediately register these symbols in order to move on to higher processing. When a dyscalculic brain attempts a mathematical activity, the use of the intra-parietal sulci is seriously limited, which is the fundamental function of the brain during mathematical activity. Along the same lines, the typical connection between the parietal lobes and the left frontal lobe can be seriously lacking causing inefficient or non-existent transitions from fundamental to complex activities. “Dyscalculic learners have not sufficiently developed the structures needed to coordinate the components needed for calculation” (p. 1051).
The first step in helping a child with dyscalculia is to determine what gaps exist in the child’s abilities. To do this, the child requires individual assistance, which can be expensive at times, but it will pay for itself 12-19 times the amount invested as the child becomes cognitively competent, according to Butterworth, et al. In other words, the investment for an individual tutor is well worth it. Most people with dyscalculia need to experience the meaning behind each number, making numbers represent something tangible instead of just being two-dimensional symbols. To do this, use physical, visual, and verbal activities intended to help the child past his or her current understanding. For example, use blocks that are as long as the numbers that are written on them and have the student put them together to see which lengths add up to the length of the ten-rod.


In many schools, students receive special education if their reading skills are not up to grade level. However, below average mathematical achievement is often overlooked. Approximately 6% of students have mathematical deficiencies and mathematical learning disabilities are just as common as reading disabilities. In the long run, not understanding mathematics is just as crippling as illiteracy, yet the problem is often ignored.

Research has indicated the existence of many different types of mathematical disabilities with varying severities. However, mathematical disabilities themselves are far from concrete. It is difficult to classify a learner’s difficulty as any specific type of mathematical disability, due to a lack of research in this area.
One of the most common problems seen among beginning mathematics students is a lack of ability to memorize simple number facts. For example, some students have difficulties memorizing that $5 \times 4 = 20$ and would have to count it out, while many just know the answer. When teaching one who has an issue such as this, which stems mainly from a lack of memorization, do not stop the child from learning more simply because he or she cannot memorize the basics. Instead, Garnett suggested that the student be allowed to carry and use a list of all the addition, subtraction, multiplication, and division equations that he or she feels will be necessary. When this student memorizes one of the items on the list, this item should be crossed off so that the student does not become dependent upon it. A few strategies to help a student internalize simple mathematical facts include “interactive and intensive practice with motivational materials,” “much practice in small doses,” “student self-charting of progress,” and “instruction, not just practice” (p. 2).

Another type of mathematical disability is based upon difficulties with actual arithmetic. These students seem to generally understand the concepts but often forget to carry the one, subtract a negative number, borrow when subtracting, and make other noncomplex errors. One strategy for a student with such a disability is to work with the student to come up with a plan for checking for these errors before submitting, a way the student can remember all the things he or she should check for before turning in the paper. Also, it is important that both the student and the teacher are aware of and recognize the problem and continue in their efforts to bolster these skills.
Another grouping of mathematical disabilities includes children who struggle with the written part of math, for example taking what they see and know as three pencils and connecting that to the actual number 3, or memorizing the different symbols used along with the numeric notation. For a child who fits this description, it is important to understand the absolute basics before moving on to something more complicated. Often teachers think that they can go on to the next problem and that the material is simple enough to reinforce the first problem. However, many students who struggle with the notational part of math could never catch up from skipping to the next problem. One strategic suggestion is to have the students read and write the math problems with a partner, writing and reading one problem in as many ways as possible.

Yet another grouping of mathematical disabilities includes students who have difficulties with the spatial components of math. These students should be taught using tangible teaching materials, such as “Stern blocks” and “Cuisenaire rods” (p. 4). When a child consistently visualizes the number 2 along with a rod that is twice the length as the 1 rod and half the length of the 4 rod, they will begin to grasp the meaning of the numbers. Also, help the students memorize simple verbal cues that will help them to associate to the math. “A college freshman who had this deficit could not ‘see’ what a triangle was without saying this to herself when she looked at different figures or attempted to draw a triangle:” “A triangle has three sides. When we draw it, it has three connected lines” (p. 4). A difficulty with this particular grouping is that it can affect students of any intelligence. Sometimes even
the brightest students struggle with the spatial aspects of mathematics. Be sure not to scold a child with these issues and instead help him or her to work around it.

**Summary**

Mathematics can be viewed as magnitude, or size, and value. In order to manipulate these concepts, students need to be comfortable with the procedures and the concepts of math. All three studies highlighted the similarities between mathematical disabilities and reading disabilities. Yet, often, these are not viewed or treated with the same intensity. Both areas use long-term and working memories. For this reason, a solution presented in all of these articles is to teach the students to chunk, or to find patterns and use the grouping to remove steps from the procedure.

Garnett (1998) wrote that mathematical learning disabilities are problematic to categorize due to the lack of research in the field. This is clearly true, due to the contrasting categories among the articles. Das and Janzen (2004) categorized mathematical learning disabilities into three groups: students who struggle with mathematical procedures, students with difficulties in long-term memory, and students with difficulties in conceptualizing the math. Many other groupings use more specific concepts. A common issue with mathematical procedures is simply memorizing the basics. If this is determined to be the student’s difficulty, he or she should be allowed to carry a list of simple mathematical facts. In this way, he or she will continue to learn the concepts even if it takes a longer time for the basic facts to be stored in memory. Other students will struggle more specifically with the spatial concepts in mathematics. The parietal lobes, the foundation of all spatial-logical
intelligence, are used to perform mathematical procedures and when a student has a mathematical disability these receive less stimulation. Another issue is students who make “stupid mistakes” – forgetting to carry the one, missing a zero on the end of the number, forgetting the decimal point, etc. Students like this need to be reminded to check their work often and to create a plan to simplify everything they must remember. Still others find their difficulties in transferring the symbols on the page to an actual meaning.

Due to these many varied disabilities within mathematics, the first step in helping a child perform to his or her potential in math is to find the gaps in his or her abilities. Then these gaps need to be bridged by finding activities to strengthen that specific area, not necessarily through math.

**Music Instruction to Enhance Overall Academic Achievement**

**Waller, G. D. (2007)**

When school funding is cut, there is often an argument for eliminating the subjects that are not included on standardized tests and instead focusing on the subjects that are. However, this policy has yet to demonstrate an improvement on test scores. Instead, Waller hypothesized that music and other subjects not included in the core at most schools can greatly improve the test scores and achievement of students. This study was conducted to “quantify general education claims by examining high school academic achievement data, attendance rates, and student
The conduct of the 2006 graduating class in one Southeast Virginia school division” (p. 2).

The students were differentiated by the years of their musical training, either vocal or instrumental, and students with at least 4 years, students with 3 to 3.5 years, students with 2 to 2.5 years, students with 1 to 1.5 years, and students who did not take any music courses. The students were evaluated based on their weighted cumulative grade point average, number of absences during twelfth grade: excused or unexcused, and the number of discipline referrals between ninth and twelfth grade.

The mean grade point average for twelfth grade students in the study was 2.6203. The mean for the students active in music was 2.8181 and the mean for those not involved in music was 2.5505. This shows the difference in overall academic achievement in the music students and the non-music students. Further, the mean number of absences during the twelfth grade year was 16.17 absences while the music students had a mean of 14.44 absences and the non-music students had a mean of 16.78 absences throughout the year. Also, the mean number of discipline referrals for the whole study group is 3.46. The music students had a mean of 2.00 and for the non-music students a mean of 3.98.

This study shows the possible effect that music education may have on key aspects of overall education. Waller succeeded in showing that music should be included in the curriculum instead of pushed aside for the direct study of subjects to be tested.

In general, it is recognized that students who participate in musical activities do better academically than their less involved peers. When examining the differences in improvement on mathematical achievement between a control group without music lessons and a group with music training, the group with music training demonstrated a higher level of mathematical achievement. “Furthermore, being excused from non-music classes to attend instrumental lessons does not adversely affect academic performance” (p. 3).

However, it is not clear if the students’ success is based on their involvement in music or on the musical instruction itself and if they gained success through their musical involvement or were already more successful upon entering music. This is explained through another study, which showed that students involved in musical activities tend to have higher academic achievement than those students who are involved in athletic extracurricular activities. The students who participated in a sport and not music have a tendency to score lower on tests as they get older, while music students’ scores remain more consistent. Further, it was found “that those high school seniors who had participated in instrumental music programs from sixth through 12th grades scored significantly higher on standardized tests of language arts and math than their counterparts who had participated in non-music extra-curricular activities or who had not participated in extra-curricular activities” (p. 4).

The purpose of this study was to quantify the change in IQ test scores before and after lessons in keyboarding, voice, or drama and to compare these changes with students who took the same tests but received no lessons. Children (n=132), all 6 years of age, were separated into four different groups. The groups either received standard keyboard lessons, Kodály voice lessons, drama lessons, or no lessons at all for a full year. The students’ IQs were tested before and after the year of instruction. All children attended normal schooling throughout the year in addition to the instruction provided through this study. The tests were used to analyze changes in the students’ “full-scale IQ, the four index scores (Verbal Comprehension, Perceptual Organization, Freedom From Distraction, and Processing Speed), and the 12 subtests (Picture Completion, Information, Coding, Similarities, Picture Arrangement, Arithmetic, Block Design, Vocabulary, Object Assembly, Comprehension, Symbol Search, and Digit Span)” (p. 512).

All students had improvements in their full-scale IQ throughout the year, most likely due to the rapid learning during this age range. The Kodály group and the keyboarding group were very similar in their improvements throughout the year. The drama group and the group without instruction improved with similar magnitudes, but their improvement was less than the improvements of the music groups. “In short, the results provide evidence of relatively modest but widespread intellectual benefits from taking music lessons” (p. 513). In addition, the drama instruction had an impact on the students’ social behavior, which was not the case for any of the other groups.
Summary

These studies by Schellenberg, Hodges and O’Connell, and Waller all quantitatively show that music instruction can have a positive effect on the overall achievement of students. They provide fodder for advocacy for music education, reminding that the benefit of music education is far greater than the music learning itself. Hodges and O’Connell even showed that lessons that pull students out of non-music classes are not detrimental to the student’s learning. Music instruction appears to raise the overall grade point average, attendance, and behavior of high school students, as well as the overall IQ of elementary aged students.

Music to Enhance Mathematical Achievement

Rauscher et al. (1997)

This study was designed to investigate the effect of music training on long-term spatial achievement. Seventy-eight preschool children, ranging in age from 3 years to 4 years 9 months, were tested for their spatial-temporal reasoning skills. Thirty-four children received private piano lessons, 20 received private computer lessons, and 20 students were a control group. The control group was necessary to determine if instruction impacted spatial intelligence or if improvements were a result of normal growth. In the early stages of life, spatial intelligence is growing at great pace.

The private music lessons consisted of piano instruction with very specific methods. Professional keyboard teachers from the Irvine Conservatory of Music
were asked to teach these lessons for 10 minutes each day to the students. The lessons took place during the actual school day on Yamaha Portasound PSS 190 keyboards that were placed on child-sized tables. During the lessons, the children were taught that each finger corresponds to a number – the thumbs are ones and the pinkies are fives. The teachers wrote these numbers in the music in order to relate fingers to the written notation. Simple melodies such as Beethoven’s *Ode to Joy* was used in this beginning stage. During the first month, the lessons focused on playing with individual hands; in the second month the technique of using both hands was introduced. By the fourth and fifth months the students were taught how to play in different tonal centers – moving their hands from the, so far, stationary positions. The lessons focused on “pitch intervals, fine motor coordination, fingering techniques, sight-reading, music notation, and playing from memory” (p. 3).

After six months of these piano lessons, each child was able to perform basic pieces by Beethoven and Mozart on the keyboard. They also had an extremely basic foundation of music theory as it relates to the piano (Rauscher et al., 1997). The students who received these piano lessons showed great improvement on the spatial-temporal testing, showing that music can enhance the “cortical firing patterns used in spatial temporal reasoning” (p. 2).

**Graziano et al. (1999)**

This study demonstrated the possible influence of music on other intelligences. Second-graders (n=136) were presented with a video game, which attempted to increase their spatial temporal reasoning. Beyond this “game,” the
children were assigned into one of three groups. One group received training only through the video game, one group used the video game and lessons in language and grammar, and the third group used the video game and received lessons in music.

The music lessons consisted of basic piano lessons and basic musical notation instruction. The group that took part in both the video game and the music lessons averaged 15% higher on the game than the group that had language study and the video game. Furthermore, both the musical and language addition to the video game greatly increased the scores of the students, demonstrating that directly training spatial skills is helpful, but using indirect training can be even more helpful.

**Geist E. A. & Geist, K. (2009)**

Geist and Geist examined the effect of music on students who are at risk for mathematical failure that is associated with a low socio-economic status. “The National Assessment of Educational Progress found that children who are eligible for school lunch programs in 4th grade score on average 13 points lower on the math portion of the assessment than the overall average and 22 points below those who were not eligible for school lunch programs” (p. 995). This study focused on the “mathematical anxiety/aversion in the teachers and parents” (p. 995) as well as the conditions in which math was introduced and taught in normal classroom time. This demonstrated that for many students, mathematical failure goes hand in hand with an aversion to mathematics. Students get stressed just knowing that the math class has begun.
Geist and Geist found that when teachers incorporated musical activities into their mathematical lessons, the students were not as concerned and stressed over the mathematical lesson. The musical activities served to break the tension and lesson the students' aversions to mathematics. This was not an expected part of the study, but after observing numerous teachers in order to conduct the study, there was a clear correlation between the positive math scores and the teachers who used music during their lessons. “Observations also suggested that children responded more strongly to the math activities that included music. During free playtime, children could be observed singing the songs and making patterns from songs” (p. 996).

Summary

Results from all three of these studies demonstrate the ability of music to heighten mathematical achievement. Rauscher et al. and Graziano et al. conducted studies that provided music lessons outside of classroom time to a group of elementary aged students. Both studies showed that those students who received music lessons in addition to their normal schooling demonstrated higher mathematical understanding than those students who received no music lessons. Geist and Geist did not intend to include music in the study whatsoever. However, when studying math teachers and what about their teaching generated the most successful results, they found that the “unexpected theme that emerged from this study was the efficacy of using music activities in the classroom” (p. 995). These three studies show that not only can music be used as a tool in teaching
mathematics but also, when studying music for music's sake, student's mathematical achievement can be enhanced.

**Chapter Summary**

The purpose of this study was to explore the effect of basic lessons in musicianship, vocal technique, and keyboarding technique on a specific student's fundamental mathematical and spatial achievement. In order to hypothesize and to best prepare lessons that could potentially aid the participant in her mathematical understanding, a review of related literature was conducted. Mathematical disabilities are much more common than is generally realized and these disabilities have many similarities to disabilities in reading and writing. A common solution to these disabilities is the idea of chunking or finding patterns and using the grouping to remove steps from the procedures. In addition, once the gap in a student's ability is discovered, it can be strengthened both by mathematical activities and by non-mathematical activities.

Research has also focused on the effect of musical instruction on overall academic achievement. Schellenberg (2004) demonstrated that both music instruction and drama instruction had a high impact on the overall academic achievement of the students involved. Shellenberg used standard keyboard lessons, Kodály voice lessons, drama lessons, and a lack of lessons to differentiate the students and found that both types of music lessons yielded a similar increase in IQ test scores and the drama lessons were not far behind. Hodges and O'Connell (2004) and Waller (2007) conducted studies that investigated students already active or
inactive in music programs within their school setting or privately. Waller found that musical activities lead to higher grade point averages, better behavior, and better attendance within the high school setting, which is a pivotal point of advocacy for music education.

Lastly, some researchers have investigated the ability of music instruction to enhance mathematical achievement, the topic of this study. Both Rauscher et al. (1997) and Graziano et al. (1999), conducted studies in which music lessons outside of classroom time were provided to a group of elementary aged students. It was found in both studies that those students who received music lessons in addition to their normal schooling demonstrated higher mathematical achievement than those students who received no music lessons. Similarly, Geist and Geist unexpectedly discovered that higher mathematical achievement in an elementary setting corresponded to a lack of aversion to the subject, which again correlated directly to music instruction. Based on this review of appropriate literature, the hypothesis for this study is that music instruction will be effective in enhancing Claire's mathematical achievement.
Chapter 3

METHODOLOGY

The purpose of this study was to explore the effect of basic lessons in musicianship, vocal technique, and keyboarding technique on a specific student's fundamental mathematical and spatial achievement. Through this exploration of alternative teaching techniques, the end goal was to aid in Claire's growth and help her bridge this deficiency in logical capabilities.

Subject Selection

Claire, the participant in the study is a third grader who enjoys music but has difficulties keeping up with her mathematics. Claire was an easy choice to serve as the participant. Her mother mentioned in a normal conversation with me, the primary investigator in this research study, that her child would enjoy private music lessons. Upon realizing that I was also minoring in mathematics, she mentioned that her daughter Claire was really struggling in math class. As the conversation progressed it became clear that Claire is no ordinary student. Her mother even said that she was working with Claire on memorizing her math facts through catchy tunes. At this point the whole study was launched into motion. After reviewing the literature about different effects of music on mathematical achievement, I decided to apply these strategies in the hopes of aiding Claire. Her mother was more than willing for Claire to be a participant in a case study that focused on her specific
difficulties. So before the case study was even planned, Claire was chosen to be its subject.

**Research Design**

This study utilized a case study design but test score data were also collected. Claire was given eight music lessons. A mathematical test was given before the first lesson and after the last. Claire was timed while she took these tests, both before and post instruction. Each lesson consisted of 25 minutes of piano lessons, 15 minutes of vocal technique, and 20 minutes of scale work using solfeggio and numbers for the scale degrees.

The independent variables in the study were the music lessons and the continuing mathematical instruction during school. The dependent variables were the scores she obtained on her pre- and posttest, her grades in math class, and the time she took to complete the pre- and posttests.

The following questions guided this inquiry:

1. Does music instruction increase Claire’s mathematical and spatial achievement?

2. Does music instruction increase Claire’s speed at recalling and processing mathematics?

3. Does music instruction increase Claire’s achievement in her third grade math classes?

In answering these questions, it is hoped that the overall effect of music instruction on a third grade student’s mathematical achievement can be addressed.
**Instrumentation**

Data were collected via several different instruments. Each is described below.

**Pretest and posttest**

Claire’s third grade elementary teacher provided a cumulative math test based on what the students should know by the end of the year. This teacher also provided the standards set by the school district that describes what third graders are expected to learn in mathematics. The cumulative test lacked a few of these standards and so a few questions were added on to the original test compiled by Claire's math teacher. The completed test aims to be inclusive of all the mathematical knowledge needed in third grade (see Appendix A).

**Time spent taking the pretest and posttest**

Using a timer, the amount of time that it took Claire to complete the mathematical test before the eight lessons and after the eight lessons was documented.

**Academic grades**

At the start of the eight lessons and at the end of the eight lessons, Claire’s teacher agreed to share Claire's current math grades. These grades helped to demonstrate the effectiveness of the lessons.
Materials
For this case study to occur, a piano, sheet music, and a video/audio recording device were needed for each lesson.

Validity of the Study
It is highly possible that increased achievement at the end of the study on the posttest could be due to the participant’s mathematical education during the school day. For this reason, the student’s grades in school were also collected in the hope of showing improving scores on the in-school mathematics as well as the pre- to posttest fluctuation.

Treatment
As Hetland stated, it is important that lessons be individual because they will have a greater impact on the child’s learning (2000). For this reason, these lessons were between only Claire and myself. The lessons included an explanation of a major scale through numbers, basic piano training using numbers, and a beginning voice lesson. Learning music without notation will improve spatial achievement, but learning with musical notation will create more drastic improvements (Hetland, 2000).

Modeled after the experiment by Rauscher et al. (1997), the piano lessons began by assigning each finger a number – thumbs are 1 and pinkies are 5. We began by learning a few basic exercises including only 5 notes for each hand and having the finger number written in above the pitches. This was the first step of
correlating the fingers to the keys of the piano. After the basic exercises were mastered, the student began to learn very simple pieces, such as Beethoven’s *Ode to Joy*. In the first lessons hands were always separate, but by the fourth lesson, the child will began using both hands at the same time.

Beyond the fourth lesson, the goal was to switch tonal centers so that Claire would understand how the first five pitches sound similar regardless of which key one played in. The overall goal of the lessons was to build proficiency in reading musical notation, coordinating the fingers, and sight-reading – both vocally and on piano (Rauscher et al., 1997).

The individual lesson plans can be found in Appendix B, but each lesson focused on the same few concepts: piano, vocal technique, and vocal scales. Lesson plans for the first meeting with Claire were determined before the case study began. As this case study was based entirely on an individual, the lesson plans were constantly assessed and adapted as necessary. During each lesson, I video recorded the lesson and took diligent notes on what was taking place. In this manner, I was able to document the lessons and report them in this study as well as analyze what appeared to be effective or ineffective for Claire. After the first lesson was completed and Claire’s musical skill was assessed, further lesson plans were developed. In this way, lessons could be tailored for Claire’s individual needs.

**Study Procedures**

Before beginning the case study, I completed the training in human subjects protection. Next, permission to complete the experiment was requested and
approved through the Pennsylvania State University Institutional Review Board. Upon approval (#38491) from the Institutional Review Board, the parental consent (Appendix C) and location consent (Appendix D) were signed and the study was ready to be conducted. The name of the participant was then changed to provide anonymity.

While this was taking place, previous research was reviewed on mathematical issues in the classroom and the strategies to prevent and work through them. Further literature was then identified on using music to help reinforce mathematical achievement. The suggested strategies from both were then combined to create the lesson plans for Claire’s lessons. Before the first lesson, Claire was administered the comprehensive math test based on the test provided by her teacher, the time it took her to complete the test was documented, her current math grades were documented, and the lesson plan was prepared.

Over the next few weeks Claire was given eight music lessons. (See Appendix B for the actual lesson plans.) After each lesson, the video recording of the lesson was reviewed, notes were taken (Appendix E), and the next lesson plan was prepared. After the last lesson, Claire was administered the posttest, which was again timed and her school grades were documented in order to determine fluctuations.
Data Analysis

Claire's scores from the two tests were compared, as well as her grades in school and the time it took her to take the test. This was the data that determined the effectiveness of the music lessons on Claire's mathematical achievement.
Chapter 4

RESULTS

The purpose of this study was to explore the effect of basic lessons in musicianship, vocal technique, and keyboarding technique on a specific student's fundamental mathematical and spatial achievement. Each research question and answer based on the data analysis is presented below.

Does music instruction increase Claire’s mathematical and spatial achievement?

This first question that the study proposed to answer was strictly based on the fluctuation between Claire’s pretest and her posttest scores. On the pretest, Claire had 63 points correct out of 95 total points. On the posttest, Claire successfully answered 76 questions out of the 95 total points. This shows that she went from understanding and correctly manipulating 66.3% of the material on the pretest to 80% of the material on the posttest.

Table 1 below displays the number of questions for each specific skill or concept on the mathematical test. It also documents the number in each category that Claire correctly answered on both the pretest and the posttest. Based on the concepts that Claire consistently missed, such as subtraction that required carrying two digits, it was clear that Claire does not understand whole concepts. However, most of the incorrect answers on both the pre- and posttests were on problems where she had correctly used the concept in a previous question but made a simple
mistake in the next problem. For example, on the posttest, when asked to solve “78 + 78” Claire wrote “146” after having successfully completed the three previous two-digit addition problems. This shows an understanding of the concept and a lack of accuracy in the actual problem solving.

Table 4-1: Pretest and Posttest According to Each Mathematical Skill

<table>
<thead>
<tr>
<th>Concept or Skill</th>
<th>Total Questions</th>
<th>Correct on Pretest</th>
<th>Correct on Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Digit Multiplication</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>1-Digit Addition</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2-Digit Subtraction</td>
<td>6</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2-Digit Addition</td>
<td>17</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>3-Digit Subtraction</td>
<td>7</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3-Digit Addition</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Subtraction with 1 carry</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subtraction with 2 carries</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Time</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Money</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Shapes</td>
<td>7</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Boxes/Sticks/Circles</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Volume</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Word Problems</td>
<td>7</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Value of Numbers</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Hundred/Tens/Ones</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Odd/Even</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Rounding</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Fractions</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Patterns</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

In both two-digit subtraction and two-digit addition Claire demonstrated great improvement from the pretest to the posttest. She understood two skills on
how to do on the pretest, as demonstrated by her getting at least half of these questions correct, but she was not consistent or accurate in the process. On the posttest however she demonstrated a much higher accuracy in both of these skills. This demonstrates a greater mathematical achievement during the posttest, as the concept was already memorized on the pretest but actually using the concept was still difficult.

**Does music instruction increase Claire’s speed at recalling and processing mathematics?**

Data to answer this research question was to be based upon the length of time Claire needed to finish the mathematical pretest and posttest. She spent 18 minutes taking the pretest and 33 minutes taking the posttest. Just this data is deceiving. The time was most likely greatly affected by the atmosphere in which Claire took the tests. During the pretest, her family was all in different rooms and she sat at the kitchen table while I watched her from a separate room. During the posttest, she sat at the same table, but this time, her brother was also sitting there. She began to talk with her brother while testing, so I walked over and sat down with them to be sure she was not asking for mathematical help. While this proximity aided in the validity of her test scores, it lessoned the validity of the speed of the test. Part way through the test all validity was lost when her mother came home from work and had much to say to Claire, her brother, and myself, and only after a few minutes of chatter was the testing situation restored. Therefore, this limitation did not allow for Research
Question #2 to be validly answered - Claire’s speed in recalling and processing mathematics.

**Does music instruction increase Claire’s achievement in her third grade math classes?**

Claire’s third grade mathematics teacher sent me copies of unit assessments that Claire had completed so far in the year. On the first unit assessment, which focused on monetary coins, 1- and 2-digit addition, 1- and 2-digit subtraction, value, and boxes, sticks, and circles, she received 11/20, which computes to 55% correct. The unit 3 assessment covered skills including up to 3-digit addition and 3-digit subtraction, time, multiplication, division, carrying one and two digits in subtraction, hundreds/tens/ones columns, and word problems. On this assessment, Claire received 14 out of 20 total points, which computes to 70% correct. The unit 5 assessment covered skills of addition and subtraction, but focused on multiplication and division. On this assessment she successfully completed 7 out of the 20 total questions. This computes to 35% correct. Adding these three assessments together, at the time that Claire began taking music lessons through this study she had 32 points out of 60 possible points for the year, which computes to 53.3% correct.

Table 2 displays the breakdown of the questions on these three assessments and her accuracy on each skill. In many categories her improvement is clear due to the drastic increase of correct answers from the unit assessments to the pretest and posttest. She had been thoroughly struggling with many concepts, for example the concept of money, and she was much more successful with this by the posttest
examination. Her teacher, who had previously been concerned about Claire's mathematical abilities and giving her separate material to work on throughout the year, reported that by the end of the year, she had worked her way up to receive an A in math. This is an incredible increase from the 53.3% correct score that she had at the beginning of the study. She made much progress, which could be due to many different aspects of her life, including the increased mathematical instruction during school, but it also shows that her music lessons through this study may have been effective in increasing her mathematical achievement and that they certainly were not detrimental.

Table 4-2: Unit Assessments According to Each Mathematical Skill

<table>
<thead>
<tr>
<th>Skill or Concept</th>
<th>Number on Unit Assessments</th>
<th>Correct on Unit Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Digit Multiplication</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>2-Digit Subtraction</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2-Digit Addition</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>3-Digit Subtraction</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>3-Digit addition</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Subtraction with 1 carry</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Subtraction with 2 carries</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Time</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Money</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Boxes/Sticks/Circles</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Volume</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Word Problems</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Value of Numbers</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Hundred/Tens/Ones</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Division</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>
Unexpected Observations

Each lesson was highly dependent upon Claire’s mood at the beginning of the lesson. During some lessons, Claire was incredibly insightful and excited to learn, but, during others, she purposefully did what she was asked not to do (see Appendix E for my reflections from each lesson). Her mood and willingness to learn greatly affected what was accomplished during each lesson, which is to be expected for individual lessons.

Another unexpected observation, as earlier mentioned, was the proximity of family members during the lessons. This greatly affected the time it required Claire to take the pretest and posttest, but it also had an affect on the actual lesson time. This did not affect the results as drastically as Claire’s mood, but it is still important enough to be noted.
Chapter 5

SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Summary

The purpose of this study was to explore the effect of basic lessons in musicianship, vocal technique, and keyboarding technique on a specific student’s fundamental mathematical and spatial achievement. Through this study, the following three questions were investigated:

Does music instruction increase Claire’s mathematical and spatial achievement?

Does music instruction increase Claire’s speed at recalling and processing mathematics?

Does music instruction increase Claire’s achievement in her third grade math classes?

Methodology

The study began simultaneously with the participant selection, when the participant’s mother told me of how her daughter was struggling in mathematics yet doing very well in every other area of academics. She explained that she had been researching mathematical disabilities and had been using simple songs to help her daughter learn a few basics of mathematics. I put the two ideas together and began researching the effect of music instruction on mathematical achievement. Her mother even suggested that Claire be the participant for my case study.
After gaining the necessary permissions to begin the study, Claire’s current math teacher provided the grades that Claire had earned in her math class. Upon first meeting, Claire was asked to complete a mathematical pretest and was timed while taking the test. She was then given eight private music lessons that focused on building proficiency in reading musical notation, coordinating the fingers, and sight-reading. Then Claire again took the mathematical test and the time it took her to complete this posttest was recorded. Again, Claire’s math teacher provided Claire’s current grades in math class. The fluctuations between the pretest and posttest scores and times and between the two math grades were compared and conclusions were drawn.

**Results**

Claire’s mathematical and spatial achievement as measured by the pretest and posttest was greatly increased over the course of this study. On the pretest, she correctly answered 66.3% of the material and on the posttest she correctly answered 80% of the material. There were entire concepts that Claire was not comfortable with on either test, such as subtraction that required two carries, but overall she was more accurate with the concepts that she understood on the posttest. In other words, she made fewer mistakes and was only held back by her lack of certain knowledge.

Claire’s speed at recalling and processing mathematics decreased as based on the time she required to take the mathematical test. She spent 18 minutes taking the pretest and 33 minutes taking the posttest. Due to the numerous interruptions and
unexpected events during the posttest administration, this data does not suggest that Claire’s speed decreases but instead that the two times cannot be compared due to the number of differences between the two testing situations.

Claire’s achievement in her third grade math class was greatly increased over the course of this study. At the time that Claire began taking music lessons through this study she had 32 points out of 60 possible points for the year, which computes to 53.3% correct in her math class (a grade of F). By the end of the marking period, when this case study was complete, Claire’s grade in her math class was an A.

**Discussion**

Claire’s academic math score was greatly improved by the time the music instruction was completed. However, there are numerous variables that may have affected this improvement as well, such as math instruction during the school day. It is proposed that the music instruction was influential in bringing her from a failing grade in math to an A, but there is no way to prove that these lessons and not another independent variable helped to improve her mathematical achievement.

Many factors led to a decrease in Claire’s speed at taking the posttest and it may not be connected to her speed at recalling and processing the mathematics. This second question remains unanswered due to the lack of control over the study.

As suggested by Rauscher et al. (1997), the piano aspect of these music lessons focused on using numbers to correlate to certain fingers. As was found in their study, the participant’s mathematical achievement was improved. Due to the use of numbers, patterns, and the spatial reading of musical notation this is not a
surprise. However, after teaching music through this logical and numerical system for four lessons, I began to question the appropriateness of the actual music instruction. Is teaching music by assigning numbers enhancing her musical achievement? This sort of music instruction takes away from the listening and creating aspect of music by focusing only on the black and white delegation of notated patterns. Also as suggested by Rauscher et al. (1997), these lessons included a study of intervals using half steps and whole steps. This enforced simple addition and subtraction as well as patterns. However, teaching intervals in this manner and even teaching a major scale in this manner contradicts accepted approaches to music education. This style of musical instruction removes the creative and aesthetic components from the music and enforces the aspects of music that align with mathematical and spatial intelligence.

The most important result of this study is the increased consistency that Claire showed on some concepts from the pretest to the posttest. The concepts that she consistently got incorrect on the pretest, such as subtraction that requires two carries, she consistently got wrong on the posttest, demonstrating that she did not yet understand this concept. Yet the concepts that Claire manipulated correctly a few times and incorrectly a few times on the pretest, she had a tendency to more consistently use the concept correctly on the posttest. She made fewer mistakes in the math calculations on the posttest. This is a huge improvement. Concepts can be taught, but when a student understands a concept and still incorrectly manipulates it, it is a much more difficult fix.
Recommendations

For Research

To further support the use of music instruction to enhance mathematical achievement, it is suggested that a similar study be conducted on a larger scale. A larger sample size would allow for more generalizable results. Also, if this study were conducted over the summer months, it would remove the possible effect of regular math instruction in the school. While this would take away one of the ways of testing for increased achievement, it would also remove one of the largest uncontrolled dependent variable in the study. If the participant was not taught math each day in school or taking private math lessons, this study could have a greater claim to the entirety of the participant’s improvement from pretest to posttest based on music instruction. Further, it is recommended that the researcher teach all aspects of music, not just the aspects that correspond to logical and spatial intelligences as Rauscher et al. suggest, in an attempt to show that even music as a whole can enhance mathematical achievement.

For practice

First of all, it should be noted that in teaching fundamental levels of mathematics, music can be a teaching tool. Students flourish through many different styles of learning, and music is just one example. Further, when teaching music, the techniques described above were effective in building the participant’s mathematical achievement and in providing her with basic music theory skills,
however many aspects of music were overlooked. As a music teacher, one needs to teach the creative and aesthetic components of music as well as the notational and rhythmic components.

**Conclusion**

After seemingly stumbling upon the topic for this study and rashly discarding a previous topic of study, the research and case study that were part of this thesis were incredibly rewarding. I set out attempting to help one particular student through individual lessons. Not only did Claire successfully increase her mathematical achievement in her class and on the provided test, but she also gained fundamental music skills. The one on one time with a student and the research that helped me prepare the lessons created an effective learning environment. I would gladly partake in a similar study again, in effort to help more students overcome their specific challenges through individualized and well-researched lessons.
References


Appendix A

Mathematical Pretest and Posttest
1

Write the missing number. Watch the signs.

1. $7 \times 4 = \underline{\hspace{1cm}}$
2. $8 + 9 = \underline{\hspace{1cm}}$
3. $1 + 8 + 2 = \underline{\hspace{1cm}}$

4. $8 + \underline{\hspace{1cm}} = 15$
5. $12 - 9 = \underline{\hspace{1cm}}$
6. $7 + \underline{\hspace{1cm}} = 16$

Compare. Write < or >.

7. $14 \underline{\hspace{1cm}} 12$
8. $6 \underline{\hspace{1cm}} 10$
9. $17 \underline{\hspace{1cm}} 15$

Write the numbers in order.

10. $18$ $20$ $14$ $\underline{\hspace{5cm}}$
11. $7$ $15$ $12$ $\underline{\hspace{5cm}}$

Solve the story problem.

12. There were 18 trucks. Then 9 drove away. How many trucks were left?

\[
\begin{array}{cc}
\text{(number)} & \text{(label)} \\
\hline
\end{array}
\]

13. Use boxes, sticks and circles to show 192.

14. What number is shown? Write the number and number word.

\[
\begin{array}{c}
\text{(number)} \\
\hline
\end{array}
\]

Adapted from *Math Expressions* from The Houghton Mifflin Company along with the third grade math standards of the participant’s school district.
Add.

15. 69 + 9
16. 30 + 50
17. 80 + 30

Add.

18. 56 + 27 = ........................
19. 14 + 46 = ........................

20. 82 + 94 = ........................
21. 78 + 78 = ........................

Count the money.

22.

<table>
<thead>
<tr>
<th>Coin Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter</td>
<td>3</td>
</tr>
<tr>
<td>Nickel</td>
<td>1</td>
</tr>
<tr>
<td>Dime</td>
<td>2</td>
</tr>
<tr>
<td>Penny</td>
<td>5</td>
</tr>
</tbody>
</table>

Subtract. Ungroup if you need to.

23. 50 − 13
24. 98 − 36
25. 85 − 59

26. 199 − 88
27. 200 − 25
28. 110 − 17

Adapted from *Math Expressions* from The Houghton Mifflin Company along with the third grade math standards of the participant’s school district.
Solve the story problems.

29. Toby read 35 pages on Monday and 46 pages on Tuesday. How many pages did he read altogether?

__________  ________________  __________________________

label

30. There were 137 pennies in a jar. Jake took out 49 of them. How many pennies are left?

__________  ________________  __________________________

label

40. Write the total.

| | | | | |  

| | | |  

| | |  

Total  ________

41. Use boxes, sticks, and circles to show 461.

42. Write the hundreds, tens, and ones.

643 = __________ + __________ + __________

Adapted from Math Expressions from The Houghton Mifflin Company along with the third grade math standards of the participant’s school district.
43. How much money is shown here?

![Image of money]

---

Add.

44. \[439 + 134\]  
45. \[601 + 368\]  
46. \[\$5.45 + \$2.45\]

Subtract.

47. \[808 - 243\]  
48. \[600 - 527\]  
49. \[\$10.45 - \$2.99\]

50. Count by 2s. Then multiply. Eyes on a face \[6 \times 2 = \]

---

Adapted from *Math Expressions* from The Houghton Mifflin Company along with the third grade math standards of the participant’s school district.
51. Draw in your answers. Write the numbers.

Tomás has twice as many marbles as Ben.

Tomás has _________ marbles.

Ben has _________ marbles.

Write the fraction for each shaded part.

52. 

53. 

54. Circle the equation that matches the story problem.

Matt bought 3 oranges. Lee bought 9 oranges. How many oranges did Matt and Lee buy?

3 + 6 = 9

3 + 9 = 12
55. Complete the table.

<table>
<thead>
<tr>
<th>Number of Weeks</th>
<th>Number of Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>42</td>
</tr>
<tr>
<td>7</td>
<td>49</td>
</tr>
</tbody>
</table>

Continue each number sequence. Write the rule.

56. 42, 36, 30, ________, ________, ________, ________ Rule: n ________

57. 18, 27, 36, ________, ________, ________, ________ Rule: n ________

58. 34, 38, 42, ________, ________, ________, ________ Rule: n ________

59. Write the name of the shape with 3 sides and 3 corners.

________________________________________

60. Is each shape 2-D or 3-D?

___________________

___________________

Adapted from *Math Expressions* from The Houghton Mifflin Company along with the third grade math standards of the participant’s school district.
61. Draw two diagonals in the parallelogram. Describe the new shapes.

62. Ring each pair of diagonal lines.

63. Place a check mark beside each word that names the shape.

64. Is the figure symmetrical? Write yes or no. If yes, draw one line of symmetry.
65. Write the time of each clock.

[Clocks with times 10:10, 11:00, and 12:30]

Find the volume of each shape in cubic units.

66. [Shape with 3 cubic units]

67. [Shape with 4 cubic units]

68. Complete the table.

<table>
<thead>
<tr>
<th>Feet</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>12</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

69. Use the picture graph. Write the number. Circle more or fewer.

<table>
<thead>
<tr>
<th>Raul</th>
<th></th>
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</table>

<table>
<thead>
<tr>
<th>Leila</th>
<th></th>
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</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Paul read ________ more   fewer   books than Leila.

Adapted from *Math Expressions* from The Houghton Mifflin Company along with the third grade math standards of the participant’s school district.
70. Circle the even numbers below.

14  72  993  678  2  1  60  955  26  9  77  288

71. Shade the squares to represent ¼ of the whole.

72. Estimate by rounding each number to the nearest 10.

36 + 18 = ________________

73. Estimate by rounding each number to the nearest 100.

259 – 120 = ________________

74. Annie left her house at 5:48 and arrived at school at 6:27. How much time did it take her to walk to school?

__________________________ ___________________________________________________________________

label

75. Circle the best answer.

Susan eats breakfast at  8:00 AM  1:35 PM  9:30 PM

76. About how tall is a soda pop can?

5 inches  5 feet  5 miles

Adapted from Math Expressions from The Houghton Mifflin Company along with the third grade math standards of the participant’s school district.
Appendix B

Lesson Plans
Lesson One

I. Preparation
   a. Math test
   b. Parental Consent
   c. Location Consent
   d. Piano Exercises – number above the pitch
   e. Scale/Three Blind Mice

II. Math Test

III. 25 Minutes of Piano

IV. 15 Minutes of Vocal Technique

V. 25 Minutes of Scale Work

VI. SOMETHING FUN!

VII. First Section
   a. Physical Warm-ups
      i. Jumping Jacks
      ii. Bend over and touch your toes, hang there, roll up slowly
      iii. Shoulder rolls
      iv. Stand tall with feet shoulder width apart and arms at your sides
   b. Vocal Warm-ups – give constant feedback and discuss posture!
      i. Hiss like a snake!
         1. Big breath and sssss
         2. Echo my patterns
      ii. Lip trills 5\1 (GM\BM)
      iii. Busy Bees are Buzzing By BZZZZZZ 1 3 2 4 3 2 1 1---
           (CM/Bflat)
      iv. Oh how I love to sing
         1. Connected
         2. Squat at the top
         3. Dipthong on I
      v. Sighs on Lip Trills!
      vi. Scale on Solfeggio syllables
      vii. Scale on Numbers!

VIII. Second Section
   a. Find Middle C
   b. Find other Cs
   c. Learn the first five notes in the scale – on the piano
   d. Thumbs are 1 and Pinkies are 5
   e. Right Hand – try a few exercises with numbers
      i. Stepwise motion
      ii. Skips
      iii. Leaps
   f. Left hand try the same exercises
   g. Left hand and right hands together!
h. More exercises without the numbers written in – to write in
i. Lots of exercises to work through – some include two hand exercises!

IX. Section Three!
   a. Every song has a resting note called the tonic.
   b. This might take some getting used to, but let’s try to find that resting note for a few songs.
      i. Sing a few simple songs and find the tonic.
      ii. (CM) Three Blind Mice: ”Three Blind Three Blind Mice. See how they run. See how they run. They all ran after the farmer’s wife. Did you ever see such a sight in your life, as three blind mice? Three blind mice.”
      iii. (DM) Twinkle Twinkle Little Star
      iv. (FM) Michael Finnegan “There was an old man named Michael Finnegan. He had whiskers on his chinnegan. The wind blew them off but the grew in again. Poor old Michael Finnegan.”
      v. (Bflat M) B-I-N-G-O
      vi. Ask her to suggest a song she likes if we have time.
   c. Explain that the tonic or resting note is the bottom note in a scale.
   d. Sing one of the same pieces, and now play the scale that accompanies it.
      i. Three Blind Mice-it is mainly stepwise motion.
      ii. 321, 321 543 543 5887678555 5887678555 4321 321
   e. Sing this Major scale, CM, on solfeggio.
   f. Have her sing along and sing it again.
   g. Show her a scale in musical notation
      i. C Major ascending
      ii. Ask her to fill in the numbers under the CM descending scale
      iii. Look at three blind mice in notation and write in the solfeggio

X. Section 4
   a. Ask her if there is any music she is working on in choir or at school
   b. Sing through it with her
   c. Ask if there is anything she wants to work on – a Disney song? A song you really like?

XI. Section 5
   a. Half-steps/Whole Steps
   b. Explain on piano
   c. Quiz her – How many half steps is it from C to E?
      i. How many whole steps would that be?
   d. Look at our major scale and determine the steps in between.

XII. Do Do Re Do DRMRD DRMFMRD DRMFS…. Just for fun!
Lesson 2

I. Objective: Student will continue to progress in all areas of the lessons, particularly in identifying resting tone of simple songs.

II. First Section – warming up
   a. Physical warm-up
      i. Wiggle
      ii. Reach up and stretch down and roll up slowly
      iii. Shoulder rolls
      iv. Reach up, align shoulders on the way down
      v. Posture in general
   b. Breathing warm-up
      i. Closed mouth breaths
      ii. In through your nose out through your mouth
      iii. On exhale – shh, ss, zz, lip trill
      iv. Rhythm consonants
   c. Vocal warm-up
      i. Shoo shoo shoo (5 3 1)
      ii. Bi Di Bi Di Bi Di Bi Bi Bi Bi (123454321)
      iii. Busy Bees are Buzzing By (13 24 3 2 1 ---)
      iv. Oh How I love to Sing!
      v. Solfeggio Syllables on a major scale
      vi. D DRD DRMRD DRMFR... 
   d. Mrs. Clause Song
      i. She has a Mrs. Clause song that she just learned?

III. Section 2 – piano
     a. Work through exercises again
        i. One hand and then the other hand

IV. Section 3 – Resting Tone
    a. Ask her to explain the resting tone
    b. This might take some getting used to, but let’s try to find that resting note for a few songs. I sing it and she echos and then eventually, she finds it on her own
       i. Sing a few simple songs and find the tonic.
       ii. (CM) Three Blind Mice: “Three Blind Three Blind Mice. See how they run. See how they run. They all ran after the farmer’s wife. Did you ever see such a sight in your life, as three blind mice? Three blind mice.”
       iii. (DM) Twinkle Twinkle Little Star
       iv. (FM) Michael Finnegan “There was an old man named Michael Finnegan. He had whiskers on his chin. The wind blew them off but the grew in again. Poor old Michael Finnegan.”
       v. (Bflat M) B-I-N-G-O
       vi. Ask her to suggest a song she likes if we have time.
c. Explain that the tonic or resting note is the bottom note in a scale.
d. Sing one of the same pieces, and now play the scale that accompanies it.
   i. *Three Blind Mice*—it is mainly stepwise motion.
   ii. 321, 321 543 543 5887678555 5887678555 4321 321
e. Sing this Major scale, CM, on solfeggio.
f. Have her sing along and sing it again.
g. Show her a scale in musical notation
   i. C Major ascending
   ii. Ask her to fill in the numbers under the CM descending scale
h. Look at three blind mice in notation and write in the solfeggio

V. Section 4 – Rhythms
a. Ta titi—ask her what rhythm syllables she uses in school
b. Read through the rhythm examples
   i. One measure at a time on repeat
   ii. Then move on
   iii. At the end, do the whole line!

VI. Section 5 – Half steps/Whole Steps
a. Ask her to explain these
b. Quiz her
c. Discuss a major scale
d. Ask her how we would write it in notation

VII. Section 6 – repertoire (be sure to start with at least ten minutes left)
a. Rhythm syllables first
b. Then solfege
c. Then adding text at the end
Lesson 3

I. Objective: SWBAT accurately identify the number of half and whole steps in given intervals and accurately sing through “Let it Grow.”

II. Section 1 - Warm-up
   a. Physical
      i. Stretches
      ii. Jumping Jacks
      iii. Shoulder Rolls
      iv. Reach up and settle arms
   b. Breathing
      i. In through nose, exhale through nose
      ii. Breath through a straw
      iii. Open throat and mouth
      iv. Exhale on lip trills
   c. Vocal
      i. Rhythm consonants
      ii. R trills on 5 3 1
      iii. Vi (1 3 5) Va (8 5 3 1)
      iv. Busy Bees are Buzzing By
      v. Solfeggio Scale
      vi. Do, Do Re Do, Do Re Mi Re Do, ...

III. Section 2 – Half Steps and Whole Steps
   a. Ask for an explanation
   b. Quiz her on the steps between two pitches
   c. Discuss a major scale
   d. Find a major scale starting on a pitch other than C

IV. Section 3 – Piano
   a. Stickers!

V. Section 4 – Resting Tone
   a. Define
   b. Simple Songs
      i. Baa Baa Black Sheep
      ii. B-I-N-G-O

VI. Section 5- Rhythms

VII. Section 6 – "Let it Grow" refrain
   a. Rhythms
   b. Notes on piano
   c. Words
   d. Singing
Lesson 4

I. Objective: SWBAT accurately identify the tonic or resting tone of numerous songs as reinforced by the piano and vocal exercises.

II. Section One – Warm-ups
a. Physical
   i. Stretches
   ii. Jumping Jacks
   iii. Shoulder Rolls
   iv. Bend down and roll up
b. Breathing
   i. In/Out through nose
   ii. In through nose/out through straw
   iii. In through mouth/out on lip trill
   iv. In/out through mouth
   v. No shoulder movement – hands on hips – feel your hands/ribs expand
c. Vocal
   i. Rhythm Consonants
   ii. R trills 5-1 slides
   iii. Vi (1234) Va (54321)
   iv. Ma Me Mi Mo Mu (5 5 5 5 5 54321)
   v. Busy Bees are Buzzing By Bzzzz
   vi. Solfege scale
   vii. Do, Do Re Do, Do Re Mi Re Do, Do Re Mi Fa Me Re Do etc.

III. Section Two – Piano
a. Find C – find C an octave down – place your hands there – figure out CM
b. Play through exercises that haven’t yet earned a sticker
c. Play through new exercises

IV. Section Three – Half Steps and Whole Steps
a. Half Step?
b. Whole Step?
c. Pick two notes and count
d. C Major scale
e. Other Scales?
f. Find G – Play GM scale

V. Back to piano!
a. Play the exercises in GM

VI. Section Four – Resting Tone
a. Resting tone definition?
b. Resting tone when thumbs are on C?
c. On G?
d. Simple Songs
   i. B-I-N-G-O
   ii. Baa Baa Black Sheep
iii. Paint with your hands
iv. Mary Had A Little Lamb

VII. Section Five – Rhythms
   a. Rhythm exercise on numbers 1 + 2 + 3 + 4 +

VIII. Section Six – “Let it Grow”
   a. Note names?
   b. Sing through
   d. RESTING TONE?
Lesson 5

I. Objective: SWBAT accurately identify the tonic or resting tone of numerous songs as reinforced by the piano and vocal exercises.

II. Section One – Warm-ups
   a. Physical
      i. Stretches
      ii. Jumping Jacks
      iii. Shoulder Rolls
      iv. Bend down and roll up
   b. Breathing
      i. In/Out through nose
      ii. In through nose/out through straw
      iii. In through mouth/out on lip trill
      iv. In/out through mouth
      v. No shoulder movement – hands on hips – feel your hands/ribs expand
   c. Vocal
      i. Rhythm Consonants
      ii. R trills 5-1 slides
      iii. Vi (1234) Va (54321)
      iv. Ma Me Mi Mo Mu (5 5 5 5 5 54321)
      v. Busy Bees are Buzzing By Bzzzz
      vi. Solfege scale
      vii. Do, Do Re Do, Do Re Mi Re Do, Do Re Mi Fa Me Re Do etc.

III. Section Two – Piano (short!)
   a. Find C – find C an octave down – place your hands there – figure out CM
   b. Play through exercises that haven’t yet earned a sticker
   c. Play through new exercises

IV. Section Three – Half Steps and Whole Steps
   a. Half Step?
   b. Whole Step?
   c. Pick two notes and count
   d. C Major scale
   e. Other Scales?
   f. Find G – Play GM scale

V. Back to piano!
   a. Play the exercises in GM

VI. Section Four – Resting Tone
   a. Resting tone definition?
   b. Resting tone when thumbs are on C?
   c. On G?
   d. Simple Songs
      i. B-I-N-G-O
      ii. Baa Baa Black Sheep
iii. Paint with your hands
iv. Mary Had A Little Lamb

VII. Section Five – Rhythms
   a. Rhythm exercise on numbers $1 + 2 + 3 + 4 +$

VIII. Section Six – “Let it Grow”
   a. Note names?
   b. Sing through
   d. RESTING TONE?
Lesson 6

I. Objective: SWBAT accurately identify the letter names of the pitches on the piano and on a treble clef staff.

II. Section One – Warm-ups
   a. Physical
      i. Stretches
      ii. Jumping Jacks
      iii. Shoulder Rolls
      iv. Reach up and release downward
   b. Breathing
      i. In nose/out nose
      ii. In through mouth/out on lip trill
      iii. In/out through mouth
      iv. No shoulder movement – hands on hips – feel your hands/ribs expand
   c. Vocal
      i. Rhythm Consonants
      ii. Shoooo 5-1 slide
      iii. Bi Di (1), Bi Di (2), Bi Di (3), Bi Di (2), Bi Di (1)
      iv. Busy Bees are Buzzing By Bzzzz
      v. Oh How I Love To Sing!
      vi. Solfege scale
      vii. Do, Do Re Do, Do Re Mi Re Do, Do Re Mi Fa Me Re Do etc.

III. Section Two – Piano
   a. Note name review
      i. Quiz her/explain letter note names on the piano
      ii. Quiz/explain letter note names in notation
   b. Play through exercises that haven’t yet earned a sticker
   c. Play through new exercises

IV. Section Three – Half Steps and Whole Steps
   a. Half Step?
   b. Whole Step?
   c. Pick two notes and count
   d. Ask her first what a major scale is comprised of, she has a tendency to jump into the playing as an answer
   e. C Major scale
   f. Other Scales?
   g. Find G – Play GM scale

V. Section Four – Resting Tone
   a. Resting tone definition?
   b. Resting tone when thumbs are on C?
   c. On G?
   d. Simple Songs
      i. B-I-N-G-O
      ii. Baa Baa Black Sheep
iii. Paint with your hands
iv. Mary Had A Little Lamb

VI. Section Five – Rhythms
   a. Rhythm exercise on numbers 1 + 2 + 3 + 4 +

VII. Section Six – “Let it Grow”
   a. Note names?
   b. Sing through
   c. Play along to the parts that she already knows
   e. RESTING TONE?
Lesson 7

VIII. Objective: SWBAT accurately play and sing through the entirety of “Let It Grow”.

IX. Section One – Warm-ups
a. Physical
   i. Stretches
   ii. Jumping Jacks
   iii. Shoulder Rolls
   iv. Reach up and release downward
   v. Reach down and roll up
b. Breathing
   i. In through a straw/out through a straw
   ii. In nose/out straw
   iii. In through mouth/out on lip trill
   iv. In/out through mouth
   v. No shoulder movement – hands on hips – feel your hands/ribs expand

c. Vocal
   i. Rhythm Consonants
   ii. Hmmmmmm (5), Ma (5), Ma (3), Ma (1)
   iii. Fi (1), Fi (3), Fi (5), Fi (54321)
   iv. Busy Bees are Buzzing By Bzzzz
   v. Oh How I Love To Sing!
   vi. Solfege scale
   vii. Do, Do Re Do, Do Re Mi Re Do, Do Re Mi Fa Me Re Do etc.

X. Section Two – Piano
a. Note name review
   i. Quiz her/explain letter note names on the piano
   ii. Quiz/explain letter note names in notation
b. Play through exercises that haven’t yet earned a sticker

c. Play through new exercises

XI. Section Three – Half Steps and Whole Steps
a. Half Step?
b. Whole Step?
c. Pick two notes and count
d. Ask her first what a major scale is comprised of, she has a tendency to jump into the playing as an answer

e. C Major scale
f. Other Scales?
g. Find G – Play GM scale

XII. Section Four – Rhythms
a. Rhythm exercise on numbers 1 + 2 + 3 + 4 +

XIII. Section Five – “Let it Grow”
  a. Note names?
  b. Sing through
c. Play along to the parts that she already knows


e. RESTING TONE?
Lesson 8

I. Objective: SWBAT accurately play and sing through the entirety of “Let It Grow” and also identify the familiar songs by playing them on piano.

II. Section One – Warm-ups
a. Physical
   i. Stretches
   ii. Wiggles
   iii. Shoulder Rolls
   iv. Reach down and roll up
   v. Reach up and release into proper position
   vi. Feet shoulder width apart and hands at sides!
b. Breathing
   i. In through a straw/out through a straw
   ii. In nose/out straw
   iii. In through mouth/out on lip trill
   iv. In/out through mouth
   v. No shoulder movement – **hands on hips** – feel your hands/ribs expand
c. Vocal
   i. Rhythm Consonants
   ii. Shoo (5), Shoo (3), Shoo (1)
   iii. Vi (1234) Va (54321)
   iv. Busy Bees are Buzzing By Bzzzz
   v. Oh How I Love To Sing!
   vi. Solfege scale
   vii. Do, Do Re Do, Do Re Mi Re Do, Do Re Mi Fa Me Re Do etc.

III. Section Two – Piano
a. Play through exercises that haven’t yet earned a sticker
b. Present page of new exercises
   i. These are all untitled familiar pieces
   ii. The goal is that she plays through it and is able to recognize the tune and write in the title
   iii. Go through all 6 exercises

IV. Section Three – “Let it Grow”
   a. Play through
   b. Sing and Play through it
   c. Discuss vocal technique when needed and sing through it again if there is time focusing on vocal problem spots
Appendix C

Parental Consent Form for Child Participation
Informed Consent Form for Social Science Research
The Pennsylvania State University

Title of Project: The effect of music on spatial and mathematical achievement - a case study

Principal Investigator: Mary Katerman
560 Shady Lane, Hummelstown, PA 17036, mtk5054@gmail.com, 717-364-0949

Advisor: Dr. Joanne Rutkowski
206 Music Building, University Park, PA 16802, rvi@psu.edu, 814-863-0419

1. Purpose of the Study: The purpose of this study was to explore the effect of lessons in musicianship, vocal technique, and keyboarding technique on a specific student’s fundamental mathematical and spatial achievement. Through this exploration of alternative teaching techniques, the end goal is to aid in the participant's growth and help her to perform better in mathematics.

2. Procedures to be followed: Your child will be asked to take a math test once before all of our lessons and once at the end of the lessons. Beyond that, your child will be given a typical music lesson. Each lesson will include twenty-five minutes of learning to play the piano, fifteen minutes of working on vocal technique, and twenty minutes of learning to sight-sing based on the steps of the scale. Your child will therefore be playing piano, reading music, listening to her teacher, and singing. The lessons will be audio and visually recorded for documentation and preparation for the next lesson.

3. Benefits: The benefits to your child include the music lessons she will be provided as well as the hoped for increase in her mathematical skills.

4. Duration/Time: The first and last lesson will be 1 hour and 20 minutes in order to include the math test and each lesson in between will be 1 hour in duration. There will be eight weeks of lessons, so in total 8 hours and 40 minutes.

5. Statement of Confidentiality: Your participation in this research is confidential. The data will be stored and secured on Mary Katerman’s computer in a password protected file. In this file, a pseudonym will be used for your child and only Mary Katerman and Dr. Rutkowski will know the true identity of your child. This information will not be written anywhere except for this document of consent. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared.

6. Right to Ask Questions: Please contact Mary Katerman at (717) 364-0949 with questions, complaints or concerns about this research. Questions about research procedures can be answered by the research team.
7. **Voluntary Participation:** Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

You must be 18 years of age or older to consent for your child to take part in this research study. If you agree to allow your child to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this consent form for your records.

I, _____________________________________________, give permission for my child,

(print parent’s name)

____________________________________

(print participant’s name)

__________________________  _____________________

Participant’s Parent Signature  Date

__________________________________________  _____________________

Person Obtaining Consent  Date
Appendix D

Location Consent Form
Location Consent Form for Social Science Research
The Pennsylvania State University

Title of Project: *The effect of music on spatial and mathematical achievement - a case study*

Principal Investigator: Mary Katerman
560 Shady Lane, Hummelstown, PA 17036,
mtk5054@gmail.com, 717-364-0949

Advisor: Dr. Joanne Rutkowski
206 Music Building, University Park, PA 16802,
rvi@psu.edu, 814-863-0419

1. **Purpose of the Study:** The purpose of this research is to explore the effect of lessons in musicianship, and keyboarding technique on a specific student's basic mathematical skills. Through this exploration of alternative teaching techniques, the end goal is to aid in the participant's growth and help her to perform better in mathematics.

2. **Procedures to be followed:** The participant will be asked to take a math test once before all of our lessons and once at the end of the lessons. Beyond that, the participant will be given a typical music lesson. Each lesson will include twenty-five minutes of learning to play the piano, fifteen minutes of working on vocal technique, and twenty minutes of learning to sight-sing based on the steps of the scale. The participant will therefore be playing piano, reading music, listening to her teacher, and singing. The lessons will be audio and visually recorded for documentation and preparation for the next lesson.

3. **Discomforts and Risks:** There are no risks in allowing this research to take place at your house other than those experienced in everyday life.

4. **Duration/Time:** The first and last lesson will be 1 hour and 20 minutes in order to include the math test and each lesson in between will be 1 hour in duration. There will be eight weeks of lessons, so in total 8 hours and 40 minutes.

5. **Statement of Confidentiality:** Your participation in this research is confidential. The data will be stored and secured on Mary Katerman’s computer in a password protected file. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared.

6. **Right to Ask Questions:** Please contact Mary Katerman at (717) 364-0949 with questions, complaints or concerns about this research. You can also call this number if you feel this study has damaged your house. Questions about research procedures can be answered by the research team.
7. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

You must be 18 years of age or older to consent for your house to be used for this research. If you agree to allow your house to be used for this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this consent form for your records.

I, _____________________________________________, give permission for my home, (print home owner’s name)

______________________________________    ___________   ___________,
(street address)                                               (state)             (zipcode)

to be used for this research study.

_________________________________________________             ___________
Home Owner’s Signature                                          Date

_________________________________________________             ___________
Person Obtaining Consent                                          Date
Appendix E

Notes on Each Lesson
April 22, 2012 – Lesson One

This was my first lesson with Claire. The first step in the lesson was to have Claire’s mother sign the parental and location consent forms. When these had been signed, Claire also signed the consent form and then began taking the mathematical pre-test at her dining room table. I timed her while she worked on completing the test. When she completed her test, we moved to the piano in a different room.

I had intended to get her ready to go with a few jumping jacks, but found that our space was small and jumping jacks were not going to fit. So instead we began by stretching and wiggling it out. She seemed nervous to wiggle with me at first but eventually she let loose and shook out all the tension from her math test.

Overall, she was eager to learn. Talking when I gave her a chance but working through the more difficult parts when that in turn is what I requested. An hour is a very long time to teach one subject in one setting to a ten-year-old but it is also a very long time for that ten-year-old to sit still and keep focusing. Claire exceeded my expectations. She was constantly on-task and her brief moments that were not filled with musical instruction were because I attempted to get her to talk or laugh, just to break up the teaching.

When singing, Claire knows what her teachers have prescribed as good posture, but often, when I am not reminding her, she shrinks back into her rounded-shoulder position. Next time, I hope to do a bit more posture development. If she learns to breathe correctly, singing well will follow.
Claire finds it much easier to sing on a rolled r than a lip buzz. I wonder if this means anything with a young singer? It seems as though she does not have enough air to support the buzz. We are going to switch to the rolled r when warming-up the voice, but for practicing breathing I think we may continue buzzing our lips.

Often throughout our lesson, I felt trapped by the piano. She would stand over my left shoulder and I would be stuck between the wall and the piano and have no choice but to sit on the piano bench. I should have made more of an effort to get out so that I could be a physical demonstration. Next time, I intend to push in the piano bench, and even if it means I do not have direct access to the piano, I will stand with her for some of our warm-ups. This will provide her with a physical example and I will also be able to use some hand motions to help her find the support we are searching for.

Amazingly enough, Claire is already familiar with her scale on solfeggio syllables. When I asked, she informed me that she is not only familiar with the scale, but she often does the warm-up “Do, Do Re Do, Do Re Mi Re Do, etc.” I was thoroughly impressed. I sang this exercise with her and she had a few memory lapses along the way but for the most part she did a great job. I would like to further solidify the scale itself before we do that exercise again. It felt as though she had tried to memorize the entire exercise instead of recognizing the pattern of adding one pitch each time because often from the top, she would make the mistake of starting on “Do” and then using the
ascending syllables while we descended the scale. This to me means that she does not understand it and is merely reproducing the words.

When we were doing piano exercises it was apparent that she became bored with the work. In writing the lesson plan, I forgot that this was an actual ten-year-old girl and not just a child that I could pour information down. In other words, while I hypothesize that she will gain the most in her mathematical achievement by grueling exercises in music theory, she is still a child and gets bored easily. And when she is bored she is learning less. Chances are that she will learn the most if I can find the line that is exciting to her but still as much core information as possible. I will plan more fun things for our next lesson.

While she was struggling with playing the same melody in both hands on the piano, she seemed to fly through the exercises that were both hands but one hand held a whole note while the other moved and then they switched. I expected this to be the most challenging of the piano work, but the parts in octaves were more difficult for her.

When she seemed exhausted from the piano exercises, we moved on to section three of the lesson plan in which we learned about resting tone. I’m not sure that she understands this concept yet but we will continue to work on it. After I provided the resting tone for a song, she is able to recall that pitch and use it at any point in the song but she cannot yet find it herself. We sang a song that began on the resting tone and then when we moved to the next song, she assumed that the resting tone was the first pitch, and it was not. So we will work on this.
Just something to keep in mind – middle C is low in her range. She has a nice light voice for her age and I don’t want to push it any lower. At the end of the lesson, I gave a brief explanation of half and whole steps and their functions in relation to a piano. She was excited and caught on quickly so we kept moving! We discussed how a scale is just a sequence of whole and half steps and she seemed to actually understand this because she slowly played major scales beginning on random pitches by figuring out the whole and half steps. Not only was this exciting to teach her, but she was clearly excited about learning it. It was the first thing she told her mom about when we talked with her after the lesson.

Next lesson I would like to discuss some simple rhythms. She knows quarters, eighths, half, and whole notes, but in our one piano exercise there is a dotted quarter. So this is the next step in rhythm. We will do some rhythm chanting without pitch until she grasps the new duration. Also, she requested to do “Let it Grow” or “How Bad Can I Be” from The Lorax and I think this would be great but I cannot seem to find the music. I think that I will just notate a small part of it so she can read the rhythms, play it on piano, and work on singing it and therefore, apply everything she learns in a fun way.

May 6, 2012 – Lesson Two

This lesson was incredibly difficult in the beginning. Claire had recently been fighting with her grandmother and she was not in the mood to do anything. In a one-on-one lesson it can be devastating if the student refuses to do as you ask. I tried to begin as silly as possible, making our physical warm-ups
over the top. I demonstrated and she mimicked but I just looked silly and she tried her hardest to ignore me and do the least amount of work that was required to continue. Also, she had a candy bracelet and she seemed bent on eating it every moment that she was not actively singing, including while we were stretching our arms up or doing jumping jacks. She would do these exercises with one hand until I told her to use both. It was a tough beginning to a lesson, but she is a bright and engaged kid and soon her passion for learning took over. She eventually just gave in and enjoyed her lesson.

During our singing in this lesson I found that her voice switches around G4 to a lighter more head-like voice that she can carry the whole way up to C6. This is a wonderfully high range and I try to keep our singing in her upper voice because she will be more successful up there at this point in her development. We worked through the scale in solfeggio better attempting the warm-up that she does with her choir: “Do, Do Re Do, Do Re Mi Re Do,...”

After her difficulties last time with this, I was expecting to have to help her through it again. However, it was clear that she had been practicing. She nailed it, making only a few mistakes that she quickly remedied. I was very impressed.

When reading the piano exercises, she always starts reading it through with her right hand and then plays both hands at the same time. After a short discussion it was clear that she was reading the right hand notation and numberings and then just mimicking it in her left hand because the exercises were in octaves. I let it go for this lesson, but next lesson we will be sure to
read the left hand notation and then put it all together to ensure skills from each hand.

Claire blew through the rhythm worksheet. I had intended to do it one measure at a time and then maybe at the end attempt to put multiple measures together. When she saw it, she simply read through it all. I was again impressed. The end of this exercise was filled with dotted half notes because Claire had not known what these were during lesson one. When she read through them perfectly I questioned her, explaining that I had thought that she did not know what those notes were. She confidently responded that I explained it last lesson so now she knows. I was a bit taken aback. Most children would need a refresher or some sort of reinforcement given that we only talked about it for a moment and that was over a week ago, but not Claire. Her mother happened to be walking through the room at that moment and afterward we had a conversation about Claire’s issues at school. It seems that she really only needs to be told most things once and she remembers it. She finds herself bored and babied when the teachers repeat concepts over and over and often even says negative things to her teachers and classmates insulting their intelligence. This is beautiful in its own way and highlights some of the biggest problems in public education right now – the inability to give every student the education they deserve at the pace that works best for them.

In all of this wonderful learning we were doing, we did not have a chance to get to the whole steps and half steps portion of the lesson. This was even the
part she seemed most excited about during lesson one so I was bummed that we did not get there. I’ll be sure to cover it in our next lesson and we’ll see just how long she remembers concepts for!

I also spent nearly an hour trying to plan out a schedule for the rest of our lessons with Claire’s family. It was tricky but it looks like we will at least be able to fit in eight lessons before the end of the school year, which is where it has to stop so that I can use Claire’s school grades as part of my research. It’s disappointing that we cannot have a full ten lessons but scheduling is much trickier than it seems and we are lucky to have eight.

May 7, 2012 – Lesson Three

This lesson I brought stickers! It was a huge success. At first she pretended that it was not a big deal but as we continued, if I didn’t immediately go for my stickers to mark off a certain exercise, she would sigh and play it again until it was good enough to receive a sticker. I gave her stickers on her piano exercises. The ones that she can play well I put a sticker on so that we need not come back and work on these again.

This lesson was only a day after the second lesson and I found that she was at basically the same point, not having had much time to practice in between lessons. Therefore, we just took everything one more step. She excelled greatly during this lesson because she was excited, unlike lesson two, which got off to a bad start.

I brought up half steps and whole steps right after our beginning vocal warm-up and after a very brief reminder she was accurately counting the half steps
and whole steps between many large intervals. At points we lacked a bit of communication, for instance, when I wanted her to play a major scale starting on a G, she merely counted the half steps from G to the G that is an octave higher. She did this accurately however so I did not protest and just more clearly explained what I was requesting.

She is overly excited about working on “Let It Grow” but doesn’t really want to look at the music I brought. She wants to sing the parts she remembers from watching the movie. I think I may just scratch the idea of her reading the music when she sings and just use the music for my own reference.

Although, I really like that she is learning to play the melody on the piano along with learning to sing it. I asked her to fill in the rest of the note names and work on playing it for our next lesson so I am excited to see where that ends up.

May 14, 2012 – Lesson Four

Claire was excited for her music lesson this time. Having a student who is ready to learn can make all the difference in the lesson. However, she informed me that because she had stayed at her dad’s house all week, she was not able to practice because she did not have a piano. I noticed immediately that she had not made significant improvement like she had done for the previous lessons. In fact, she seemed to have regressed slightly. Nevertheless, she was ready to work. And work we did.

After her usual physical, breathing, and vocal warm-up we dug deep into the piano work. As we went through, there were numerous exercises that were
not as prepared as they were last week and that we had to do multiple times. I told her that we would slide our hands to a new position during that lesson, but we just didn’t get around to it. We worked diligently through a few pages of piano exercises and when I looked at my clock, I realized that I only had a few minutes left in the lesson.

First of all, this is poor planning on my part because I should have been more aware of how much time we are spending. Normally, after ten or twenty minutes of piano she is clearly getting restless and we move on to more exciting things. Her focus during this lesson allowed us just to continue working until I checked the time, and we moved on to working on “Let it Grow” because that is a fun sort of application for Claire. She did well with the singing and enjoyed that I had written out the whole song for her. So we sang through the whole thing together and played through the refrain in three different keys! We even found the resting tone for each new key.

May 26, 2012 – Lesson Five

The lessons are becoming repetitive in my mind, however Claire is making progress as we go. Each lesson plan is incredibly similar due to the plans to keep the same time frame of each aspect of music. We just take each concept a bit further each time. This time, I showed Claire how to move her hands to a new tonal center. All the exercises that she has done so far were from C-G. I provided a few new exercises this lesson that range from G-D, therefore the resting tone was G. Claire seemed to understand that G is now that elusive
concept that I have termed “Resting tone” or “tonic” but I still am not sure that she entirely gets it, although she is getting better at finding it, in general. Another concern that I found during this lesson was her lack of notational understanding. She is not confident on the letter names of the notes on the piano or on the staff. This is a big part of reading music. I felt like she understood this better a few lessons ago. I think perhaps the problem is too much terminology. When I ask what note it is, she says 2 (her fingering) or re (the solfeggio) but never pulls out the letter name, even when I specifically ask for it. Maybe it is just a different way of understanding it. And if she actually grasps that it is “re” then it may be even better than her understanding that it is a “D” but I’m not sure that she does.

This lesson was very early in the morning and I was nervous about her voice. She said that she had been awake for quite some time but she sounded a bit raspy and I did not want to push it. We sang less than normal and did very gentle vocalizes. I will be interested to see if things are resolved at our next lesson a few days from now.

May 29, 2012 – Lesson Six

This lesson presented me with a few difficulties. Claire was not excited by the piano work in the slightest. While we were working on it, she actually laid her head down on the piano because she did not want to work on it any longer. We had done piano for less than twenty minutes at that point! In order to not give, I had her complete another exercise and then hastily moved on to something that would perhaps keep her attention better. We
ended the lesson with "Let It Grow," like we usually do and she thoroughly impressed me on this end of the lesson. She was able to play much more of it on piano than she had yet played. It goes through three different keys and we’ve not even talked about it much because we were just using the music to sing along with. However, she has figured it all out and read through two thirds of the song. After, she ran to the other room of the house and asked her grandmother to come and listen to it again. I was quite content with the progress we had made and it was nice to know that she too was proud of her work and wanted to show it off.

May 30, 2012 – Lesson Seven

When I arrived at Claire’s house, I found Claire at the piano, practicing all the materials I left her. This was a good sign. During the vocal warm-ups she stayed focused and for the most part, maintained her posture. She has a tendency to just out a hip and just generally wiggle instead of standing up straight and tall. During this lesson I only needed to remind her of her posture once.

Her preparation on the piano was evident when we moved on to the piano section of the lesson. We flew through the numerous piano exercises that we had previously worked on. The new piano exercises were a bit of a challenge but she was excited and didn’t seem to get bored, so we plugged on through many of the exercises. When writing in the numbering on the piano exercises she has a tendency to confuse the numberings for each hand. Sometimes, she writes both hands as if the lowest of the five notes is 1 and the highest is 5
and other times she writes them as I initially taught her, with the thumbs being 1 and the pinkies being 5. I decided not to correct this as long as it wasn’t confusing her. She is reading the music and playing the correct notes and that means that the numbers have served their purpose.

Like usual, she is thrilled to reach the point of the lesson when we begin to work on “Let It Grow.” She clearly worked on this between lessons because she is much more comfortable on the parts that we labeled and worked on last lesson. She still needs help on the third page, but when we sing along, it helps her find each note – less reading and more listening, which is a crucial music skill.

June 4, 2012 – Lesson Eight

This lesson was the most interesting of all the lessons. When I arrived, I was informed by Claire’s grandmother that she was having a tough day and that she was being “talked to” and should be out soon. After a few minutes of small talk, I questioned what a rough day entailed and was informed that Claire had been mistreating family, teachers, and peers all day and that she was “impossible” to deal with today. I thought that maybe I should try to come back another day due to the situation but was informed that Claire would soon be joining us. Nearly thirty minutes after our lesson was intended to begin, Claire quietly came into the room, tears still streaming down her cheeks, shoulders hunched, and eyes downcast. This lesson seemed to hold little promise and frankly, I was uncomfortable at the idea of spending the next hour with a pupil who on this day seems to either yell at
adults or cry in their presence. Neither would provide a healthy learning environment.

After a few silent moments on her part while we did our physical warming up, she was forced to make noise when we got around to the singing warm-ups. By the end of the first five minutes, she looked like a whole new child: standing up straight, tears gone – though the streaks down her cheeks were still visible, and head lifted high with a sure smile as we proceeded through the lesson.

I made sure to create a particularly fun lesson plan for our last lesson, and I am lucky that I did, because it really helped to insure her continued pleasant attitude. She identified the six piano exercises that were familiar songs with relative ease. For the most part she could play the correct notes and every now and then would need a bit of help on the rhythms. One song was particularly fast and she could not recognize it at the tempo she was playing it so I played it for her to see if she could identify the song, and she did. She had a lot of fun with these exercises and even asked if she could keep the paper that they were on so that she could continue to play through them! We also played and sang through “Let It Grow,” which she is getting better at each week! This last lesson she did not need my help to find any notes and played through the first two keys at a pretty consistent tempo and only had to really think in the third key. Overall, I’d say she went out with a bang and learned a fair amount along the way.
During the final math test, she took far longer than she probably would have needed because she was very distracted. There was not a place that I could hide her at that there were not other family members around. At one point, she asked me a question and I ended up teaching her how to do a specific problem. When this sort of problem came back up, she tried and failed to do it correctly, so I gave up on the experiment momentarily and just took the time to teach her the concept in depth. I circled the problems that pertain to the concept that I taught and will not count them as correct as I go through, but I felt that it was worth potentially skewing my meager results in order to remedy her confusion.
VITA

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  The Pennsylvania State University
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• TEACHING EXPERIENCE
  Cambridge-South High School
  Choir and Algebra Teacher
  Cambridge, MD
  2012-2013
  • Will teach two choirs and three algebra courses for grades 9-12.

  Lebanon High School and Elementary Schools
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  Student Teacher
  Spring 2012
  • Taught 1st-3rd grade general music, 4th and 5th grade choirs, auditioned and non-auditioned high school choirs, and high school learning support music classes.

  Camp Confidence
  Dubois, PA
  Assistant Music Director
  Summer 2009
  • Taught and mentored children with special needs in 4 classes of about 30 students each day.
  • Interacted with campers and aided with their daily needs.

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  Penn State Hershey Medical Center
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  Volunteer music therapist
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  • Observed Janice Stouffer stimulate and treat patients through music.
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• WORK EXPERIENCE
  The Hershey Trolley Works
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  Tour Guide and Concierge
  Summer 2004-present
  • Perform entertaining historical tours of the town of Hershey.
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• HONORS AND AFFILIATIONS
  Schreyer Honors College
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