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The dissertation of Mary Roy Weiss, SSND entitled *Background Music and Cognitive Learning Effects in Mathematics with Middle School Students* submitted to the School of Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Instructional Leadership for Changing Populations at Notre Dame of Maryland University has been read and approved by the Committee.

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Background Music and Cognitive Learning Effects

in Mathematics with Middle School Students

by

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A Dissertation

Submitted in Partial Fulfillment of

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ABSTRACT

This quasi-experimental research study examined the cognitive effects of background music used with middle school students during mathematics classes and mathematics testing. Eight schools, nine teachers, 23 classes, and 302 students participated in the project. A series of five compact discs of Mozart selections, a specifically selected composite of 12 CD albums, was used over a period of 10 class days and one testing day. The tests were teacher-designed for use during the regular regimen of testing for their specific classes. The conditions of music and no-music were reversed so students were their own controls. Results showed a nonstatistical gain overall; however, sixth grade females had a net music gain that superseded all other male and female groupings. In addition, an incremental gain was found with those who had played instruments. Other gains/losses were noted for these conditions: if students liked or did not like background music during classes and testing, if they liked or did not like listening to music while doing homework, if they liked singing or not, and whether they felt that the music was a help or hindrance to their attention, concentration, and/or distraction. The students' perspectives concerning the quasi-experiment were reported as supplemental qualitative data which included impressions about the experiment, opinions about the experience they had, and suggestions for future experiments.

DEDICATION

I dedicate this dissertation to:

--my mother Pauline whose zest for life and hard work supported my life-long inquisitiveness about many subjects

--my father Roy C. who was a great example to me as a constant reader and as a singer of songs that energized the human spirit

--my brother Roy A. who has persevered throughout many years as a listener to my questions and who toasted me receiving a doctorate in a moment of vision long before this degree work began

--my sister-in-law Lynn who has taught me that it is valuable to streamline my belongings, including my words

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Lastly, I thank Tessie for showing me how to be on heightened alert, to notice the hidden mysteries in our world, and to have fun when things seem overwhelming. Her spirited welcomes and walks helped me journey through responsibilities and challenges along the way.

"At all times, I will bless the Lord." –Psalm 34:1

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INTRODUCTORY CHAPTER

Students are expected to pay attention and concentrate in their classes, yet listening to music may be considered as an attention and concentration device for some or a distracter with the task-at-hand for others. This research explored the use of background music in middle school classrooms as a focusing activity for attention and concentration. The effects of listening to background music while completing mathematics work and performing on mathematics tests was analyzed.

Rationale

This researcher, having been a music educator and music therapist, has a continued interest in how music affects students. While music is known to affect behavior and mood (Bock, 2010; Hallam & Price, 1998; and Rickson, 2006), the impact of music listening on cognitive achievement continues to be debated (Anderson & Fuller, 2010; Carlson, et al., 2004; and Jäncke & Sandman, 2010). Moreover, background music listening may affect students in different ways (Sigman, 2005; Anderson, Henke, McLaughlin, Ripp, & Tuffs, 2000; Hallam & Price, 1998; Register, Darrow, Standley, & Swedberg, 2007). This research investigated the effects of background music listening on middle school students' learning and outcome summative assessments in mathematics

Specifically, it compared results to findings from the widely studied *Mozart Effect* which surfaced initially in the 1990s with Rauscher, Shaw, and Ky (1993). This effect was named based on the results of college undergraduates scoring eight to nine points higher on part of the Stanford-Binet spatial-temporal IQ test after they had listened to Mozart's Sonata for Two Pianos in D Major (K. 448) for 10 minutes (p. 611). Twenty years later, Taylor and Rowe (2012) found a similar connection between the Mozart Effect and mathematics in a study with six college trigonometry classes, in which background music by Mozart was played during testing for three classes and no background music was played during six tests for the other three classes. The students who listened to Mozart's music improved their math scores in outcome assessments (p. 62). For the current research, a longer composite selection of Mozart's music was used in the experiment, not the frequently used first movement of the Mozart Sonata K.448 (p. 66). This current experiment used the second movement only, the Andante, from the same sonata. Additionally, over this span of 20 years, there have been mixed results with different populations, different subject matter and varied treatments. Thus, there is a need for more definitive answers to this alleged Mozart Effect.

Purpose of the Study

The purpose of the study was to investigate the impact of music listening on middle school students in a classroom setting during mathematics lessons and mathematics summative assessments. This current study considered research about background music contributing to, or detracting from, students' attention, concentration, and cognitive achievement in mathematics. It attempted to add to the scholarly literature on the topic by expanding the data on middle school children experiencing background music, as opposed to data most often derived from studies with younger students in elementary school and/or young adults in college/university settings.

Researchers have used a variety of genres of music for their experiments. This researcher employed the use of classical music, specifically an all-Mozart program, rather than popular music, or music selected by listeners' preference. Most previous studies used brief music segments of three to 11 minutes for music listening during experiments. The current study used a longer time-span of listening to background music and a longer, more concentrated period of time over a few weeks for the music condition. This study compared the data of previous research studies that tried to replicate the Mozart Effect. In those studies, standardized test results, such as from the Stanford-Benet test, were used to measure the effects of music listening. Unlike those studies, this research relied on typical summative assessment scores within regular classroom settings, derived from teacher-created assessments, rather than on state and national test scores in mathematics.

Problem

One issue that leads to the interest in this current study is that students live in an American culture that promotes a musical ambience, with music often permeating stores, sports arenas, malls, grocery stores, restaurants, homes, doctors' offices, and places of worship. However, what is the level of musical ambience in schools? Does it exist at all, and if so, when and how is it used to further academic achievement? Another issue is that students may access music listening while multitasking, since personal technological listening devices are available. Yet, school settings often prohibit the use of such listening devices. Students may be used to listening to music while doing their homework with these devices or with sounds from the radio, computer, and/or TV permeating their study space at home. Whether music listening helps or hinders personal performance in various academic tasks depends on several factors. One of those factors may be the natural ability of individual students to maintain attention and concentration, whether music is present or not. Students may experience music as a stimulating force or a distracting deterrent to their studies. They may acknowledge that they like listening to music while they study but may not know whether music has any academic benefit or detriment for them. This current study investigated how middle school students responded to musical ambience in the classroom and during testing procedures. The ambient musical condition was evaluated as to its efficacy with student learning.

Keywords—Music terms

Adagio	Slow, but quicker than *largo* and slower than *andante*
Andante	A movement in moderate time but flowing easily, gracefully
Andantino	A little slower than *andante* and generally used as meaning quicker than *andante*
Cantabile	Singing or playing in a melodious and graceful style, full of expression
Chord	The union of two or more sounds heard at the same time.
Concerto	The concerto displays a solo instrument, or sometimes more than one. The accompaniment is generally orchestral and the form is that of a *sonata.*
Con moto	With motion; rather quick
Consonant	Accordant, harmonious
Divertimento	A short, light composition, written in a pleasing and familiar style; an instrumental composition like the suite, of several short movements.
Dynamics	The different degrees of power to be applied to notes in expressing them

Fantasia	Fancy, imagination, caprice: a species of music in which the composer yields to his imagination and gives free scope to his ideas, without regard to restrictions in form
Grazioso	In a graceful style
Instrumentation	The act of writing for an orchestra or band with a practical knowledge of each instrument, and of the distribution of harmony among the different instruments.
Major	Greater, in respect to intervals, scales, etc.
March	A military air or movement especially adapted to martial instruments
Meter	Measure of long and short syllables in verse, an arrangement of poetical feet; the succession of accents in music; the rhythm of the phrase, not of the measure.
Minor	Less; smaller; in speaking of intervals, etc.
Mode	A particular system or constitution of sounds, by which the octave is divided into certain intervals, according to the genus. The arrangement of notes in a scale—major, minor, etc.
Non troppo	Not too much; moderately
Notation	Representation of tones by written or printed characters
Pitch	The highness or lowness of a sound; the rate of vibration of a sound; rapid vibrations create a high tone, slower vibrations create a low tone
Poco	Little
Rhythm	The division of musical ideas or sentences into regular metrical portions; the regular pulsation of music
Serenade	A rather free suite of pieces forming a short program of music for an evening performance.
Sinfonia	An orchestral composition in many parts
Sonata	An orchestral composition, usually of three or four distinct movements, each with a unity of its own, yet all related so as to form a perfect whole
Sostenuto	Sustaining the tone

Symphony A grand composition of several movements, for a full orchestra. It is a *sonata* for orchestra. The second movement is a slow movement.

Tempo The speed of the music, the speed of the rhythm

Theme and variations A simple tune on which variations are made

Timbre Quality of tone or sound

Tone color The particular quality of the sound of any voice, or instrument

Definitions for above terms were taken from Elson (1909)

Additional keywords

Calm Without rough motion, tranquil, serene, freedom from disturbance; may be considered synonymous with ambient and easy-listening

Ceiling effect scores Score limitation at the top of a scale. Highest possible scores (or ceiling) reached on a test; high-scoring participants cannot be correctly measured since the true extent of their abilities cannot be determined if tests are relatively easy (see Wang, Zhang, McArdle, & Salthouse, 2008)

Mozart Effect An effect that purports to cause an increase of spatial-temporal reasoning and other intellectual gains by listening to music composed by Wolfgang Amadeus Mozart. The term has been used to include music by other composers and to include other mental, emotional, and motivational healing effects by listening to music.

The Significance of the Study

This researcher gathered data about how background music listening affected learning experiences and assessments in mathematics. With much of the research that has been produced, there are stated requests for additional research that are needed in the area of music listening effects. Sweeny (2006) suggested that all research about the Mozart Effect, whether published or unpublished, needs to be included in developing a collaborative picture of this effect. Significant results are considered more valuable in the field of research, so a lack of nonsignificant results is not as prevalent in the literature. The Mozart Effect studies either have a disproportion of strongly supportive findings or findings of zero effect. The current research added to the mixed results pool of findings.

The current researcher found a basis to conduct the research from the work of several previous researchers. Anders (2011) reviewed the effects of classical background music on mood, emotion, performance, classroom management and behavior of children in elementary school (p. 31). His review suggested that good behavior, facilitated by background music, benefits students and teachers alike, but that more research needs to occur.

Anderson and Fuller (2010) evaluated adolescents who listened to music while studying. In their research they used top hit songs listed in Billboard Magazine (p. 182). These researchers recommended further study concerning differential effects of various potential sources of distraction. For example, they suggested that other genres of music should be used in experimental studies. This current study did not use top hit songs in the music condition, since this researcher operated on the side of caution: she felt that any familiar music would distract the students from the lessons being taught and learned.

Fassbender, Richards, Bilgin, Thompson, and Heiden (2012) experimented with background music in a computer-animated history lesson with adults in a virtual environment (p. 490). They wanted to test the effect of music on memory. They used experimental music that they categorized as peaceful and gentle, in the major mode, and they used expansive synthesized orchestral accompaniment with string pad timbre. Their findings were divided since there were a statistically higher number of facts remembered by participants in one condition of background music and not in another. Two different display systems were used. Those who used the 3-monitor display system remembered more facts, especially when no background music was played in the second half of the history lesson. Those who used the Reality Center exhibited significantly higher recall of facts when there was background music in the second half of the history lesson. The researchers suggested follow-up studies using different musical styles, tempos, and timbres. The current research employed a variety of timbres that followed their suggestion of using "soothing, ambient music" (p. 499), and chose orchestral music by Mozart, often with the timbre of stringed instruments, often in major mode. In the current research, memory skills were tapped in the learning and testing situations through usual classroom procedures.

In Bock's (2010) experiment, 36 young adults listened to different pieces of contemporary pop music that the author labeled serene, neutral, and sad music (p. 738) and used a self-assessment procedure to code arousal (by color) and valence (by pictogram faces). Bock suggested future research using self-assessment methods that are less prone to response biases. Response biases may include statements that may seek to please or impress the researcher. The current researcher incorporated the wisdom of this suggestion in the qualitative assessment of the experimental process by students through the closing questionnaire/survey, not by using color and pictogram faces to note their impressions, but by having a self-assessment survey that included multiranged responses and the opportunity for free expression.

Jäncke and Sandmann (2010) used background music in trying to assess its influence on verbal learning (p. 1). Their ultimate finding was that background music did not have a substantial nor consistent influence during verbal learning. The music effects on learning were found to be neither enhancing nor detrimental. They recommended future experiments which would use musical pieces that are familiar to the listeners (p. 11). However, the current research intentionally did not use music that was familiar to the students; again, this researcher viewed familiar music as a possible distracter. Students' attention might have been deflected through trying to keep the beat of the music, and/or humming and singing familiar themes during instruction. The researcher realized that there was a possibility that the classical music chosen for the current research might have been used as background music for other media purposes; e.g., children might have been exposed to some of the classical music used in cartoons, background music in movies, TV programs, video programs and computer games. By choosing less prominent second movements by Mozart, the researcher intended to minimize such familiarity.

Kampfe, Sedlmeier and Rendewitz (2010) reviewed 97 studies that categorized music, specifically background music, as helping or hindering primary cognitive tasks, emotions, and behavior. They found no uniform effect for background music, since many variables affected the outcome of these studies. They named variables such as the kind of music used, the type of task and the context of the task, and the personal and social characteristics of the participants being researched (pp. 140-141).

Hallam and Price (1998) found an increase in mathematical performance in 10 children, aged 9 and 10, who had emotional and behavioral difficulties, when background music was a calming influence on their behavior. Hallam, Price and Katsarou (2002) experimented with children aged 10-12, who listened to calming music, which was so defined by a group of pupils who assessed music as happy/sad, calming/exciting, and like/dislike. Those authors viewed music on a continuum, delineated by Gaston (1968), as highly stimulating and invigorating to soothing or calming (p.111). It was found that students performed statistically better on tasks in arithmetic and memory for the number of problems completed while listening to calming background music. There was not a statistical significance for accuracy rate with background music, although there was a higher percentage rate for accuracy with background music. Yet, there was a significant difference in the variance of the two sets of scores: with background music, the standard deviation was 12.7 and without background music the standard deviation was 5.57, $p=0.025$ (p. 115). The researchers discussed how some music can disrupt concentration and mood. Similar to their research, the current research used music for classroom and testing work that was considered by the researcher as calming background music, more tranquil and serene than more active music.

Pring and Walker (2004), in working with 24 psychology students, found that music with lyrics interferes with brain processes. Even to hear music that was learned in association with words was more disruptive to the listeners than just listening to purely instrumental music (p. 169).

Based on what has been learned from the aforementioned studies, the researcher decided to use classical music by Mozart for the current study. Many of the selections used the second movements from his symphonies, sonatas, quartets, quintets and other works. These selections have slower tempi and more dynamically subdued movements which could be less distracting than music with faster tempi and dynamically louder movements. Instrumental music was the music of choice for this study, not music with lyrics, since the latter could be a distracter to the students.

Realizing that the "background music-mathematics" combination seems to be the most correlated combination for significant effects in past studies, the researcher explored this combination with children in middle school, a suggested population for further research as called for in the literature. The connections made in the brain for music and mathematics relationships are noteworthy; with the younger population as subjects in the study, the new data informed this research study. A relatively longer exposure to background music during class and test time was used as opposed to shorter musical sessions. A concluding survey with self-reflection responses from the students added to the data, including their experiences during the research study and their personal preferences, as well as demographic information.

Research Questions

With the accumulated composite of previous research studies, and with this researcher's piqued interest in the academic outcomes of listening to background music, the following research questions were developed.

1) How does listening to music affect middle school students in their mathematics classes and mathematics testing environments?

2) Will female or male students score better in the music condition testing?

3) Will age and grade levels indicate differences in results?

4) Does liking classical background music being played during class time have an effect on mathematics scores?

5) Does liking classical background music being played during test time have an effect on scores?

6) Do students perform better on summative mathematics tests if they acknowledge routinely listening to music while doing homework?

7) Do students perform better on summative mathematics tests if they like singing?

8) Do students perform better on summative mathematics tests if they play musical instruments?

9) How do students self-report their levels of attention, distraction, and concentration in such an experiment?

10) What other impressions will the students offer about their experiences in being participants in this research?

The answers to these research questions were obtained by analyzing whether gain scores were higher in the music condition.

Chapter II

REVIEW OF THE LITERATURE

This literature review gives an overview of the history, theories and experiments which formed the background that led to the formation of the current research. It informs the reader about how music affects the brain and how researchers over the years have studied the effects of music's impact on the human person. The elements of gender, age, musical preferences, musical genres, and the effects of musical training are explored. Special emphasis is on the reputed Mozart Effect throughout the discussion.

Music and the Brain

To understand the implication of how music impacts the brain, one needs to understand the functions of the brain. Music listening involves several areas of the brain—all lobes, cortical and subcortical structures, the cerebellum, the amygdala, and neural processing units (Levitin & Tirovolas, 2009, p. 226). Hemispheric laterality is bilateral brain processing. Traditionally, left hemisphere functions seem primed for detail, syntax, meaning, reading, and math processes (Szirony, Bargin, & Pearson, 2008, p. 171), whereas the right hemisphere is described as holistic and more geared to visual and spatial processing. Peretz and Zatorre (2005) explained how pitch relations in music involve the right auditory cortex, and that the widespread bilateral neural network extracts musical time relations (p. 106-107). They discussed how the right hemisphere handles meter better and that the left hemisphere works at grouping (p.94). The latter would help account for the brain recognizing musical patterns, phrases, and organizational structures of musical form. The former would assist in rhythmic interpretation.

Boettcher, Hahn, and Shaw (1994) explained that the basis for higher brain functions in mathematics, music, and chess is that these categories use abstract or spatio-temporal functions. The firing pattern development occurs by groups of neurons firing over large regions of the cortex for some 10s of seconds. Spatio-temporal functions are related to ratio and proportion in mathematics and music. Advanced math is more related to spatial ability (pp. 55-57). Music patterns occur in time, with rhythm being the structure that organizes the beats, and melody and harmony building within that structure, as well.

Thompson and Andrews (2000) expressed the concept this way: there is no one music center in the brain (p. 184). They spoke of the importance of the ear having strong interconnections to the central nervous system. Music can be used to stimulate these interconnections. The quality of the sound source may affect the auditory stimulation or the neurological system. Stimulation of the senses, in this case the auditory sense, can increase cerebral blood flow and encourage growth. Yet, a person can decipher between sounds that one wants to hear and sounds that one wants to "tune out" (pp. 180-183).

Rauscher et al. (1995) suggested that cortical symmetry operations in higher brain functions are "enhanced and facilitated by music" (p. 47). Jones and Estell (2007) categorized Rauscher et al.'s work as part of the neurological theory/rationale for the Mozart Effect—that "listening to Mozart enhances the inherent cognitive functioning of the brain" (p. 219). Other researchers disputed the neurological causal relationship—that music listening affects the intellect. Instead, they suggested that if there is a causal relationship between music listening and intellectual enhancement, it is due to arousal theories (p. 223). Music arousal may evoke some kind of emotional response.

Taylor and Rowe (2012) named background music listening as "passive music intervention" (p.60). Since it had been established that music by Mozart is "most efficient in priming cross-modal brain activities" (p. 60), they used Mozart's music as background music for their mathematics assessment learning intervention. They acknowledged that their experiment did not evaluate whether or not the Mozart Effect was caused only through priming cortical firing patterns, or by helping to reduce test anxiety or by generating arousal/mood states during the testing. (p. 60).

The Musical/Math Brain in Children and Adults

A study examining 5-year-old and 9-year-old children found that boys predominantly process language and music in the left hemisphere of the brain; girls process language and music more bilaterally (Koelsch, Grossmann, et al., 2003, p. 689). These results were obtained from electroencephalograms and event-related electric brain potentials recorded during a music listening task (p. 690).

Playing a music instrument can help develop the auditory system in the brain. Meyer et al. (2011) studied children aged 7.5 to 12 years old who had several years of experience with Suzuki violin lessons. These researchers added to the literature about neural plasticity and the sustainable and enduring effect of music training on the auditory system (p. 763). The current research took into account the effects of background music listening on students who had years of music lessons.

Rauscher et al. (1997) found that music training produces long-term modifications in underlying neural circuitry areas in the brain, most likely the right prefrontal and left temporal cortical areas. These areas may not be primarily concerned with music, yet may still be affected. The magnitude of the improvement in spatial-temporal reasoning from music training was greater than one standard deviation; the increase went from the 50th percentile to above the 85th percentile on the Wechsler Preschool and Primary Scale of Intelligence-Revised test (p. 7).

It is reported by Brizendine (2006) that women have 11% more neurons in the brain than men do (pg. 5) even though both sexes have the same number of brain cells (pg. 1). She noted that when girls and boys reach their teen years, that the difference in their math and science capacity is nonexistent (pg. 7). One of the comparisons sought in the current study was based on gender.

Brain Principles and Learning

This researcher is aware of Caine and Caine's 12 brain-based principles of learning (2000) and found them applicable to the current study. Caine and Caine's earlier set of principles from 1991 were altered slightly. The page references noted below are from the 1991 work; the principles without page references are from the online copyrighted version from 2000.

Principle 1: All learning engages the physiology.

The body may experience auditory, visual, sensory, and kinesthetic processes simultaneously. Simply put, the brain is a multimodal working organism. Having students listen to background music while working on mathematics is what may be called multitasking, which the brain is tailored to do. The body may be alert, energized, relaxed, rested, tired, stressed-out, hurting. The possibilities are many. Even the basic presence of, or need for, food and water can affect one's physiological functioning and, therefore, the learning process. How students perform in school is intimately related to their body-brain interdependence. Background music listening may have contributed to a pleasurable experience or not depending on the students' body condition at the time. The assessment scores were one source of recorded outcomes of this mind-body connection on a given day.

Principle 2: The brain/mind is social.

The social nature of learning is honored by letting students interact and relate to one another and to their teachers. As members of a classroom group, the students in the research participated in a particular situation: they all listened to background music during lessons and testing time. Each class as a learning community had a social bonding opportunity due to having a similar experience. No matter how the students felt about the experience, or what the outcome scores were, they were in a social learning situation.

Principle 3: The search for meaning is innate (p. 81).

Students may inquire, "Why are we spending time learning this subject? Why are we listening to background music in mathematics class?" The search for answers is innate. The brain responds to familiar experiences; e.g., the same teacher, same classmates, same room. The brain also responds to novel experiences, which in turn are absorbed by making sense with the new knowledge obtained. Each student's brain may be acting continuously to make sense of such combinations of experiences. This research may have had novel effects for students: listening to music during classes and testing time, listening to unfamiliar music, answering a reflective survey about being in an experiment.

Each student's brain assigns meaning to the new experiences, all of which builds on the familiar experiences that have already been meaningful.

Principle 4: The search for meaning occurs through patterning (p. 81). There are patterns in music's elements: melody, rhythm, harmony, dynamics, and form. There are patterns in mathematics: mathematical equations, formulas, pictorial graphs. The brain continues to develop patterns through the educative process. The "aha" moments are ones which reveal that patterns are recognized, and are often linked to some prior knowledge. The brain may have silent "aha" moments continuously.

Principle 5: Emotions are critical to patterning (p. 82). Tolstoy's remark is cited in Bush (1995): Music is the shorthand of emotion (p. 47). The music used in the experiment consisted of patterned sound in major and minor keys which represent a plethora of emotions. Students' emotions about mathematics and music would impact any further patterning by the brain in the learning situation. These emotions would determine whether or not the student wants more or less of this music experience.

Principle 6: The brain processes parts and wholes simultaneously (p. 83). Since both hemispheres of the brain interact in almost all experiences, the brain reduces information into parts and simultaneously perceives the information holistically. A mathematics lesson consists of elements that are parts of building mathematics concepts and understandings. Background music is structured in musical forms that are parts of larger works. The combination of all these parts in mathematics and music simultaneously may form new "wholes" in classroom and testing experiences.

Principle 7: Learning involves both focused attention and peripheral perception (p. 83).

In this experiment, the mathematics lesson/test would be considered the point of focused attention and the background music would be on the periphery. Yet, if music had been the point of focused attention and the mathematics lesson/test on the periphery, then the reversal would be considered a distraction to the main matter at hand—cognitive learning. The brain is capable of both focused attention and peripheral perception. Included in peripheral items, which were not variables measured in the current study, could be classroom decorations, other classroom/school noises affecting the experimental situation, teacher expectations and attitudes, being aware of classmates' likes and dislikes.

Principle 8: Learning always involves conscious and unconscious processing. In this experiment, the main conscious activity was the mathematics lesson. Music listening was an element of unconscious processing, which underscored part of the teaching time as well as part of individual work time. Since the background music was played for a segment of the entire class time (25 minutes each day of the experiment), the remainder of the class time had a shift in focus, with perhaps more silent unconscious processing. Learning benefits from both the conscious and unconscious processing. The unconscious processing is needed to support the conscious processing, and subsequent learning may even occur days, weeks or months later.

Principle 9: There are at least two approaches to memory: Archiving isolated facts and skills or making sense of experience.

Mathematics learning may require memorization of facts; music learning may require practicing skills. Both mathematics and music take root in memory as the student engages in multiple mental systems. By combining these two modalities, comprehension may be more effective in both—there are multiple ways to remember.

Principle 10: Learning is developmental. What one learns tomorrow builds on what one learns today.

Assessment scores at the end of a unit of mathematics work reflect the cumulative learning that has taken place. The experience of combining classical music listening and mathematics may have been novel to the students at first, but the cumulative effect of exposure and repetition over a period of time (10 days of class plus a testing day) may have added to the mental alterations their brains accommodated.

Principle 11: Complex learning is enhanced by challenge and inhibited by threat associated with helplessness and/or fatigue.

The ideal learning situation as defined by Caine and Caine is one in which the mind is in a state of relaxed alertness. Low threat and high challenge operate together for a supporting and empowering classroom atmosphere. Background music could be a source of eliminating fears that come with helplessness. Testing may be a time of fear and helplessness. Students may have been less stressed since the testing situation in this experiment used a modality that they also experienced in class time. The closing student surveys revealed the students' impressions about this combination of mathematics and background music; their scores reflected their likes and dislikes according to what they preferred.

Principle 12: Each brain is uniquely organized.

Education usually takes place in group settings, unless one is an only child who is home-schooled in the context of a family. With the combination of so many different persons in a classroom, how are the unique differences catered to? In this current research, each class listened to the same preselected music. The music constituted the same input to the brains of the students, but the students' brains absorbed it uniquely. The resulting scores in the experiment would reveal commonalities in output or differences in output, depending on how each brain perceived the input.

If one looks at the variety of music that students prefer and listen to while doing homework (see Appendices J and K), one may realize that each student of the 302 students in this experiment is unique, with a plethora of interests reflected in the wide range of musical genres and artists. Even if all of that information was available to the researcher ahead of time, she could not have designed a group experience to accommodate all the uniqueness. Instead, each student's brain accommodated uniquely to the presenting music, learning situation and testing situation. Neural plasticity is the functioning factor in each person's unique brain.

Multiple Intelligences

The theory of multiple intelligences (MI) was forwarded by Howard Gardner in the early 1980s. Originally, he proposed seven intelligences exist in humanity, but over the years his theory has now included at least eight intelligences: musical, body-kinesthetic, logical-mathematical, linguistic, spatial, interpersonal, intrapersonal, and naturalist. He maintained that "except in abnormal individuals, intelligences always work in concert" (Gardner, 2008, p. 8). The current study activated at least two of these intelligences—musical and logical-mathematical. The solution process in mathematics has a nonverbal nature and the solution process is totally invisible. Spatial intelligence could also be evident in certain forms of mathematics. As seen in forerunner studies of music listening effects, spatial-temporal reasoning skills were assessed. The current research was conducted in the social setting of a classroom—thus, the interpersonal social interaction of teacher with students, and students with students helped to include the interpersonal category of multiple intelligences.

Music and Emotions

There are conscious and unconscious ways to listen to music. There are also a range of responses to hearing music. In a recent report, Holohan (2014) referred to those who show no reaction to music listening. Such persons are those who derive no pleasure and no reward from listening to music. The label for this condition is musical anhedonia, described by Satoh, Nakase, Nagata, and Tomimoto (2011) as "normal perception of elementary musical components and emotion perception coexisting with impaired capacity to respond emotionally to music" (p. 415). The literature on this topic suggested that the right hemisphere of the brain, specifically the parietal lobe, may participate in the emotional experience of listening to music (p. 415). The researchers distinguished between the emotional processing of music which may include differences in emotional perception and emotional experience. For example, one may be able to recognize beautiful music but also may not be able to be emotionally moved by it (p. 410). Perlovsky, Cabanac, Bonniot-Cabanac, and Cabanac (2013) reported from combined research studies that students who experience no emotions from music have lower grades (p. 13). Groeger (2012) reported that less than 1% of the population is truly amusical, meaning that such persons cannot distinguish between different pitches in music. This makes it more difficult to carry a tune in singing; however, poor motor control of vocal muscles may contribute to that lack of ability (p. 12).

MacDonald, Kreutz, and Mitchell (2012) reported what Schellenberg proposed: that music changes emotional states, which may in turn impact cognitive performance. The continuum seems to be: music affects feelings, which in turn influences behaviors, which in turn includes cognitive performance. Cassity, Henley, and Markley (2007) noted that performance differences may be due to improvement in mood and arousal rather than neurophysiological priming (p. 14).

Mood and arousal may be affected by stress. In several experiments, pleasant music, as it is defined and chosen by specific researchers, has been used in what can be called a stressful situation—taking tests. For example, a person taking a multiple choice test holds and evaluates contradictory cognitions and eventually breaks the tension with a decision to choose the best answer. School tests can lead to anxiety and cognitive dissonance (Perlovsky, Cabanac, Bonniot-Cabanac, & Cabanac, 2013, p. 10). Cognitive dissonance is a discomfort caused by holding conflicting cognitions. The discomfort is usually resolved by devaluing-discarding a conflicting cognition. These researchers suggested that different types of music facilitate overcoming different types of cognitive differences (p. 12).

While conducting experiments in background music and test anxiety, Stanton (1973) found that "highly anxious students achieved superior results when exposed to background music" (p. 223). The results were found to be more effective with high school and college-aged students rather than with elementary grade students in Grade 6.

They found that students at this young level had a relative lack of test anxiety at the outset (p. 226).

Mohn, Argstaller, and Wilker (2010) conducted an experiment whereby 115 undergraduate and graduate students identified 18 short, originally composed musical instrumental excerpts, 3 to 5 seconds each, according to six basic emotions. These researchers observed that happiness and sadness were more easily classified by the participants. The additional emotions of anger, disgust, surprise, and fear were sometimes mistaken for each other or other negative emotions (pp. 510-511). How students perceived the musical pieces according to emotions in the current study was not determined; however, their exposure to major and minor keys in the music may have inadvertently affected their preferences for, reactions to, and performances in the experiment.

Mohn et al. (2010) also distinguished high levels of openness and extraversion in their participants. Those with high levels of openness have a wide range of preferences in genres of music; those with high levels of extraversion prefer pop, rock, and easy listening music. Both groups prefer a high number of melodic themes (pp.504-505). The current study did not measure levels of openness and extraversion in the students; yet, these qualities may have inherently affected their assessment scores, especially if they did not have a particular affinity for Mozart's music.

Music In and Out of Schools

Several studies have researched the positive effects of studying music in schools, having music lessons, and performing music. Schellenberg and Moreno (2009) reported some evidence that music lessons affected cognitive functioning and increased full-scale intelligence quotient (IQ) assessments. The researchers tested 6-year-olds over the course of first grade. The students were randomly assigned to keyboard or vocal lessons or to control conditions of drama or no keyboard/vocal lessons. Those who had music lessons performed well in mathematical, spatial, and verbal abilities and showed larger increases in full-scale aggregate IQ measures. Results from subtests and indexes of the Wechsler Intelligence Scale for Children—Third Edition (WISC-III, Wechsler, 1991) were used for comparison outcomes. Duration of music lessons was associated positively with full-scale aggregate IQ measures (p. 210).

McDaniel (2011) compared Title I students who participated in music programs and those who did not participate in music programs. The students who participated in music programs performed dramatically higher in proficiency for a California Standards Test and a California High School Exit Exam than Title I students who did not participate in those programs. This study revealed that teachers and administrators agreed that nonproficient students struggling in mathematics should not be pulled from music education classes to attend supplemental instruction in mathematics, and nonproficient students struggling in English should not be pulled from music classes for supplemental instruction in English. (p. iv).

Southgate and Roscigno (2009) concluded that music participation and achievement have a “robust relationship” (p. 18). Their research analyzed this relationship with data from the National Educational Longitudinal Survey and the Early Childhood Longitudinal Survey (p. 5). They analyzed variables such as family structure, socioeconomic status, race, gender, music in and out of school, amount of music coursework, reading, and number of parents/siblings (pp. 15-16). When there is music involvement, there is significance for both math and reading achievement with children and adolescents (p. 18).

Hodges and O'Connell (2007) cited several researchers involved in assessing the connection between formal music education and higher academic achievement scores. Cardarelli's investigation of the effects of instrumental music instruction with inner city third-graders on standardized tests, as cited in Hodges and O'Connell, found statistically significant differences with a positive effect of the music program on students' achievement levels (p. 2.4). Hodges and O'Connell acknowledged that researchers found mixed results when they studied the effects of background music on academic achievement with school-aged children (p. 2.18). They suggested that there be more research with this population.

Statistically significant differences in neural correlates of math processing between musicians and nonmusicians were found by Schmithorst and Holland (2004). There was increased activation in the left prefrontal cortex of musicians. They studied normal adults, some of whom had years of experience in musical training. They recommended that future longitudinal studies be performed with children in order to find causal relationships between musical training and math processing (p. 195). Hallam (2010) reviewed empirical evidence concerning how children benefit by actively engaging in music and music lessons. She cited the researchers who concluded that their subjects had higher or greater mathematics gains scores when they had instrumental studies (Haley, 2001; Cheek & Smith, 1999; and Whitehead, 2001). Cheek and Smith (1999) found that eighth-grade students with two or more years of private music lessons achieved higher mathematics scores on the Iowa Tests of Basic Skills than those students who did not. Also, those who had lessons on keyboard had significantly higher mathematics scores on the same tests (p. 760).

Ivanov and Geake (2003) examined the variable of musical experience/music lessons in their research study with the upper primary school students who were tested on a paper folding task while listening to music by Mozart or Bach, or to a regular school background environment of noise. Their results revealed that musical experience did not have a statistically significant impact on the students' scores.

Costa-Giomi (1999) provided 63 children from fourth to sixth grade with individual piano lessons. They did not find any differences in cognitive abilities or academic achievement in the beginning of the study, but after two years of instruction, the experimental group who had piano lessons obtained higher spatial abilities scores in the Developing Cognitive Abilities Test compared to those who did not have lessons. After three years of instruction, the compared groups did not differ in general or specific cognitive abilities (p. 198).

The effects of long-term study of music improving academic performance were studied by Cabanac, Perlovsky, Bonniot-Cabanc, and Cabanac (2013).Their participant population was secondary school students among the top grade levels of their school. The students who chose music elective courses in their curriculum for three years had higher mean grades in all of their subjects than those students who did not have music courses (p. 258). Statistical significance was very high. The current study examined how music lessons impacted academic scores in mathematics.

Background Music

Listening to music is linked to studies determining its cognitive advantages and/or disadvantages. In a study by Angel, Polzella, and Elvers (2010), background music was found to increase the speed of spatial reasoning and the accuracy of linguistic processing (p. 1063). This experimental research involved 56 undergraduate students in psychology who performed cognitive tasks while listening to background music. Accuracy of outcome and response times were compared (p. 1061).

Music listening during mathematics testing, as researched by Taylor and Rowe (2012), resulted in higher outcome scores in mathematics. Their study was conducted with 128 undergraduate students enrolled in trigonometry classes. The silence control group and the music treatment group were evaluated and statistically compared using six tests administered throughout the chosen semester. There was a statistically significant difference for the background music which consisted of selections by Mozart. They claimed that music listening has the “potential to assist students in performing their best on mathematical assessments” (p. 60).

Some studies were not as conclusive in their findings. Furnham and Stephenson (2007) worked with children, aged 11-12 years-old, who were seventh-graders in London. Their experiment included three music conditions and a silence condition during tasks of reading comprehension, free recall, arithmetic, and verbal reasoning. The music conditions were categorized as negatively affective, positively affective, and ambiguously affective. Only instrumental music was used and was unfamiliar to the participants. No significant differences were found in the performance of the students in the four cognitive tasks. The task performance in the silent condition was not significantly different from the music condition. Therefore, it was suggested that overall, the music had limited distracting power (p. 416).

The current research used instrumental classical music, closely aligned to the classical music used in several key Mozart Effect studies. This decision by the researcher was a result of weighing the effects of multiple types of music. The background music played in the mathematics classes and during the mathematics testing followed the suggestions of experimenters who recommended longer background music listening time.

Table 1 lists an overview of studies by researchers according to year, type of music, and whether or not the research using music and/or background music had an impact or not with the subjects participating in the research studies. In a few instances, the studies had dual effects of having an impact and not having an impact.

Table 1

Music type	**Year**	**Impact**	**No impact**	**Researchers**	**Results**
Mozart	1993	*		Rauscher, Shaw and Ky	IQ scores up 8-9 points on abstract/spatial reasoning tests
Mozart	1994	*		Rauscher, Shaw and Ky	62% increase in paper folding and cutting task
Mozart	1998	*		Rideout, Dougherty, Wernert	Enhancement of spatial performance, small effects after brief music
Mozart	1999	*		Savan	Coordination, concentration, behavior improved with special needs children
Mozart	1999		*	Manthei, Kelly	No statistical significance on test scores

Mozart	2002		*	McKelvie, Low	No statistical significance on spatial task	
Mozart	2003		**	Lints, Gadbois	Did not outperform on spatial reasoning or verbal reasoning	
Mozart	2003	*	*	Gilleta, Urbancic, Elias, Saucier	Effect for women on mental rotations	No ME on PFC task
Mozart	2005		*	Sigman	No statistical increase on concentration	
Mozart	2006	*		Ivanov, Geake	Significantly higher mean in PF Task	
Mozart	2006		*	Crncec, Wilson, Prior	No improved spatio- temporal performance on PF test	
Mozart	2010	*		Angel, Polzella, Elvers	Speed of spatial processing, accuracy of linguistic processing	
Mozart	2012	*		Taylor, Rowe	Statistically significant ME	
Light classical	2010	*		Tze, Chou	Less distracting for reading comprehension task	
Hip-Hop	2010		*	Tze, Chou	More distracting for reading comprehension task	
Favorite music	2007	*		Greenop, Kahn	Accuracy improved with math for ADHD and Non-ADHD children; no main effects	
Calming music	2002	*		Hallam, Price, Katsarou	Improvement in memory tasks	
Bach	2006	*		Ivanov, Geake	Significantly higher mean in PF task	
Walt Disney	2002	*		Hallam, Price, Katsarou	Math and behavior better with background music	
Koan	1997	*		Cockerton, Moore, Norman	More questions answered correctly; stress reduction	
Pop rock, Billy Joel	1988	*		Schreiber	Significant higher mean scores, higher grades	

Easy listening	1986	*		Davidson, Powell	Improved on-task performance in science	
Pop upbeat music	1997	*	*	Furnham, Bradley	Small effect for memory test	Decreased scored for reading comprehension
Zorba's Dance-pop	2006		*	Crncec, Wilson, Prior	No improved spatio-temporal performance on PFtest	
Pop music	1999		*	Manthei, Kelly	NS test scores	
Aqua	2002		*	McKelvie, Low	No ME in spatial tasks, ns	
Folk	1973		*	Mowsesian, Heyer	No test effects: arithmetic, spelling aptitude, self-concept ability scale	
Rock	1973		*	Mowsesian, Heyer	No test effects: arithmetic, spelling aptitude, self-concept ability scale	
Classical instrumental	1973		*	Mowsesian, Heyer	No test effects: arithmetic, spelling aptitude, self-concept ability scale	
Classical vocal	1973		*	Mowsesian, Heyer	No test effects: arithmetic, spelling aptitude, self-concept ability scale	
Musical Acupuncture	2004	*		Carlson, Hoffman, Gray, Thompson	Reading scores up by one or 2 grade levels, statistically significant	
Lyrical music	2010		*	Anderson, Fuller	Reading comprehension declined significantly for ¾ of students	
Computer game soundtracks	2012	*		Fassbender, Richards, Bilgin, Thompson,	Remembered higher number of facts	

				Heiden	
Originally composed pieces	2010		*	Jäncke, Sandmann	Neither increase or decrease in verbal learning performance; no sufficient strong arousal of emotional feelings

Music and Math

Hallam (2010) summarized studies that show connections between mathematics and music. For example, Vaughn's work, as cited in Hallam (2010), specified how notation, the representation of tones in music by written or printed characters, is related to quasimathematical processes such as subdividing beats and turning rhythmic notation into sound production (p. 274). Understanding music requires understanding ratios, repeating patterns and aspects of math such as geometry and proportional reasoning (Vaughn, 2000, p. 149). The Cheek and Smith 1999 study as cited in Hallam was one that examined types of music training (private or nonprivate), length of music training, and what type of instrumental training eighth-grade students experienced and how the training was related to mathematical achievement (p. 275).

Bahna-James (1991) linked basic arithmetic skills and basic musical skills in rhythmic differentiation (p. 479). Six music theory classes (beginning, intermediate, advanced) from one high school were surveyed about their mathematics and music experiences. Cross tabulations were made based on their proficiency in various topics with mathematics and music theory. Quantitative analyses revealed:

> significant relationships between sight-singing and arithmetic, algebra, geometry, and graphing; rhythmic dictation and arithmetic, algebra, geometry, and logic; pitch and arithmetic; tonal relationships and arithmetic and algebra; key signatures and arithmetic, algebra,

> geometry, trigonometry, graphing and calculus; and chords and arithmetic, algebra, geometry, graphing and calculus. (pp. 483-484)

Cardarelli (2003) studied the effects of music instrumental training with third-grade students who had music instruction twice a week for five months. Students in the program averaged a 30 point gain in mathematics scores.

Costa-Giomi (2004) claimed that arithmetic computation performance was close to significance when Grade 4 children received three years of weekly, individual piano lessons. With further analyses, it was concluded that scores in the experimental group tended to be higher than the control group after two years, but post-hoc analyses did not indicate any statistical difference between the control and experimental groups (pp. 145-147).

Musical training may make a difference in the "neural architecture used for math processing" (Schmithorst & Holland, 2004, p. 195). These researchers used functional magnetic resonance imaging (fMRI) performed on college-educated adults who had music training since early childhood (n=7) and those who did not (n=8). The 15 male and female adults were given a task of mentally adding and subtracting fractions (p. 193). This study examined differences in the brain between musicians and nonmusicians. Mental fraction problems that included multiplication, with addition and subtraction functions, were presented. There were significant statistical differences found in neural correlates of math processing between musicians and nonmusicians in the experiment. The experimenters believed that these results could be replicated with children in a longitudinal study (p. 195).

Sixth-graders (n=31) in a London junior school were randomly allocated to a music group (A) and a nonmusic group (B) in an experiment designed by Hallam et al.

(2002). Calming background music, identified as such by a majority of pupils, was played while students in Group A worked on mathematics problems. The findings suggested that the students enhanced their speed in working on mathematics problems, but not necessarily their accuracy in completing the problems (p. 116).

An experiment including the math-music combination was conducted with 22 children with Attention Deficit Hyperactivity Disorder (ADHD) and 20 children without ADHD (Greenop & Kann, 2007, p. 330). Both groups worked on mathematical problems, alternating the music condition either first or second in the process. Each child chose his or her favorite songs for the 10-minute background music compact disc played while working on the mathematics problems. On the second day, the conditions of music/no music were applied during a mathematics test. Three scores were compared: one for the total mathematics problems solved correctly, one for the total number of problems attempted, and one for accuracy (correct score divided by number attempted). Scores within and across the groups were found to be similar (p. 337).

Manthei and Kelly (1999) indicated that people who perform well in mathematics may also perform well studying mathematics under background music conditions. This may seem to be a matter of what comes first: Did the students in the current research perform well due to their natural mathematics capabilities, or did they perform well on their school assessments because they listened to background music while doing classwork and homework? The music could be evaluated as a positive or negative influence on their scores once that was established.

Music Preferences

In experiments involving listening to music, researchers seem to choose Mozart's music (e.g., his symphonies and sonatas), classical-vocal and classical-instrumental music by other composers (e.g., Schubert and Albioni), or other genres of music (e.g., folk, rock, rock-n-roll, Jazz, bluegrass, pop, hip-hop, easy listening, etc.). Some researchers have chosen specific composers such as Abba, Billy Joel, and Yanni. Others have chosen specific songs, such as from a Disney collection of music or a performer's repertoire to use in an experiment. All forms of music have at least one of these similar musical elements: melody, harmony, rhythm, meter, form, dynamics, etc. These elements may exist alone or in combination with one another.

Several researchers mentioned the music selections used in their experiments; others do not. It is difficult to compare effects with the choice of music as a changing variable. This researcher was selectively specific in the choice and compilation of music selections used in the study. Stylistically, a decision was made to use predominantly second movements of Mozart's music, which are more akin to being background music—possibly less obtrusive and distracting in dynamic levels especially.

Other researchers have engaged their research participants by having their subjects state their musical preferences (Greenop & Kann, 2007; Hallam et al. 2002). In turn, that music was used for the experimental conditions. Jones and Estell (2007) found that "music produces different effects depending on each person's musical preferences and experiences" (p. 223). Preferences may be related to specific styles of music (Parente, 1976) or to particular volume levels in listening (Graham, Robinson, & Mulhall, 2009).

Overall levels of performance in tasks were better when participants worked in their preferred condition, as Nantais and Schellenberg (1999) discovered when they recruited 84 undergraduates in an experiment which tried to replicate the Mozart effect. The pretask activity was listening to music by Mozart or Schubert, or listening to a short story. Participants who preferred Mozart's music scored significantly higher than those in the story condition; those who preferred the story performed marginally better than those in the Mozart condition. Those who preferred Mozart's music scored marginally higher than all others across all conditions (p. 372).

Fogelson (1973) reported that the reading test scores of 14 eighth-grade students were lowered when they listened to popular instrumental music during their testing. The music recording consisted of favorite show tunes performed by the Mantovani orchestra. Yet, the students of higher ability preferred taking their test with the music playing which they thought was relaxing. Those of lower ability levels found the music distracting (p. 1266).

In an article by the education editor of *Education News* from the United Kingdom (2014), Graeme Paton quoted Susan Hallam, whose research has been noted in this study, as saying: "We know that preferences for music are affected by the extent to which individuals are exposed to them, the greater the exposure the greater the liking." Hallam continued to suggest that primary school children listen extensively to classical music in order to lead them to appreciate a wider range of music.

Effects with Children

The effects of music on concentration, performance and achievement have been researched with children and college-aged students/adults. Davidson and Powell (1986) used background music to measure the on-task-performance (OTP) of 25 fifth-grade children. Easy-listening background music was defined by the experimenters as having a melodic melody line over nondissonant chordal structures, with nonpercussive beats and traditional orchestration. This music was rich in its use of strings and woodwinds and more loosely orchestrated than pop music. The background music proved to be effective in the science classroom, but there was not a significant effect for the girls in the class due to the ceiling effect. The OTP of the girls was very high prior to the intervention (p. 32), so that posed a constraint on them achieving even higher scores.

Greenop and Kann (2007) observed extra-task stimulation (in this case, background music) on mathematics performance in 22 children with Attention Deficit Hyperactivity Disorder (ADHD) and 20 children without ADHD. The children's average age was 9.75 years. No main effects for group condition (music or silence) were found. Accuracy in complex mathematical calculation did improve in both the ADHD and non-ADHD groups (p. 330).

The effects of background music on learning amongst 10 boys, ages 11-12 who had special needs, were studied by Savan (1999). It was found that playing orchestral music by Mozart during science lessons significantly affected blood pressure, body temperature, and pulse rate in the boys. A further result was improvement in behavior and concentration span (p. 143).

Sixth-graders (n=31) in London were tested by Hallam et al. (2002) in how they performed in mathematics and memory tests with background music. It was found that background music enhanced the speed of working on math problems (p. 116) as well as remembering words in a memory task. Also, the students exhibited prosocial behavior

(p. 119). More recent studies, especially one directed by Schellenberg (2005), tested the impact of music listening with 10- and 11-year-olds. The children performed better on a spatial test after listening to pop music, rather than after listening to music by Mozart or having a scientific discussion.

McKelvie and Low (2002) worked with seventh-graders and eighth-graders (n= 103) to explore whether or not children's spatial ability was improved by listening to music by Mozart. There were 55 children (31 female, 24 male) in one experiment, which did not result in enhanced performance on a spatial subtask of an intelligence test while being exposed to the Mozart Sonata in D (K. 448); pretest and posttest scores of the children who listened to a piece of popular dance music by Aqua also had no significant effects. In the second experiment, 48 children (33 female, 15 male) listened to either music by Mozart or Aqua's *Cartoon Heroes (TNT Mix)*. Main effects of music, test, and music-by-test were not significant (p. 251). Ivanov and Geake (2003) conducted an experiment with 76 male and female students, ages 10 to 12 years, from grades 5 and 6 in Melbourne, Australia. They played Bach's Toccata in G major, as well as Mozart's Piano Sonata in D Major, K. 448, during the paper folding task which occurred in the students' natural school setting, not a laboratory. The results of their study did find a significantly higher result in students' scores when both types of music were used compared to a control class who listened to background school noise (p. 409).

Furnham and Stephenson (2007) studied seventh-graders (n=118) in England. The researchers found that different types of music affect introverts' and extroverts' performance on cognitive tasks of reading comprehension, free recall, mental arithmetic and verbal reasoning (pp. 416-417). Overall, though, compared to performance in silent conditions, there were no significant effects on cognitive performance in music conditions.

Anderson et al. (2000) worked in a program to enhance spelling word retention through the use of background music. Spelling test scores and report card grades showed positive academic growth, and student behavior improved throughout the project (p. 29).

Bangerter and Heath (2004) presented a social psychology study of the trends in association with the Mozart Effect. In 1994, more newspaper articles were written about the Mozart Effect with college students, but in 2002, more articles were being written about the Mozart Effect with children and babies. The researchers claimed that the narrow sense of listening to classical music improving performance was not scientifically tested with children to that point in time of their reporting (p. 617).

Crncec (2006) came to the conclusion through his study that the Mozart effect does not exist in childhood populations. He stated that prior music training and subjective responses to music did not affect the paper-folding scores. The participants in his study were 136 fifth-grade children, of whom 77 were involved in extracurricular music lessons (p. 312). The music condition included a group who listened to Mozart's K.448 and a group who listened to popular music, which was named as a modified recording of *Zorba's Dance*. There was also a comparison group who sat in silence (p.308).

Effects with Young Adults

College-aged students are young adults who have been subjects of music listening studies by several researchers. Smith and Morris (1977) experimented with stimulative and sedative music during testing with 30 music majors and 30 psychology majors. They categorized the music this way according to Gaston's (1951) definitions: stimulative music is happy and exciting, and sedative music is sad and calm. They found that stimulative music interfered with concentration (p. 1047). This information assisted in helping to make music selection choices for the current research in which stimulative music was considered to be a potential distraction.

College psychology students who listened to background music during examinations earned significantly higher mean scores than those who did not listen to music (Schreiber, 1988, p. 338). This researcher employed background music to use with younger students in testing situations.

In their 1993 seminal study, Rauscher et al. discovered that college students' IQ scores increased by 8 to 9 points after listening to the first movement of Mozart's Piano Sonata for Two Pianos in D major, K. 448. The scores were obtained as equivalents to the outcomes on spatial tasks in the Stanford-Binet series of tests (Hetland, 2000, p. 105). The methodology of the experiment included three listening conditions, of which all 36 students experienced. The music condition included 10 minutes of the Mozart piece; the second condition required listening to 10 minutes of relaxation instructions designed to lower blood pressure; the third condition required the students to sit in silence for 10 minutes. All of these three conditions were followed by the spatial tasks mentioned above. Means of standard age scores were then translated into spatial IQ scores. The benefits of scoring 8 to 9 points higher on the spatial IQ subtest of the Stanford-Binet Intelligence Scale only lasted 10-15 minutes after listening to the music.

Rauscher et al. (1995) replicated those initial findings in their subsequent study, and learned that repetitive music does not increase spatial temporal reasoning. This was a new finding since the later study used other music besides that of Mozart. It was determined that the brain processes music in many cortical areas, but there are large differences in how music by different composers is processed (1995, p. 46). The Mozart-listening group in the first experiment had significantly higher scores than a silence group or a relaxation tape group (1993, p. 611). The Mozart-listening group in the second experiment had statistically significant improvement from day 1 to day 2 in comparison to the silence group or the mixed music group. The Mozart group attained the highest scores on days 3 to 5 in the experiment and did not differ significantly from the silence group on those days. The mixed music group scores remained significantly below those of the other groups (p. 46).

All 79 students who participated in the study were issued 16 paper folding and cutting task assignments to perform after the listening conditions. The researchers found that listening to music "helps 'organize' the cortical firing patterns in the brain," "acts as an 'exercise' for exciting and priming the common repertoire and sequential flow of the cortical firing patterns responsible for higher brain functions," and that "cortical symmetry operations among the inherent patterns are enhanced and facilitated by music" (Rauscher et al., 1995, p. 47).

The Rauscher et al. articles, especially their seminal experiment "Music and spatial task performance" (1993), spurred much of the music-listening research then and continues until today. Their research undergirded so many studies in the 1990s and has been dubbed the Mozart Effect, the name given to the effect which resulted from their study. Eventually, more researchers continued to use Mozart's music in research with other age groups.

Don Campbell popularized and trademarked the title "The Mozart Effect" and continued to write books with that title and to produce recordings of Mozart's music for babies, newborns, children, and adults (Campbell, 2001, p. xiv; Hetland, 2000, pp. 138-139).

During the administration of a general intelligence test with 30 undergraduates, Cocherton, Moore, and Norman (1997) compared a *Koan* music group and a silence group. The researchers described Koan-created music as "ever-changing and free-flowing harmonious music, generated in real-time and not pre-composed. It is natural sounding music, which may have a stress-reduction quality" (p. 1435). Results showed a significant statistical increase in general intelligence test scores for the music condition which used Koan music, as opposed to the control group's scores in a no-music condition (p. 1435). This study supported the theories of the Rauscher, Shaw and Ky (1993) study, even though Koan music was not considered as complex as Mozart's music. The stress-reduction qualities of the music were not assessed in the Koan-music experiment (p. 1437).

Lints and Gadbois (2003) had two Mozart condition groups with 140 female students in an Introduction to Psychology course (p. 1171). Besides the Mozart Sonata K. 448, they used the first movement of Mozart's Symphony No. 40; neither produced score results in a paper folding and cutting task to support the Mozart Effect (p. 1173). Participants were randomly assigned to eight groups, which included four conditions: verbal reasoning with 20 word problems, spatial reasoning with 20 mental rotation problems, and music listening groups for the Mozart Sonata or the Mozart Symphony. The groupings were also balanced for musical preference and musical experience. The study was different from the Rauscher et al. research in that only females participated in the Lints and Gadbois study, and the participants were given expectation or no-expectation instructions before the experiment. In addition, students rated their mood before and after their tasks. Former studies showed enhanced mood ratings in music groups, but the Lints and Gadbois study did not prove the same effect. With all conditions, tasks, and results, the conclusion remained that a spatial reasoning task could be achieved "without listening to music, in general, or Mozart, in particular" (p. 1172).

Although the number of participants was substantially smaller than the Rauscher, Shaw and Ky 1993 study, Rideout, Dougherty, and Wernert (1998) replicated effects of 16 undergraduate students listening to Mozart's Sonata in D (K. 448) in spatial intelligence tests. Comparable effects occurred by listening to music by Yanni from his *Acroyali/Standing in Motion* album (p. 514). Yanni is a Greek artist whose instrumental works blend jazz, classical, soft rock and world music; some call it an eclectic fusion of ethnic sound. The music used from that particular album was chosen because it was considered similar to Mozart's piece in tempo, structure, melody, harmony, and predictability.

Szirony, Burgin and Pearson (2008) measured hemispheric laterality with 101 participants through brain hemispheric preference and self-report of musical and mathematical ability (p. 174). "A relatively strong correlation was found between music ability and right-brain hemisphere preference" (p. 169) and "the relationship between left (logical) brain hemisphere preference and mathematical ability was upheld marginally" (p. 177). The participants were male and female graduates and undergraduates (n=101).

Background music by Mozart increased the speed of spatial processing and accuracy in linguistic processing with 56 male and female undergraduates in psychology (Angel, Polzella, & Elvers, 2010, p. 1059).

Using light classical background music, hip hop music and no music, Tze and Chou (2010) found that higher intensity music is “more distracting and has a greater effect on task performance and concentration” (p. 36) for a reading comprehension task. Participants were both male and female students from the night school of a technical college in Taiwan. Their ages ranged from early 20s to mid-50s (p. 40).

A key to understanding the underlying basis for the current study is Taylor and Rowe’s study. Taylor and Rowe (2012) substantiated the Mozart Effect through a study of assessments in college trigonometry classes. A variety of Mozart’s compositions was used during the testing (p. 66). The students’ performance on mathematics assessments was statistically significant if they were in the music group (p. 60).

A closer look at the comparisons between the Taylor and Rowe (2012) study and the current study are evidenced in Table 2. The main difference in the current study was that background music was played during class time in addition to testing time. For the college-aged students, there were six tests; for the middle school students, there was only a comparison of two tests, one with background music. The students were their own control group. The seasons in which the experiments happened were different; however, for the middle school students, the experiment was confined to either the fall or the winter semester. The Taylor and Rowe study was meant to suggest a method for improving learner performance through the assessment environment; the current study was meant to explore learner performance throughout classroom experience and testing combined, with the assessment scores indicating whether or not a beneficial experience resulted. Both studies were designed to be conducted in a natural classroom setting, rather than a laboratory setting. Taylor and Rowe had suggested using a larger selection of Mozart's music, which this study did incorporate. Both studies chose a variety of music selections in order not to bore the listeners. The current study had a larger sample size of 302 students (female-179; male-123) compared to the 128 students (female-25; male-103) in the Taylor and Rowe study.

Table 2

Comparison of Taylor and Rowe Study with Current Study

Taylor and Rowe (2012) study	Current study (2013-2014)
One course: Trigonometry	Mathematics: different topics
Same homework	Different homework
Same professor	Different teachers
Same six tests	Different tests
Professor-created exams	Teacher-created tests
Same season: spring	Different seasons: fall, winter
Students permitted to move to testing center if music was a distraction—no one opted to move	Students could have opted out of study at any time (which would have affected the entire class); students rated any distractions at end of study
Background music during testing time only	Background music during class time and testing time
SAT scores compared to ensure homogeneity	Homogeneity of age/grade categories only
Mozart's music: 12 selections	Mozart's music: 43 selections
Total music playing time: 330 minutes	Total music playing time: 300 minutes
Duration of listening segments: 55 minutes during each of six tests	Duration of listening segments: 25 minutes during 10 classes 50 minutes during test (approximate)
Setting environment: Natural classroom	Setting environment: Natural classroom

Length of Listening Time

The timing of experimental conditions may be an independent variable that changes various statistical outcomes from one experiment to another. Studies throughout the years have had a wide variety of timings for experimental conditions of background music. The originators of the initial experiment—Rauscher et al. (1993)—found that those who listened to Mozart's Sonata in D (K. 448) for 10 minutes enhanced their spatial-task scores in the 10-15 minute period directly following the music listening. IQ scores of the listeners increased by 8 to 9 points over the relaxation condition or silence groups. The recommendation for future research was "to vary the listening time to optimize the enhancing effect" (p. 611). They suggested varying the listening time (1993, p. 611). Taylor and Rowe (2012) took heed of that suggestion and used 55 minutes of testing time to play a variety of Mozart selections (p. 60).

Some experiments included intervals that were as small as three minutes of background music, such as the Angel et al. (2010) study. These researchers found that background music was generally facilitating (p. 1063) and had predictable effects on cognitive performance (p. 1059). In using 10 of Mozart's sonatas, they found that there was increased speed of spatial processing and accuracy of linguistic processing. The music chosen was fast-tempo music from Mozart's selections.

Four studies used 10-minute time segments with music conditions. Furnham and Bradley (1997) experimented with 10 minutes of radio music in their study. They found little evidence that background music facilitated performance in cognitive tasks for extraverts and that it impaired performance of introverts (p. 454). They suggested, however, that if music was played for a longer period of time, that introverts would adapt and cognitive performance would improve (p. 453).

Rideout et al. (1998) discovered that 10 minutes of listening to music, whether by Mozart or Yanni, related to enhancement of spatial performance. The effects were not dramatic, but reliable in the predicted direction (p. 514). Lints and Gadbois (2003), having used Mozart's Sonata in D (K. 448), as well as Mozart's Symphony #40, found no enhanced performance in either verbal or spatial reasoning (p. 1171) after listening to either selection for 10 minutes.

Still other researchers used longer time periods for the music listening condition. In using 15-minute segments, Hallam et al. (2002) found that calming music produced a statistically significant result in the number of arithmetic problems completed by 10-year-old to12-year-old students. The speed in completion did not ensure correct answers, however. In Study 1 of their project, mood calming music included selections from Walt Disney films and other children's music (p. 114). The researchers questioned whether or not calming effects would habituate and lose their power if used regularly (p. 120).

A number of studies repeated or combined time segments. For instance, Mowsesian and Heyer (1973) used a 40-minute test period to play one side of a record two times (p. 107). No effect of scores occurred in arithmetic or spelling. Four different types of music were used—folk, rock, classical instrumental, and classical vocal (p. 107). The current researcher was able to use CDs that were tracked for the timing needed each day, so there was no mechanical handling change for the teachers to administer within the listening time period.

Similarly, Greenop and Kann (2007) found no main effect with children's personally chosen favorite songs for two 10-minute background music listening periods during mathematics assessment, according to group or condition. Yet, accuracy in complex math calculation improved (p. 338). This is an opposite result from the Hallam et al. (2002) study where accuracy did not improve.

Furnham and Stephenson (2007) used classical instrumental music in 11-minute time segments for the duration of an hour. The background music was used for four tasks, one of which was mental arithmetic. The researchers found an overall limited effect for the distracting power of music (p. 416).

Gilleta, Vrbancic, Elias, and Saucier (2003) found that the length of the listening condition, 8 minutes 24 seconds from Mozart's Sonata in D (K. 448), did not replicate the Mozart effect in a paper-folding and cutting task for men (n=26) or women (n=26) in this experiment. The Mozart effect did occur for the women, however, on the mental rotations task in the experiment. Mental rotations, which require the ability to correct for changes in the spatial orientation of an object, differ from paper-folding and cutting, which requires spatial visualization without changing orientation of the object. This distinction made by Linn and Petersen (1985) was cited by the researchers, who also stated that the women in the research were possibly more attentive and motivated compared to the men when listening to Mozart and completing the tasks (p.1090).

Some studies recounted that playing music segments occurred before and after academic tasks. Smith and Morris (1977) listed their music listening time as periods, with no specific time frames indicated except that they occurred simultaneously to the tasks at hand. They found significant main effects for the music conditions, which included five periods of music and five types of music (p. 1049). McKelvie and Low (2002) used either Mozart's Sonata in D (K. 448) or music by Aqua before testing with seventh-grade and eighth-grade students. In one experiment, they used 16-minute audiotapes, which included a verbal distracter task followed by musical stimuli. In another experiment, they used music segments which were approximately 8 ½ to 9 ½ minutes long. They found no main effects (p. 252), and claimed that "brief exposure to Mozart does not improve children's spatial-temporal reasoning" (p. 253).

Schreiber (1988) used background music—popular stereophonic rock music—during the first 20 minutes of class. The participants in the music condition earned significantly higher mean scores on their exams and higher overall grades than those in the nonmusic condition (p. 338).

Davidson and Powell (1986) compiled easy-listening background music for 30 minutes each day during fifth-grade science classes over a 4-month period (42 sessions). The on-task performance (OTP) was significant for males and for the total class—15 boys and 11 girls. The OTP for females was very high prior to the music listening, so significant changes were not evident due to the ceiling effect (p. 32). The current research was designed for 25 minutes of music during 10 days and then for a testing period—not as long as the Davidson and Powell study, but substantial nonetheless, compared to the brief music listening segments of the aforementioned studies.

Savan (1999) played music audiotapes for 40 minutes for 10 consecutive lessons (p. 141). Ten boys, average age 12 years, had special educational needs. They listened to orchestral music by Mozart. Their behavior improved in coordination, work output, completion of tasks, neatness and concentration span (p. 143). The current study did not intend to measure such categories of behavior; the researcher was aware, though, that these elements could have influenced the academic achievement of the students. The issue of concentration was addressed in the current study via the closing student survey with the students' self-reporting.

Taylor and Rowe (2012) played various music selections by Mozart for six testing sessions, 55 minutes each, in college trigonometry classes. Scores were statistically significantly different for the Mozart group, with the performance mean higher than that for the nonmusic group (p. 60).

This researcher's study included time frames similar to Davidson and Powell (1986) and for the daily exposure to background music and to Savan (1999) for the amount of days in the experiment. This researcher also incorporated the suggestion by Taylor and Rowe (2012) to incorporate music during class time, not just testing time.

Type of Music

Just as timing of music selections played may affect an experiment, the type of music played may affect an experiment. To this point in time, the overriding choice of music seemed to be Mozart's Sonata in D (K. 448), used first by Rauscher et al. (1993). They replicated their study and also used mixed Mozart selections in 1994. Scores increased for the Mozart conditions, not the other conditions, which included music by Philip Glass, an audiotaped story, and a dance trance piece (p. 46). Other experimenters who used the Mozart Sonata in D, the first movement, are Gilleta et al. (2003), who found an improvement with females performing mental rotation work (p. 1091), and Rideout et al. (2008), who found equal benefits with Mozart and Yanni music (p. 514).

Lints and Gadbois (2003) were not able to replicate the Rauscher, Shaw, and Ky study with either the Mozart Sonata for Two Pianos in D, K. 448, nor Mozart's Symphony #40, K.550. The reasons given for failure to replicate were: they did not use a silence group as a control group, the mental rotation task was more difficult than a paper-folding task, and the Mozart symphony was not an appropriate choice. In hindsight, they felt that a different comparison piece that matched the key elements of the Mozart Sonata in D—complexity and use of a single instrument—is more important than making a selection of a comparison piece rather than a Mozart-composed piece alone (p. 1173). In addition, they tested for effects of expectancy: expectancy groups, in which the participants were informed about the beneficial and/or detrimental effect of the listening process before their subsequent tasks. The groups that were told that there should be beneficial results had, on average, lower scores than the groups that were told that they should not experience improved performance. The researchers themselves expected enhanced performance scores for the beneficial expectancy groups, but they discovered that their expectations did not influence the findings (pp. 1172-1173).

In a study with 15 fifth-grade boys, ages 11-11.5 years old, Kaltsounis (1973) realized that creativity measures were higher in fluency, flexibility, and originality when they were in a music-listening condition (p. 737). The type of music was not mentioned. The comparison groups heard speech or industrial sound, or had a quiet environment. Music that was presented at the second loudest level yielded higher mean performance than quiet or speech. Kaltsounis cited previous studies which used either classical music or popular music, but he did not specify which music he used, or at what levels the music was played.

In New Zealand, McKelvie and Low (2002) compared Mozart's Sonata K. 448 and recordings from "*'Tower Music's Top Ten Singles' (30/03/00): Cartoon Heroes (TNT Mix) by Aqua*" for their seventh-grade and eighth-grade participants (p. 246). The effects were similar with both genres and they did not find that children's spatial ability improved by listening to music (p. 241). They were not able to replicate the Rauscher et al. (1993) study with either the Mozart Sonata in D, nor music by Aqua, which included repetitive dance music. Their experiments were purposely modeled on previous methodologies, those that were successful and those that were not, in trying to replicate the Mozart effect. Since Mozart's music and Aqua's music were identified as polar opposites in musical similarity, and the results from pretest to posttest scores were not significant for either music condition, a general Mozart effect was not evident. In the first experiment, grades 7 and 8 (n=55) in a New Zealand school were tested with an equivalent form of the Stanford-Binet Intelligence Scale-Fourth Edition. From pretest to posttest, children in both conditions performed similarly (p. 248). The main effect of music was not significant. A second experiment with 33 females and 15 males, again in the seventh and eighth years of school, was conducted with eight groups of students using different procedures, including a combination of relaxing, listening to music and testing. The main effect of music was not significant. As a result, McKelvie and Low (2002) postulated that brief exposure to Mozart does not improve spatial-temporal reasoning in children. In the end, the researchers felt that they did not replicate the Mozart effect in children, not due to their own techniques, but because children of this age level are still developing spatial abilities (p. 255).

Some studies used a mix of other Mozart selections—Taylor and Rowe (2012) used 12 Mozart selections and found benefits to that collection (p. 60). Savan (1999) used five different orchestral compositions by Mozart with positive effects (p. 146) as previously mentioned. Angel et al. (2010) used 10 Mozart sonatas that proved effective with these results: speed in spatial processing and accuracy of linguistic processing (p. 1063).

Even though Tze and Chou (2010) used 11 tracks from *Chill with Mozart*, comprehension scores were not significantly different with 133 students in a two-year technical college (p. 43). Tze and Chou also included *Hip Hop Best—The Collection* for one of their music conditions, which was found to be more distracting to the students than the light classical music condition in their experiments (p. 44). It did not produce a positive outcome (p. 41).

Hallam et al. (2002) chose Disney selections for one experiment, and for another they used Albioni's Adagio in G Minor and John Coltrane's "The Father, the Son and the Holy Ghost" from his *Meditations* (p. 116). Their findings were mixed—positive and negative. With the Disney music, the children had speed but not accuracy in completing mathematics problems. If the children perceived the music as arousing, unpleasant, or aggressive, their memory tasks performance was also negatively affected (p. 119).

Yanni's music *(Acroyali/Standing in Motion)* was included by Rideout et al. (1998) since they determined that this work was similar to Mozart's Sonata K. 448 in tempo, structure, melody, harmony, and predictability. It had a positive effect with students in the spatial performance of their testing (p. 513).

Koan Plus software package is natural sounding music that Cockerton et al. (1997) incorporated as background music in their experiment with positive results (p. 143). Schreiber (1988) included music by Billy Joel in what he called the pop rock music condition (p. 338) and the student participants had higher mean scores on examinations than those who were not exposed to the music.

Davidson and Powell (1986) preferred to incorporate "easy-listening" music in their experiment; however, they described what they meant by that, a melodic line with consonant chordal structures played by an orchestra, but did not list the specific selections. They, too, identified positive effects (p. 30).

Besides classical music, Smith and Morris (1977) employed four other categories of music in their conditions: country/bluegrass, jazz-blues, easy listening, rock/rock 'n' roll, (p. 1048). They claimed that music conditions have definite effects on cognitive processes, but that the five types of music that they used "did not contribute much to the understanding of the effects of music" (p. 1047). They also proposed that sedative music is better for concentration than no music at all (p. 1051).

Furnham and Bradley (1997) played upbeat, major-key music from a radio station as their "pop music" (p. 451). They found a main effect if music was on or off. Also, they learned that immediate recall of pictures was marginally lowered in the presence of music (p. 452).

The Mowsesian and Heyer study (1973) used the following four music conditions: rock, folk, classical-instrumental, and classical-vocal (p. 108). The type of music did not affect test-taking (p. 107); the music was found to not be a distracter.

Manthei and Kelly (1999) found no statistical effects in the math tests for 72 undergraduates when background music of Mozart or three pop ZZ Top recordings was played (pp. 38-42).

Godeli, Santana, Souza, and Marquetti (1996) also found no significant effect with the type of music used in an experiment with 27 Brazilian children aged 4 to 6. The music was folk music from different countries or heavy metal rock songs. They did find that the children's social interactions increased significantly between schoolmates during and after both music selections (p.1125).

Rauscher et al. (1995) experimented with 79 students in a variation of their first Mozart Effect study. The students were separated into a silence condition group, a Mozart-listening group, and a mixed group who listened to other music selections, something different every day of the five-day experiment. That group listened to different music each day—music by Philip Glass, an audiotaped story, and a dance-trance piece. The students were tested in 16 paper-folding and cutting tasks, a short-term memory test, and three subtests in spatial-reasoning of the Stanford-Binet Intelligence Scale (p. 45). From the first to the second day, the reported increases in correct items were 62%--Mozart group, 14%--silence group, and 11%--Mixed Group. The results yielded the claim that "the immediate improvement of the Mozart's group scores was due to listening to the music" (1995, p. 46).

Summation of Literature Review

The literature review was designed to lead the reader through the theories of the brain-music connection, the connections between mathematics and music, the effects of music listening with children and adults, both male and female. The debated theories of the Mozart Effect were examined. The components of many studies exposed the replicated procedures or refuted variables within several contexts. Laboratories, schools, and virtual technology hubs were the sites used for the research studies mentioned. Lengths of listening times and types of music made each study unique in its application. The bulk of the studies mentioned covered a condensed historical range from the 1970s to the present decade.

Overall, the consistency of the findings presented in this study seems to be split equilaterally, with half of the studies showing positive effects and half with no effects. That may be simplistic to state, since even within certain studies there are mixed findings. The examined variables are somewhat diverse in certain studies; e.g., Furnham and Stevenson (2007) evaluated extraversion and introversion, combined with a variety of music categorized into three types or styles, and then studied the effects of music according to four diverse tasks.

The most consistent time frame for music listening was 8-10 minutes. Seven studies listed here followed that time frame. Other studies increased in time periods incrementally from 15-20 minutes (4 studies) to 30-40 minutes (3 studies). Two studies used 55-60 minutes of listening time. Most of the studies had brief exposure to music in limited amounts of sessions. Exceptions were the Davidson and Powell (1986) study with a 30-minute time segment for 42 sessions, the Savan (1999) study with a 40-minute segment for 10 sessions, and the 55-minute segment of Taylor and Rowe's study (2012) for six sessions.

Most of the studies with music effects on children were conducted with fifth to eighth graders. The phenomenon of mixed results continued. There were an equal amount of positive effects and no effects in the studies examined here. A majority of young adult studies fared better with positive effects in music listening. Undergraduates were the population of choice for these studies, and often the studies included more particular variables that were evaluated: Smith and Morris (1977) compared psychology and music majors; Lints and Gadbois (2003) studied all females; Taylor and Rowe (2012) paralleled trigonometry classes. As years progressed, more studies with children were conducted from the year 2000 on; young adult studies increased from the 1990s on.

In regard to the type of music used, Mozart's music was the basis or fulcrum for a majority of studies, but researchers through the years have expanded their studies to include a wide variety of music. Table 1 gave examples of that variety. It seemed more likely to effectively compare the results of background music with a certain composer, and in this case, Mozart. Unless researchers try to duplicate the effects of the other specific music used in former studies (folk, pop, Walt Disney, easy listening, Aqua, Koan, rock, classical instrumental, classical vocal, computer sound tracks, originally composed music, etc.), they cannot substantiate the aforementioned effects accurately. Still, it is important to continue to experiment with various genres of music to determine whether or not more valuable data can be added to the Mozart Effect literature. Additionally, it is crucial to delve deeper into the research processes which will advance understanding in this field.

Chapter III

RESEARCH METHOD

Participants

The participants were middle school students, female and male, who attend grades 6, 7, and 8 in several private middle schools in an Eastern seaboard metropolitan area. A sample of 302 students from eight schools participated in the research. Twenty-three classes from the eight schools ranged in size from three to 23 students. Some schools had multiple classes involved in the research; others had one or two classes. The students were aged 11 to 14. This quasiexperiment occurred during mathematics class time and mathematics assessment time. After the experimental period, a student survey was administered to analyze students' demographic information and other qualitative responses.

Approvals

The researcher obtained approval for the research through the Notre Dame of Maryland University's Institutional Review Board (see Appendix A).

Initially, 64 schools were identified from lists of private and/or independent schools in the participating area. An invitatory letter to the principals/heads-of-school described the research (see Appendix B). Along with that letter were sent additional forms: the Letter/Consent Form for Teachers (see Appendix C), the Teacher Instruction Form (see Appendix D), the Parental Consent Form (see Appendix E), the Student Assent

Form (see Appendix F), the Student Questionnaire Survey Form at conclusion of study (see Appendix G), and a preliminary viewing list of typical music selections that would be used in the experiment. The final form of the preliminary music selection list was constructed to be a listening guide for the teachers and was distributed to them prior to the experiment (see Appendix H). In a more concise form, the 12 CDs from which the music was derived, is listed here (see Appendix I). The letters to the principals/heads-of-school were sent in the late spring, near the end of one academic year. The researcher indicated that the research would take place in the fall of the upcoming academic year. In late summer, follow-up phone calls to these school leaders revealed that some did not receive the hard copies of the invitatory letter and packet of forms sent through the mail, or they did not remember receiving the materials during the previous spring semester, in the midst of all the end-of-year activities. Subsequently, letters and forms were re-sent, mostly electronically, at the school leaders' requests. Of the invited schools, 43% requested a re-sending of the packet of materials. The researcher made 254 contacts via phone calls or e-mails to obtain a response from the school administrators. That was an average of 4 points of contact per school. Some schools responded with only one contact; others had up to 10 points of contact.

When approval for the research was obtained at the administrative level, then the teachers in the respective schools from grades 6, 7, and 8 were invited by their respective administrators to participate in the study. Although several teachers expressed a willingness to participate in the project, the next step in the process was to receive 100% parental permission and 100% student assent to participate in the research. If that complete percentage of approval was not received, a requirement stipulated by the

Institutional Review Board, the experiment could not take place in that particular class or school. The parents initially received the permission form, along with the student assent form, and the concluding student survey form, in order to make an informed decision about their children's participation. They were asked not to share the concluding student survey form with their children, since it was to be administered at the end of the project. It was given to the parents at the outset, so that they would know what the researcher was seeking in terms of information about demographics, about their children's personal musical experience, and preferential reactions by the students at the conclusion of the research project. Thus, the pool of potential participants narrowed significantly as individual school leaders declined to participate; then in schools where the leader granted permission, individual teachers opted not to participate; and then in schools where both the leaders and teachers granted permission, individual parents and/or students chose not to participate in the study. Ultimately, nine teachers in eight schools confirmed their participation in the research, since their particular classes received 100% parental permission and 100% student assent to proceed, as mandated by NDMU's Institutional Review Board. There could have been a possibility of nine more teachers participating in the study, but those nine teachers did not have full parental permission as indicated. Three additional teachers wanted to participate, but due to scheduling problems in their school, they could not match the research design.

Thirty-four schools (53%) of the invited schools offered reasons for not participating in the research. Administrators or teachers gave one to seven reasons for not participating in the research. The reasons mentioned are not listed in any particular order or sequence, but include the following: difficulty in implementing the research project, too much going on in the school, new mathematics teachers, new mathematics curriculum, lack of parental permission, trying to implement a strategic plan, Common Core standards to be met, curriculum planning issues, not in favor of doing research in the school, math program scattered among different buildings, timing of class periods, drop in enrollment, in a full transition period, being a single-track school, other research projects going on in the school, hesitancy due to student experiences of background music listening from a former school, Saxon math, having a dual-language program, concern about liability, depletion of staff, construction projects, new mathematics text books, re-evaluating course load and scheduling, having new first-time teachers, having many research programs occurring in the school already, re-accreditation involvement, many shifts in math focus, not liking the combination research of mathematics and music for the current study, preferring alums to conduct research in the school, personal reasons of not being able to review the materials and current project, teachers who were asked were not willing to participate, post-accreditation year activities, and scheduling issues.

A few administrators claimed that it was not a good year to implement the current study; however, they wanted to support the project and offered to be considered for future research. One comment was: “We would do it next year 150%!”

Several administrators and teachers wanted to meet with the researcher for further clarification of the research process before it began. The researcher met with all of the participating teachers in their respective schools and distributed the music playlists to them during those meeting times (see Appendix H). The teachers also received a composite copy of the Compact Disc (CD) covers from whence the music was derived.

The teachers asked the researcher any questions that they had before beginning the project.

Materials

The music selected for this study was classical music by Wolfgang Amadeus Mozart. The CDs for the listening condition were provided by the researcher. The researcher compiled five CDs that were contained in color-coded sleeves for easy identification and numbered one through five. The pages listing the music selections were also color-coded, with specific instructions as to what CD, and what tracks of the CD, to play each day of the experiment. Each teacher decided which CD would be used for the testing period at the end of the music section of the project.

Since the researcher was sensitive to volume and tempi suitable for background music, she purposely chose all second movements of the selected Mozart repertoire. Except for two pieces (March of the Priests from *Die Zauberflöte*, and Romance from *Eine Kleine Nachtmusik*), all of the music was listed in these tempi: andante, andantino, adagio, andante grazioso, larghetto, poco adagio, andante con moto, adagio non troppo, andante cantabile, andante sostenuto. The Mozart pieces selected were instrumental music compositions that were identified in these forms: symphony, sonata, quartet, quintet, concerto, serenade, theme and variations, fantasia, march and divertimento.

The construction of each 25-minute segment, with two segments on each CD, was carefully compiled by the researcher to balance musical instrumentation, key progression from piece to piece, tone color, and timing. The only piece that was not in its original instrumentation was Mozart's Andante from *Fantasia for Mechanical Organ in F minor*; a recorded piano transcription performance was used instead.

Teachers used a CD player or a computer-generated sound system in their particular classrooms. The volume level of the background music was regulated to be conducive to a teaching/learning atmosphere. As indicated in the Teacher Instruction Form (see Appendix D), music was played at a typical background music level. For the control group, or no-music condition, no music was played during lessons for the extent of the no-music condition; and no music was played during the mathematics test time at the end of the unit of teaching.

The mathematics scores were collected from teacher-created assessments administered by the teachers in the classroom setting. The test administered was not a uniform test across classes or schools, nor a state/national mathematics assessment test. It was a teacher-developed test for a particular class and it followed the regular content regimen for the class curriculum. For the experimental group with a music condition, background music was played during class periods for a unit of mathematics work, and then during the time when the mathematics test was given at the end of that unit of teaching. Scores from the nonmusic classes and testing condition, and scores from the last test before the experiment began, were used for comparison purposes and included in the statistical analyses.

Besides the scores used in comparative analyses, demographic and qualitative information was obtained through the completed student questionnaires/surveys obtained at the conclusion of the research period (see Appendix G).

Procedures

Teachers played classical background music for 25 minutes for a period of 10 days during a mathematics unit of work. The music selections were played during 12-13 minutes of instructional time and 12-13 minutes of class work time each day of the music condition. At the end of the unit work, teachers played classical background music throughout the mathematics assessment test. Each CD was designed to play music for at least 50 minutes; thus, each CD could be played over the course of two days of class time, and stopped as needed according to the time frames listed by tracks (see Appendix H). The testing time was most likely longer than 25 minutes, so one entire CD's playing time was sufficient for the duration of the test.

If a class experienced the music condition first, then the no-music condition followed—again, a comparable class instructional time of 10 days and ending with a mathematical assessment time, all with no background music playing.

Table 3

Experimental design for two sample classes

Group	Condition I	Condition II
Group A	Background music	No background music
Group B	No background music	Background music

This research protocol was created for within-subjects design, "where participants provide both control and experimental scores" (McKelvie & Low, 2002, p. 249), between-subjects design, within-groups design, and between-groups design. Mathematics scores from both conditions were compared and analyzed. The last math test score previous to the experiments was used as a pre-test measure. In total, three test scores were compared and analyzed.

Table 4

Research Design Sequence for Two Sample Classes

Group	Condition
Group A	a. Secure most recent unit test score (1) b. Provide music treatment during next unit (2) c. Secure test score for music-treatment unit (2) d. Provide no music treatment for next unit and unit test (3) e. Secure test score for no-music-treatment unit (3)
Group B	a. Secure most recent unit test score (1) b. Provide no music treatment for next unit and unit test (2) c. Secure test score for no-music treatment unit (2) d. Provide music treatment during next unit (3) e. Secure test score for music treatment unit (3)

Students were able to give their feedback and perceptions to the chosen music and provide reactions to the research at the conclusion of the study, using scaled responses and open-ended statements, which were a source of qualitative information. The questionnaire/survey form requested demographic information, including age, gender, grade level, whether or not the student listens to music while doing homework, music listening preferences of the student, and prior or current musical experience with singing and playing instruments. The students self-reported on whether or not they felt more attentive, more distracted, and able to concentrate more or not as well during the music listening component of the experiment. They also had the option to choose this statement: "The background music didn't make much of a difference to me." Students were able to voice their opinion about whether or not they liked or disliked the background music during the experimental period. This information was gleaned at the end of the study so that any expectations for music listening effects were not revealed to the students at the outset of the study.

The scores collected from the students, their surveys, and the permission forms from students and teachers were kept in a secure space. In the SPSS files, students were only referred to by code numbers to maintain their anonymity.

Analyses

The study provided descriptive statistics for the test scores for the control and experimental groups. ANCOVA, analysis of co-variance, was conducted using SPSS to determine whether the test scores in mathematics were significantly different among students learning and taking tests under the two different classroom environments, with background music and without background music after adjusting or controlling for the pre-test measures. The pretest measure was the last math test score before the music listening experimental period began. The key independent variable was the music/no music condition. The null hypothesis (H_0) was that background music listening will have no significant effect on the math scores after controlling the pretest measures. The alternative hypothesis (H_1) was that background music listening will have a significant effect on the math test scores after controlling for the pre-test measures. The other independent variable examined in ANCOVA was gender, which was used to examine the male-female test performance in the music or nonmusic conditions.

Discussion

The quasiexperimental design analyzed the effects of background music listening during mathematics classes and mathematics tests with middle school children. It adds to the literature about the Mozart Effect for this age group, including gender/age/grade differences in achievement, type of background music used, and qualitative information about and from the students to assist in understanding the results. Notice that the background music was not isolated as a separate listening period before the mathematics tasks at hand; it was simultaneous to the classroom and testing activities that the students experienced. This diverges from the early Rauscher et al. studies from the 1990s and from all those who tried to directly replicate the effects of those studies with music listening as a concentrated pre-activity or session before assessments. The current research did follow the suggestion of Taylor and Rowe (2012) by having background music playing during class time and assessment time.

Chapter IV

RESULTS AND ANALYSIS

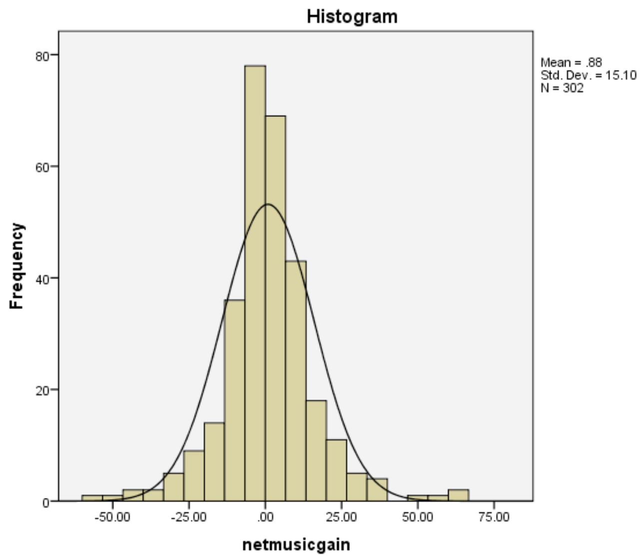
This results chapter will organize the findings of the current research according to the research questions posed at the beginning of the study. The categories to be addressed will be overall effects of background music according to assessment scores obtained during music and nonmusic conditions, differences in scores of females and males, differences in scores according to age/grade levels, differences in scores between liking or not liking background music during class and testing times. Additional research findings that emanate from the closing student questionnaire/survey administered at the conclusion of the study will also be presented. These topics will be explored: whether or not students listened to background music while doing homework, what genre/musical artists they listened to (see Appendices J and K), whether they liked singing or not, whether they played musical instruments or not, and how many instruments they played.

Students' self-reporting on attention, distraction, and concentration provided additional information to the study. The last question on the survey was an open-ended one. The student subjects had the option to answer it or not. They were asked to reflect on the experimental process as they experienced it: "What else would you like to tell the researcher about how you experienced this experiment?" Those who responded (71.5%) contributed a wealth of information for the researcher (see Appendix L).

Overall Effect

The Mozart Effect has been scrutinized as to its claims for increasing intelligence scores. Many researchers have tried to replicate the positive results in many ways. Cassity et al. (2007) noted that many of these experiments are conducted in lab settings and the benchmark tasks performed are outside the scope of everyday activities in spatial reasoning (p. 14). They claimed that in real world situations, the Mozart Effect disappears (p. 16). The current research was conducted in various schools and classrooms, with a variety of teachers and students using background music during the scope of everyday mathematics classes and testing situations. This researcher found the overall gain from premusic testing to postmusic testing was positive, but less than 1 point ($M=0.88$, $sd=15.10$) The 0.88 point gain was statistically insignificant ($t=1.02$, $df=301$, ns). This researcher cannot claim that a true Mozart Effect occurred due to these findings. Figure 1 shows the net gain in points from the nonmusic to the music condition for the participants. Figure 1 shows most participants clustered close to a zero gain in net points meaning that students scored similarly in the nonmusic and music conditions. Figure 1 also shows that some students increased their number of points by more than 50 in the music condition and a few students lost more than 50 points in the music condition, when compared to the nonmusic condition. Fifty-one percent of the students had increased scores in the music condition, 47% had lower scores in the music condition, and 2% had scores that remained the same in the music condition; this statement cannot easily be figured out by looking at Figure 1.

Figure 1. Net Music Gain



Gender Differences

Brizendine (2006) indicated that girls' brains develop two years earlier than boys' brains as they enter puberty. Several other studies mentioned the main results of childhood subjects in their experiments without specific regard to analyzing gender. Occasionally, certain studies report an independent variable of childhood gender. McKelvie and Low (2002) found no main effect of the music condition with regard to that variable. This research examined the gender differences in mean scores of mathematics assessments.

As indicated in the research questions and methodology of this current research, in order to examine the difference between male and female student gains, an independent t-test was conducted. The results indicated that female participants had a gain of 3.9 points (sd= 15.9) in mathematics scores pretest to posttest, whereas male participants had a loss of 3.6 points on mathematics scores pretest to posttest (sd= 12.6).

The effect was statistically significant and the effect size was moderate (*t*= 4.57, df= 293.7, $p<.001$, Cohen's d= .51). In addition, the t-test results showed that female participants had better overall scores in the postmusic assessment scores compared to males. A statistical significant difference in the scores was identified between the females and males at the $p < .001$ level. The mean score in net music gain for males was -3.57, whereas the mean score in net music gain for females was 3.9, with the mean difference being -7.52.

Grade Differences

This researcher's literature review of music studies included studies of children whose ages were listed or whose grades were listed. McKelvie and Low (2002) noted that intermediate school-aged children would be an ideal group for testing the Mozart effect since prominent associations between musical cognition and special ability occurs at the ages of 10 and 11 (p. 245). In most school systems of the United States of America, these children are typically in grades 6 and 7. In order to expand the pool of subjects, grade 8 students were included in the current research. Grades 6, 7, and 8 are often labeled middle school grades, so the researcher formed the study as a middle school project.

From the results of the analysis of variance (ANOVA) among grade levels in this research, a statistically significant difference was found when comparing net music gain by grade levels. Specifically, sixth-grade students had higher gains in pretest to posttest assessment scores compared to seventh-graders and eighth-graders, as shown in Table 5.

Table 5

Net Music Gain According to Grade Level

Grade	Frequency	Mean	Std. Deviation
6	108	7.23	18.29
7	62	-3.14	13.42
8	132	-2.41	10.71

Table 6 shows the HSD in the Tukey post hoc test of these grades.

Table 6

Tukey Post Hoc Test Results According to Grade Level

	Grade Level		
	6	7	8
Grade 6	--	7.78 (p<.001)	.93 (p<.001)

There was a difference of 10 points between grades 6 and 7 (SD= 2.45, p<.01 and a difference of 9.6 points between grades 6 and 8 (sd=1.99, p< .01). These differences were statistically significant at the p<.01 level; however, there was no statistical significance between grades 7 and 8.

When gender and grade were combined to analyze net music gain/loss, the females in the sixth grade had higher scores than females and males in the other levels, as reported in Table 7. Females in grade 6 had a mean increase of 10.91 points.

Table 7

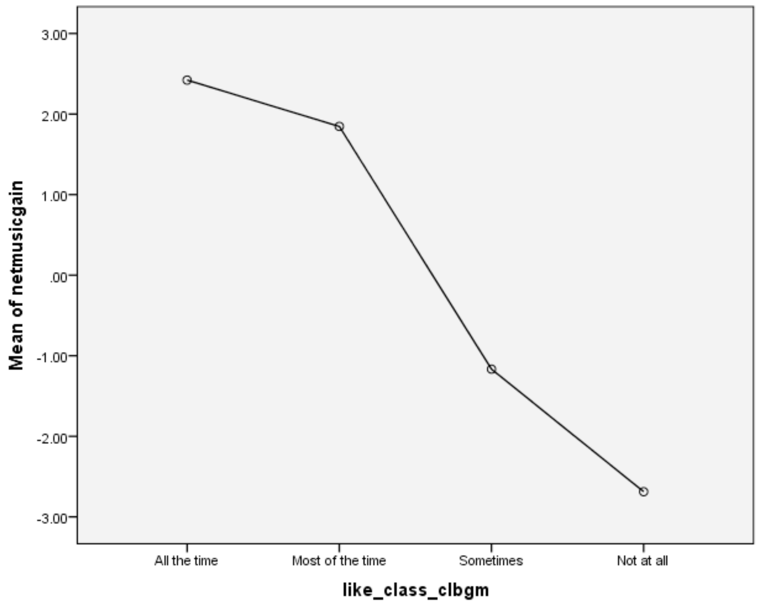
Means and Standard Deviations for Gender and Grade Combined

		Gender		Total Grade Level
		Male	Female	
Grade	N	M (SD)	M (SD)	M (SD)
6	108	-2.79 (13.31)	10.91 (18.55)	7.23 (18.29)
7	62	-3.56 (13.46)	-2.43 (13.61)	-3.14 (13.42)
8	132	-4.00 (11.84)	-1.28 (9.74)	-2.41 (10.71)
Total gain				.88 (15.09)

Liking and Disliking Background Music During Class Time

The survey administered to the students gave the students an opportunity to let the researcher know whether or not they liked background music during their class time. By examining the responses, it was learned that 83 students out of 302 students (27.8%) liked the Mozart music playing during class "all the time." One-hundred-and-ten students from the group of 302 students (36.85%) liked music playing "most of the time" during classes. Ninety students, roughly one-third of the group of the total population (30.1%), liked it "sometimes." Sixteen students (5.4%) did not like having background music played at all during class time. Figure 2 shows the mean of the net music gains and losses in the assessment scores. If students liked background music all of the time during their classes, they had a gain of 2.4 points. If they liked it most of the time, they had a gain of 1.8 points. If they liked it sometimes, they had a loss of 1.1 points. If they did not like it at all, their loss was 2.6 points. These results point to the correlation with the emotional connection to the music: the more the students liked it, the better they did; the less they liked the music, the poorer their results.

Figure 2. Net Music Gain and Liking Class Music



Liking and Disliking Music During Test Time

The results from the students' perceptions of liking background music during testing time included 36.5% of them liking music during their test time. Seventy-two, or 24.1% of them liked the background music during test time most of the time. Sixty students (20.1%) would have preferred the background music playing only part of the test time and 57 students (19.1%) did not like the music at all during testing time. See Table 8 for the comparison of net music gain in the testing scores. Please note that 299 responded to the class time category; 298 students responded to the test time category. The data reveal that when students did not like the music during class time or test time, their mean gain score dropped, and if students liked the music during class time or test time, their mean scores increased. The results were not statistically significant as can be viewed in Table 8. Later in the survey, students provided additional responses concerning attention, distraction, and concentration. These results will be reported toward the end of the results section. Figure 3 indicates students' gain scores compared to their liking/nonliking frequencies of music during their test time.

Figure 3. Net Music Gain and Liking Test Music

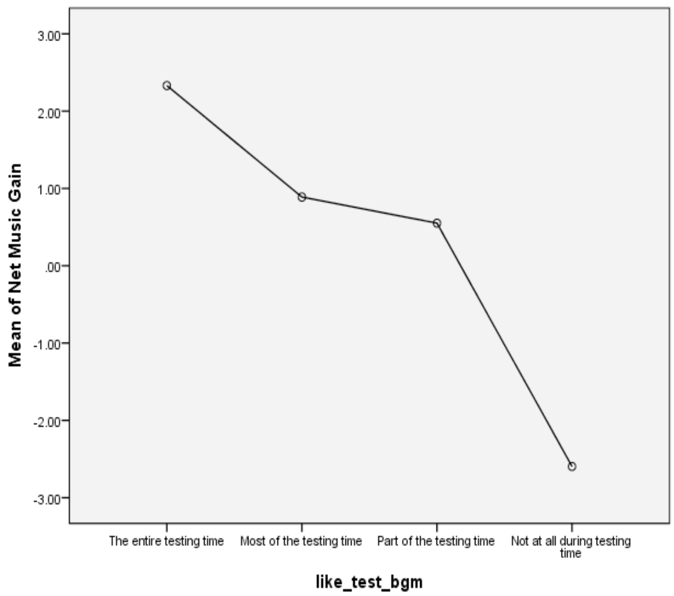


Table 8

Degrees of Liking/Not-Liking Music During Class Time and Test Time

	Class time			Test time		
Liking music	N	%	Net music gain	N	%	Net music gain
All the time	83	27.8	2.4	109	36.5	2.3
Most of the time	110	36.8	1.8	72	24.1	.9
Some of the time	90	30.1	-1.2	60	20.1	.6
Not at all	16	5.4	-2.7	57	19.1	-2.6

Listening to Music While Doing Homework

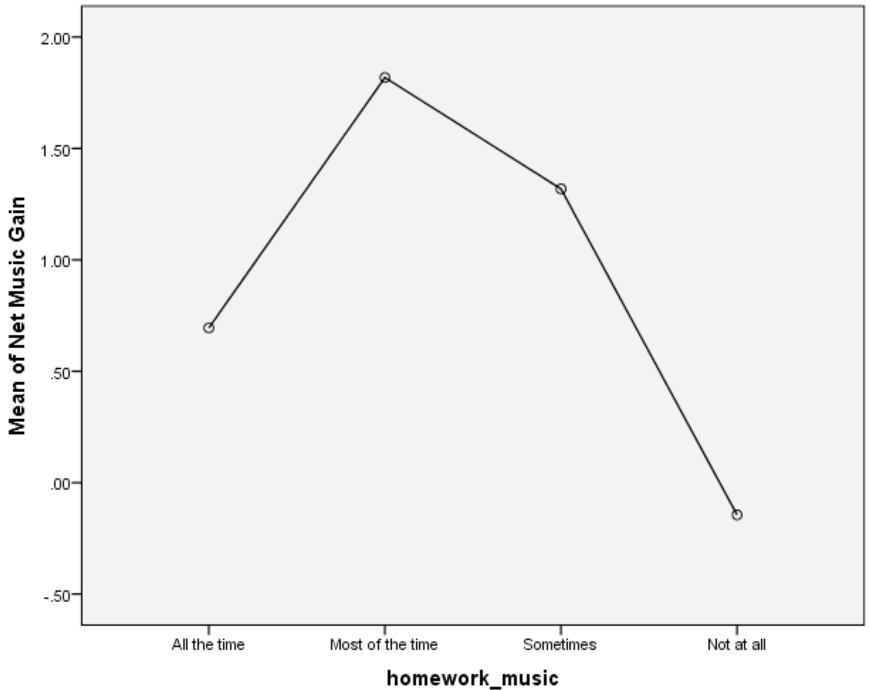
In the closing student questionnaire/survey, students were asked to inform the researcher about their habits of listening to music or not while they did homework. Their usual practices at home may have had an influence on the classroom-related research study. As can be seen in Table 9, and the following graph in Figure 4, students who listened to music all the time when doing homework did not perform on their assessment scores in the research study as well as students who listened to music most of the time when doing homework. Even those who listened sometimes to music while doing homework did better than those who listened all the time. Those who did not listen to music at all while doing homework performed the lowest of any other category in terms of the net music gain in the research assessments. The results were not statistically significant.

Table 9

Listening to Music While Doing Homework

			Net music gain	
Homework music	N	%	Mean	SD
All the time	36	12.0	.7	11.95
Most of the time	60	20.0	1.8	17.89
Sometimes	113	37.8	1.3	14.32
Not at all	90	30.1	-.1	15.49

Figure 4. Net Music Gain with Homework Music Effects



Liking and Not Liking Singing

As indicated in the literature review, there have been several studies which attribute academic gains for students who have had instrumental lessons. This study included student feedback concerning attitudes toward singing as possibly impacting academic gains. The closing questionnaire/survey included self-reporting on liking and not liking singing. For those who liked singing, the mean of the net music gain in summative scores from the music condition testing is 2.92. For those who did not like singing, the mean is -1.99. Table 10 lists the descriptive statistics of the two groups. Even though the current research did not use music with lyrics, the instrumental music may have seemed lyrical. Violins can produce sounds similar to vocal music; thus, the connection may have had a correlation in the minds of the student listeners.

Table 10

Net Music Gain for Liking/Not Liking Singing

Singing	N	Net music gain	SD
Liked singing	177	2.92	1.74
Did not like singing	125	-1.99	1.72

Note. There was a statistically significant difference between these two groups (*t*= -2.82, df=300, p< .01, Cohen's d=.33).

The researcher took note of how many students had singing lessons and what effects this may have had on their assessment scores. Ninety-three percent of students (n=281) did not have singing lessons. Of the 7% (n=21) who did have singing lessons, one student had lessons for five years, three students had lessons for four years, two students had lessons for three years, five students had lessons for two years, two students had lessons for one year, three students had lessons for less than a year, and five students who had singing lessons did not indicate how many years of lessons that they had. For comparisons in net gain scores between those who had singing lessons and those who did not, please see Table 11.

Table 11

Net Gain Scores of Those Who Did or Did Not Have Singing Lessons

Lessons	N	%	M	SD
Singing lessons	21	7.0	12.85	17.38
No singing lessons	281	93.0	-.01	14.55

Note. There was a small effect size for those who did have singing lessons (t=3.85, p<.01, d= .26).

Playing Instruments

Several studies as noted in the literature showed academic gains when students were enrolled in instrumental lessons either within the school setting or as an extra-curricular activity (Cheek & Smith, 1999; Southgate & Roscigno, 2009; and Hallam, 2010). One of the reasons that instrumental lessons benefit students is that music involvement improves spatial reasoning, which is related to skills needed in mathematics (Hallam, 2010, p. 281). The methodology for this current study included an opportunity for students to indicate their musical background through the concluding survey. The instruments that the students played are indicated in Table 12. They are listed in traditional orchestral designations of instrumental families: woodwinds, brass, percussion, strings. Guitars are stringed instruments which are acoustic or electrically amplified. Flutophones are similar to recorders; they may be the preferred precursor instrument to be played before one learns how to play the recorder. A ukulele is a smaller guitar-like instrument. The ocarina is a small handheld wind instrument with a mouthpiece and finger holes. The piano is harp-like with its string component, but it is percussive since felt-covered hammers strike the metal strings via a person who plays the keyboard that operates the hammers.

If students played three or more instruments, the instruments most frequently played were: clarinet, recorder, flutophone, guitar, trombone, trumpet, and piano. If students played two instruments, the choices were: bass clarinet, saxophone, ukulele, cello, violin, tuba, drums, and xylophone. If students played only one instrument, the choices were: flute, tenor sax, string bass, bass guitar, electric guitar, snare drum, and ocarina.

Table 12

Instruments Played by Students

Woodwinds	**Brass**	**Percussion**	**Strings**	**Guitar**
Flute	Trumpet	Percussion	Violin	Guitar
Clarinet	Trombone	Drums	Cello	Bass guitar
Bass Clarinet	Tuba	Snare Drums	String Bass	Electric guitar
Saxophone		Xylophone		
Tenor Sax		Handbells		
Recorder				
Other				
Flutophone				
Ukulele				
Ocarina				
Piano				

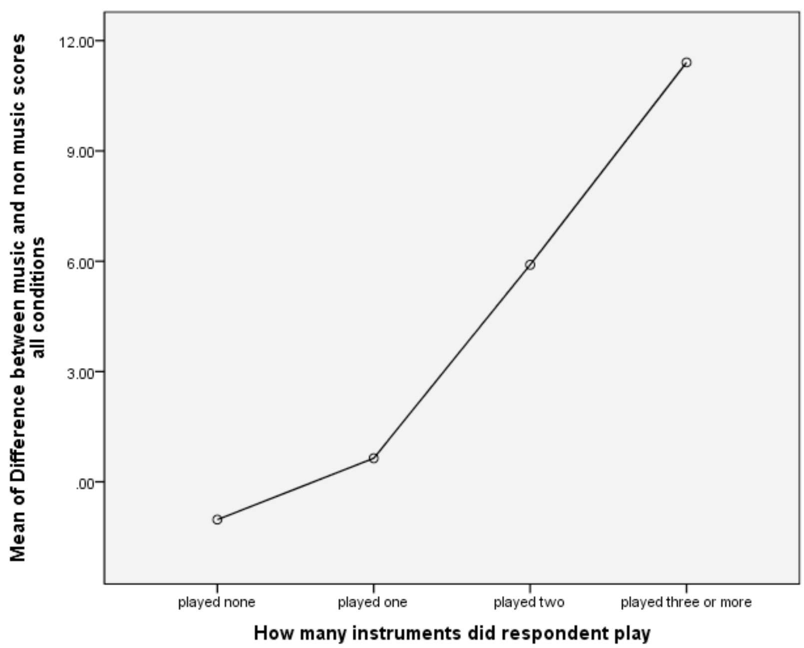
When examining the relationship between whether playing an instrument and the number of instruments played affects the score of net music gain, the results of analysis of variance (ANOVA) suggest the differences among and between each comparison group (see Table 12). (Group A—36 % no instrumental playing; Group B—38 % played one instrument; Group C—17% played two instruments; Group D— 9% played three or more instruments.) There was a statistically significant difference between playing no instruments and playing three or more ($F= 7.28$, $p < -.001$). The means and standard deviations are shown in Table 13, and Figure 5 is a visual representation of the information.

Table 13

Net Music Gain According to Number of Instruments Played

Number of instruments	N	M	SD
No instruments (Group A)	109	-1.02	15.31
One instrument (Group B)	114	.64	12.32
Two instruments (Group C)	52	5.90	12.98
Three or more instruments (Group D)	27	11.40	18.39

Figure 5. Net Music Gain and Number of Instruments Played



Of the 193 students who played an instrument, the mean of their assessment scores increased 2.6 points (sd=14.36); of the 109 students who did not play any instrument, the mean of their assessment scores decreased by -2.15 (sd=15.93). See Table 14 for the number of years students played one or more instruments. In general, it was also revealed in the data that the longer the students played an instrument, the mean scores declined slightly. The correlation was -.12 (ns).

Table 14

Years of Playing Instruments

Cumulative years of playing instruments	Number of students (n=193)
1 year or less	48
2 years	42
3 years	48
4 years	20
5 years	18
6 years	10
7 years	4
8 years	3

Music Attention and Inattention

In the closing survey, students were able to self-report on their levels of attention, distraction, and concentration. Data show that if students felt more attentive during the experiment (as expected), their gain scores were higher (n=60, m=4.03, sd=13.93). Students who felt that they were not more attentive during the experiment had lower gain scores (n=242, m=.10, sd=15.30). Differences were statistically insignificant. An independent sample difference of means test showed differences were statistically insignificant (t= 1.81, df=301, p<.05, Cohen's d= .26). There was only a small effect size.

Data suggest that there were a greater percentage of students (61%) who felt that they did not concentrate more during the music condition. A smaller number of students (37%) felt that they were able to concentrate more during the music condition (n=113, m=2.94, sd=16.8). The test for the differential net gain in music scores was not significant between these two groups (*t*= -1.78, df=298, ns).

Those students who felt that they concentrated as well during the music condition numbered 85% (n=257). Those students who felt that they did not concentrate as well during the music condition numbered 15% (n=45). The statistical difference in net music gain was not significant (*t*=.48, df=300, ns).

For the 173 students (57%) who felt that the background music made a difference, the mean of the net music gain was lower *(t* = -1.62, m= -.33, sd=15.84, ns). One-hundred-twenty-nine students (43%) reported that "The background music didn't make much of a difference to me." The mean of this group's net music gain was higher at 2.51 with a standard deviation of 13.93. An independent *t*-test showed a small effect size, not statistically significant.

Qualitative Responses to Questionnaire/Survey Question #10

The results of the previous questions in the survey already indicated whether or not the students liked or disliked listening to music during their class and testing times. The fact that students added to their impressions in text form served to complement the checked statements in the survey.

Nearly 72% (n= 216, 71.5%) of all the students (n=302) responded to the open-ended question, the last item on the survey administered at the conclusion of the study: "What else would you like to tell the researcher about how you experienced this experiment?" The researcher was able to analyze qualitative thematic material from the students' comments. It was helpful to the researcher to learn through their comments how the students reacted to the experiment while they were experiencing it. Their quotes are grouped into prominent themes. See Table 15.

Table 15

Themes of Open-Ended Question #10

N	Valid	216
	Missing	86

Theme	Frequency	Percent of Valid N
Calm, relaxed, soothing	33	15
Genre, type of music	24	11
Blocked out, ignored	20	9
Fun	13	6
Wanted longer music	12	5
Couldn't hear music	7	3
Tired, sleepy, headache	4	1

Included in Appendix L are three more themes with selected quotes. The themes include students' opinions about the research, suggestions for future experiments, and personal self-reflected learnings. The opinions ranged from critiques about the music and the survey, to the overall experience. The majority of the suggestions were about using specific types of music. The personal self-reflected learnings revealed expectations that they had before the experiment began and comparisons about background music and when they listened to it.

Other Observable Results

There were eight schools that participated in the research and nine teachers who participated. Thus, one school had two teachers participating. One may question whether or not a teacher effect had any bearing upon the research. Were the attitudes, teaching styles, and teacher-prepared assessments additional variables that may have affected the students, in addition to other causal factors that impacted the students' performance? Additional research is needed in this area.

Chapter V

CONCLUSIONS AND RECOMMENDATIONS

This study evaluated the effects of background music on middle grade students during mathematics class time and mathematics test time. The study was based on previous research findings which either bolstered or failed to replicate the Mozart Effect. The general effects of background music on cognitive benefits for students were evaluated with several parameters in mind. Rauscher and Shaw (1998) suggested considering subjects' age, musical training, preferences of music, and aptitude for the task (p. 839). In the current research, grade level, liking/disliking the experience, musical preferences, evidence of singing and instrumental lessons, and self-reflection responses to the research experiment were analyzed.

Even though many venues and locations provide an ambience of background music, and many students may multitask with homework and background music simultaneously, this research focused on discovering the impact of background music on students in a classroom and in a testing environment.

The significance of the study is that it researched a childhood/preteen population in a natural school setting. The teacher-prepared tests were part of the usual test protocol for the particular classes. The students were their own controls in the study. The background music was tailored to represent one specific genre of music—classical, one specific composer—Wolfgang Amadeus Mozart, and one specific musical modality—less obtrusive music in tempo and dynamics. The closing student questionnaire/survey provided a wealth of student data and their personal reactions that augmented the findings of the current research.

The background music ambience for the classroom/testing times was formulated into five CDs for each of the teachers involved in the experiment. Each CD was used for two class periods of 25 minutes each. The total background music time during the class lessons was 250 minutes. At the end of the unit of mathematics work that was designated as the music condition, one of the CDs was repeated for the length of the closing test. At the end of the music condition, the researcher administered the closing student questionnaire/survey. The student surveys were coded numerically to maintain anonymity and confidentiality. Data were analyzed with ANOVA procedures and descriptive statistics. The conclusions for this research follow according to the 10 research questions.

Research Questions Answered

Research Question # 1: How does listening to music affect middle school students in their mathematics classes and mathematics testing environments?

In this research, background music during mathematics classes and during testing had no overall change on student scores on a mathematics assessment. Fifty-one percent of students had increased performance scores in summative assessments; 47% of students had a decrease in performance scores in summative assessments; 2% remained the same in their summative assessment performance scores from the premusic scores to the postmusic scores. It must be noted, however, that there was no statistical significance in the scores of the students whether they were assessed after the music condition or after the nonmusic condition. The outstanding results of the Mozart Effect in studies such as in Rauscher, Shaw, and Ky (1993) or Taylor and Rowe (2012) did not occur. Compared to Ivanov and Geake's 2003 study with upper-primary school-aged children, the first to be claimed as having a Mozart Effect for school children in a natural setting, the same results cannot be claimed for the current study. Yet, it is important to explore the results of all the categories covered in the additional research questions of the current study in order to understand the implications of any effects that did occur.

Research Question # 2: Will female or male students score higher in the music condition testing?

Many prior studies concerning the musical effects on children do not delineate gender differences, such as in Crncec (2006), or do include gender differences, such as in McKelvie and Low (2002). For those who have included gender variables, findings are mixed: 1) there are no significant interactions between gender and music conditions, such as in Hallam, Price and Katsarou (2002); 2) gender is listed in the methodology section, but results according to gender are not evaluated nor presented in the findings; and 3) definitive results are mentioned, such as in Koelsch et al. (2003) where girls were found to process music bilaterally and boys with a left predominance in the brain.

The current study determined that female participants, especially those in grade 6, superseded the male participants with statistically significant gain scores in the mathematics assessments.

Research Question # 3: Will age and grade levels indicate differences in results?

Some studies indicate the ages of the student participants, such as in Koelsch et al. (2003); some include both age and grade of the student participants, such as in Crncec (2006), Davidson and Powell (1986), Furnham and Stephenson (2007); and some indicate only the grade level of the students in the study, such as the mentioned sixth-graders in the Madsen and Forsythe (1973) study. This current study presented results based on grade level, which assumes the typical ages of students in the middle grades in the United States. The sixth-graders in the study had higher gains in the assessment scores compared to seventh-graders and eighth-graders. In breaking out gender, from the previous research question, and age, from this research question, it was found that females in grade 6 had higher scores than any other subgroup in the study. This group could be further studied as to teacher effects and difficulty level of mathematics concepts for that grade.

Research Question # 4: Does liking classical background music being played during class time have an effect on mathematics scores?

The researcher purposefully asked the students in the postresearch survey about their likes and dislikes in having background music play during their class and test times. For class time background music, 65% liked it all of the time or most of the time. Those 65% of the students gained points in their assessment scores, as was viewed in Figure 3. Of those who only liked it sometimes or not at all, 35% of the students had a loss in their scores. Nantais and Schellenberg (1999) found that overall levels of performance were better in their participants' preferred condition than in the nonpreferred condition (p. 372). Their study also included two conditions: a music condition and a story condition. Crncec, Wilson, and Prior (2006) chose three conditions to compare: Mozart's K. 448, popular music, and silence. Ratings of preference, happiness, interest, and surprise were significantly higher following the popular music. The researchers proposed that the popular music condition was intended to induce positive mood and arousal. It did not have an advantage on paper-folding performance (p. 310). The current study had only one music condition, Mozart's music, in order to streamline the evaluation variables. Given the plethora of popular music to choose from, as exhibited in the students' postexperiment survey, it was beyond the realm of possibility to incorporate popular music of choice for the current research. However, future studies might afford students a choice of preferred popular music in advance to study these results.

Research Question # 5: Does liking classical background music being played during test time have an effect on scores?

Sixty percent of the students who participated in this research liked background music being played during the entire testing time or most of the testing time. The continuum of liking music to not liking music during testing time is similar in pattern to the former category of liking/disliking music during class time. It is apparent that if students did not like the background music playing during testing time, their scores decreased. If they did like it, their scores increased. In the Mowsesian and Heyer (1973) study, whether the students liked or did not like the music they were exposed to, their mean scores were not significantly varied. The current study doesn't seem to contradict that finding; it does contradict that finding unless the differences were sufficiently small to be statistically insignificant. When further disaggregating these data by gender, it was found that females in grade 6 had better scores than any other subgroup examined in the study.

Stanton (1973) claimed that sixth-graders lacked test anxiety. The current study did not attempt to measure test anxiety in students. Stanton continued to propose that highly anxious students had superior test results while listening to background music. If students who had test anxiety in the current study, the researcher would not have known if their anxiety was lessened due to the music, except for those who freely offered comments in the open-ended question in the closing questionnaire/survey. Perhaps a future study might include questions of this order in advance of the experiment, rather than at the end.

Research Question # 6: Do students perform better on summative mathematics tests if they acknowledge routinely listening to music while doing homework?

McAdams Jones, Bacon, and Williams-Schultz (2010) sampled prenursing and first year nursing students to gather their feedback about the benefits they gained through studying with music. The students found it therapeutic, relaxing, de-stressing, soothing, and reduced anxiety. They claimed that listening to music helped them focus, concentrate, and kept them on track. Anderson and Fuller (2010) claimed that 79% of their subjects liked to listen to music while studying.

In the current study, 70% of the students who participated in the research listen to music while doing homework. Those who fared the best in their classroom assessment scores were those who listened to music most of the time while doing homework, not those who listened all the time, nor those who listened sometimes. The benefits of listening to music, while doing homework, were more evident compared to those students who did not listen to music at all. The current research did not specifically question the students about why they listened to music while doing homework or what they perceived as benefits in doing so. Yet, some of them did remark about such benefits in their closing survey question, such as “the music helped me concentrate and encouraged me to listen to classical music while I did my homework” and “I like listening to it because it was relaxing and made me feel like some stress…was lifted off my shoulders to some degree.” The students’ personal decision as to which genre of music to listen to while completing homework may have been affected as a result of this study. If the students’ assessments were lower due to the music condition, perhaps that would indicate to them that listening to music may not be the best condition for them while doing schoolwork or homework.

This opens up another potential area to study: the awareness of students’ understanding regarding the impact of music in their learning patterns and how to capitalize upon that learning.

Research Question # 7: Do students perform better on summative mathematics tests if they like singing?

The researcher was more aware of correlations between instrumental playing/ instrumental music lessons and cognitive effects from a variety of studies. Yet, this question was worth pursuing, since not all students may have the opportunity to play an instrument or to take instrumental lessons; but most human beings have the ability for sound production, which may include singing. This study examined whether or not there was a correlation between summative mathematics scores and liking to sing. Fifty-nine percent of the students in the study reported that they liked to sing. Forty-one percent did not like singing. There was a statistically significant difference between those liking singing and those not liking singing. The net music gain score was higher for those who liked to sing. For those who had singing lessons, only 7% of the group, there was a small effect size in gain scores. One of the essential elements of the instrumental music was melodic contour, which is a primary force in lyrical singing.

Since much of the music that was listed on their personal listening repertoire was lyrical—songs with words—perhaps students could now discriminate in their listening and alternately choose instrumental music as a listening option for them if it increased their summative assessments. This could be another future area of study to explore.

Research Question # 8: Do students perform better on summative mathematics tests if they play musical instruments?

Norton, Winner, Cronin, Overy, Lee, and Schlaug (2005) did not find any preexisting neural, cognitive, motor, or musical differences in music perceptual skills correlated to children's brains or visual-spatial measures. They did find a correlation between music perceptual skills and both nonverbal reasoning and phonemic awareness (p. 124). They also stated that it is unclear whether music training may enhance cognition since music training fosters attention, motivation, concentration and discipline. Length and intensity of music lessons may predict outcomes, also (p. 131). The current study found that the net mathematics gain scores increased with the number of instruments played. Rauscher et al. (1997) found that music training with preschool children, especially with piano keyboard lessons, produced a dramatic overall increase in their object assembly scores, and that the enhancement on their tasks from the keyboard training lasted at least one day, a long-term memory standard achieved (p. 7).

It was also discovered that the longer the students played instruments, their scores, in general, were slightly worse. This calls attention to Ivanov and Geake's (2003) study which indicated that music experience did not contribute a significant amount to the variance in paper folding task performance and there was little variance dependent upon the years of music lessons (p. 410). Yet, Schellenberg and Moreno (2009) found that the duration of lessons had a positive association with IQ scores. In the current study, perhaps those who played longer were more sensitive to the background music with its elements of melody, harmony, tempo, dynamics, form, etc., and the music may have been a distracter for the students who were more musically trained. These findings warrant further research.

Research Question # 9: How do students self-report their levels of attention, distraction, and concentration in such an experiment?

In this study it was found that students' scores were higher if they felt that they were more attentive. If they felt that they were not more attentive, their gain scores were lower. This was the only category (attention) that had a small effect size. The results of Tze and Chou's (2010) study introduced the following concept: music that is perceived as distracting will affect task performance and concentration. If the students in the current study perceived that the music in the experiment was distracting to them, they probably had a loss in their gain scores.

Even though 61% of the students felt that they did not concentrate more during the music condition, a higher percentage of students (85%) felt that they concentrated as well during the music condition. It is reported from the results that those who felt that the background music didn't make much of a difference (43%) had a higher music gain than those who felt that the background music made a difference to them (57%). None of the parameters of attention, concentration, and making a difference had any statistical significance.

Research Question # 10: What other impressions will the students offer about their experiences in being participants in this research?

Of the 71.5% of the students who included personal comments about the experiment, 15% mentioned that the music seemed calm and soothing. They felt more relaxed with it playing. In reference to the genre of music, there were those who favored the Mozart selections, and there were several that expressed a desire to have had other music selections.

Some students claimed that they blocked out the background music or just did not notice it. Some wanted the music listening to extend beyond the experimental period. Others thought that the experiment was fun and enjoyed participating in the exercise of combining music listening and mathematics work. For some, the music made them tired, sleepy, or gave them a headache. Two-percent of the total group of students in the project (n=302) claimed that they couldn't hear the music. The researcher does not know if this was due to the particular sound system in a classroom, the sound level that was coordinated by the teacher playing the CDs, or the hearing ability of the particular students who commented on this factor. The students' hearing ability was not pretested by the researcher; also, it is difficult to know if the student's placement in the classroom was a factor in this. This study was very far removed from the listening experience provided by Carlson et al. (2004) when the participants had the availability of a vibroacoustic chair. In that study, each of the 13 students listened to music in a bean-bag type chair with internal speakers that allowed the listener to feel the vibrations of the music in his or her body. The average of the 20 minute listening times extended for 3 times a week for 23 weeks. For these at-risk students, 88% of them showed an increase of one to two years in their individual scores for sight-word recognition and comprehension" (p. 248). All of the students improved their performance to grade level or higher. The current study did not have the luxury of using a vibroacoustic chair. The goal was to reach many students in a classroom setting simultaneously.

Conclusion

The results have been analyzed specifically according to age/class level, gender, and whether or not the students liked background music listening times during classes and testing. The students' feedback from the questionnaire/survey at the completion of the research study also included additional responses about their self-reported levels of attention, concentration, and distraction, their practice of listening to various genres of music during personal homework times, and their personal preferences as to liking or not liking singing, along with a report of their personal history of playing instruments and of having instrumental and singing lessons.

If students benefitted academically through the process, perhaps they learned a valuable tool for their education: listening to classical background music while doing academic work in mathematics may be a boon to them. Perhaps they may incorporate listening to this type of music while at home doing homework. If the students did not benefit in cognitive effects through this experience, or if they did not like the experience, perhaps the experiment assisted them in realizing more clearly their own personal preferences and limits in such an exercise. Perhaps they may try listening to different music; they may have become more selective in choosing music to listen to while working academically. Perhaps they may have learned that they do class work, homework and study best without background music.

The researcher is hoping that these perceptions have taken place for some, if not all of the students, who experienced this research study. Based on the personal reflections indicated on the student survey, with actual statements about individual student recognition of increased or decreased summative assessment scores during the background music times, there is a sense that students were aware of the impact that the background music had on their scores (see Appendix L).

To recap the current study, significant effects included the following: 1) female participants had higher overall scores than males; 2) sixth-grade students had higher gains in pretest to posttest assessment scores; 3) females in the sixth grade had higher scores than females and males in the other levels; 4) students who liked singing had a statistically higher gain in their scores; there was a small effect size for those who had singing lessons; 5) students who played three or more instruments had the highest gain scores, those who played no instruments had the lowest gain scores, and the longer students played instruments, their scores were slightly worse.

If students liked background music during class and test time, their scores were higher. Students who listened to music most of the time, not all of the time while doing homework, had better gain scores. There were no statistically significant findings concerning feeling attentive in the music condition, concentrating in the music condition, and being neutral about the music listening.

If students realized that by listening to classroom background music their scores increased, then they may have continued the practice during homework times. If they already had the practice of listening to music while doing homework, and became cognizant of the findings of this current study, then they may have altered the amount of time listening to music while doing homework. McAdams Jones, Bacon, & Williams-Schultz (2010) sampled prenursing and first year nursing students to gather their impressions of how they viewed the benefits gained through studying with music. The students claimed that music in the environment helped them to relieve stress, to focus, to tune out distractions, and to concentrate more. "If students perceive listening to music is enhancing their learning experience they will likely continue to repeat this behavior" (p. 371).

Limitations

There were various limitations in structuring and enacting the experiment. The main researcher was not able to be simultaneously present at several locations at once. That prevented the researcher from assuring that the details of the plan were followed accurately and that decibel levels for the music were truly background level. There were, by necessity, a plethora of teachers, teaching styles, methods of mathematics instruction, and a variety of mathematics topics and assessments used (See Appendix M). Neither the researcher nor the teachers administering the experiment could control extraneous sounds in the classroom, or unexpected changes in scheduling that may have affected results.

These aberrations were not accounted for: fire drills and/or students' proximity to the sound source, which may have affected their experience by being too close or too far away from the music. The time of year scheduled for the experiment was the fall season. With schools receiving permissions in staggered form, a couple of schools were particularly late in starting the project; thus, their experimental time moved into the winter season, with snow days perhaps interrupting the consistent progression of the 10 listening times during class time.

The time of the mathematics class during the school day may have affected assessments. There was no attempt to evaluate this condition in the current research. Likewise, whether or not the students experienced the project early in the semester or later in the semester may have had an impact. More progression in mathematical skill sets as the academic year moved on could have affected the assessment results. Although the sample population exceeded the researcher's expectations, the sample size would have been even larger if all of the interested parents and students had given permission and assent.

The closing questionnaire/survey revealed what the students liked and disliked about the experiment. Much of the literature in assessing background music effects deals with arousal and mood theories. The researcher did not measure particular mood states of the students. Steele (2000) tried to refute the Mozart Effect by calling to light the fact that in order to truly measure subjects' performance, one needs to measure their mood and arousal states. He also stressed that student participants in the research groups may differ in grade point average and whether or not they had the opportunity for music lessons. Effects may be masked since the students are not on equal footing . (p. 188).

In hindsight, it might have made more sense to have everyone listen to the same CD during the testing time in order to control for variability. In this experiment, the teachers made a selection from the five CDs used in the project.

Recommendations

Even though there have been many pros and cons for even attempting to replicate the Mozart Effect, this researcher recommends further research. In 1999, Steele, Bass and Crook claimed that there is "little evidence to support basing intellectual enhancement programs on existence of the causal relationship termed the Mozart effect" (p. 368). There have been many studies since that time which land on either side of the fence for recommending background music to affect cognitive change. After examining the current research results, it is apparent that definitive results are not black and white. The Mozart Effect has created a lot of grey matter in between.

The focus of the current study was on cognitive effects and only organized feedback from the students about the project. The researcher did not study the feedback of the teachers about the experiment, specifically since the IRB limited that option for the researcher. It could be that future research would somehow include that input. One teacher did write to the researcher after the current project and in her note she said, "The students continue to request to hear classical music during tests or quizzes so I feel it was a positive experience for all." Of interest would be the behavioral tone of the classes: how did the music impact the behavior of the students? This research approached music listening in a positive way, expecting beneficial cognitive results; perhaps there were beneficial or detrimental behavioral results unaccounted for in that pursuit. Midgette (2012) relates how music listening was used in a punitive way for misbehaving and disobedient children in Derby, England. They were expected to sit and listen to classical music for one hour. Behavior improved 50% with these children. The current study did not use listening to music as a punitive measure; it was used with a positive influence in mind—to benefit students in a cognitive way. In retrospect, would the teachers continue to use background music at all in their classrooms for either cognitive or behavioral effects?

There is need for further research in learning the effects of background music during class and assessment times. One might use music during instruction time only, or testing time only. Whitehead (2001) claimed that the frequency and intensity of the music intervention is positively related to mathematics posttest score advantages (p. 67). His 28 secondary school students from grades 6 through 12 had different music conditions: one with music-intensive interventions for 50 minutes every day for more than 20 weeks, the other with music-intensive interventions for 50 minutes one day a week for more than 20 weeks. Again, the current researcher limited the variables with the standard listening time set by this project—25 minutes a day for 10 days.

The current research did not include studies about seasonal effects on the students. Future studies could investigate the effects as to the part of the school year in which the research occurs. The timing of when music happens during the school day and how many sessions are used to listen to background music may affect the results, as well. If one chooses to continue the research with background music and mathematics, one might consider evaluating what the results are according to the mathematics topics covered in class and subsequently assessed (see Appendix M). Different selected music may produce different results. The quality of the sound source, such as mentioned in Thompson and Andrews (2000), could be chosen more specifically.

Focusing more on gender differences is another possibility; more experimentation could be done with different age levels of students. If one has the luxury of time available, it is suggested that listening to music 5 to 10 minutes before academic work and assessment time may indicate different results in attention and concentration.

Cabanac et al. (2013) have paved the way for comparing music courses in the curriculum with benefits to many other subjects (p. 258); perhaps other researchers could continue to explore how background music affects other subjects in the curriculum.

For students who experienced this as a "success story" with personal gains, there is a recommendation to continue the practice of listening to background music while doing homework, at least. Also recommended is a feedback session to have with the student participants in their respective schools; this session could be an educable moment in their lives—an opportunity for the researcher to share what was learned about the experiment and an opportunity for the students to ask questions about the research.

In conducting the current research, the researcher found a gamut of variables that possibly affected the students on their assessment scores. As Lints and Gadbois (2003) expected enhanced performance scores with their participants in their study, so too did the current researcher with the current study. The researcher has concluded that under certain conditions and variables, a Mozart Effect could occur. The results were highly individualized, with a broad base of influential factors. This research aligns with Gardner's MI theories that recognize the inborn attributes that persons possess, as well as the cultural influences that shape the operative domains of those intelligences. Gardner (2008) names intelligences as a "mental chemistry set" (p. 27). In this current study, the set of operatives combined in a unique way to produce a unique product, the outcomes of which may be evidenced in the data.

Gardner (2008) claims that "an individual with high musical intelligence finds it easy to remember melodies, to recreate rhythms, to trace the changes that take place in a theme over the course of a composition" (p. 31). The subjects (n=302) who participated in the current study may have been musically involved mentally and subconsciously as they listened to background music in their classes and testing situations. The interfacing of music listening and mathematics created different tasks that demanded combinations of intelligences to operate. Students who were sensitive to music may have been intellectually challenged by the process, aided in the creation of new neural pathways in the brain. Those who were not akin to a musical intelligence may have found the process a distraction or a deterrent to their other modes of intellectual learning.

What is certain is that the effects of background music listening during classes, tests, and homework will continue to combine to produce what musicians term a theme and variations: music affects each person in a complex way.

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Appendix A

IRB Approval Letter

NOTRE DAME
OF MARYLAND
UNIVERSITY

March 24, 2013

Dr. Gary Thrift, Ed.D.
Notre Dame of Maryland University
4701 N. Charles St.
Baltimore, MD 21210

RE: IRB-13-1-111196

Dear Dr. Thrift:

The Institutional Review Board (IRB) of Notre Dame of Maryland University has approved the proposal entitled *"Background Music and Cognitive Learning Effects"*.

Your approval to conduct research will expire March 25, 2014.

During the course of carrying out your research you are responsible to promptly report to the IRB any unanticipated problems involving risks to participants, investigators, or staff. In addition, any changes in research activity during this approval period may not be conducted without IRB review and approval. Please refer to your unique IRB proposal number on all responses to the Board.

If you have any questions, please do not hesitate to contact me at bconnor@ndm.edu.

Sincerely,

Dr. Bridget Connor, Chair
Institutional Review Board
Notre Dame of Maryland University

APPROVED
NDMU IRB
FWA 00011406

4701 North Charles Street | Baltimore, Maryland 21210 | T 410.435.0100 | ndm.edu

Appendix B

Principal/Head of School/Administrator Invitatory Letter

Date

Principal/Head of School/Administrator
Invited School
Street Address
Location, MD 00000

Dear Principal/Head of School/Administrator

Your school is being invited to participate in a Fall 2013 research study being conducted to determine if there are any cognitive effects of classical background music used during mathematics class time and mathematics testing time with sixth, seventh, and eighth grade students. The researcher is Mary Roy Weiss, SSND, and is currently a doctoral candidate under the supervision of Dr. Gary Thrift in the School of Education at Notre Dame of Maryland University (NDMU).

The NDMU Institutional Review Board has approved this study and we would like to know if you and one or more of your sixth, seventh, and eighth grade mathematics teachers would be interested in participating in the study. Your school is one selected from a group of private, non-public middle schools in the Baltimore area. Even though many schools may respond affirmatively to this request, we may need to choose a random sample from among those agreeing to participate. If you are in agreement to participate, and are chosen to participate, we will provide the CDs of selected music for the experiment. The music is intended to be background music, not a distracter to the class or testing times. One potential benefit in this study is improved knowledge in mathematics.

The experiment is meant to occur within the usual class teaching time and testing time, for the duration of two units of work— the teacher will play classical background music (see attached) during ten days of mathematics instructional time and during the students' classwork time (about 12-13 minutes for each). The music will also be played during the administration of one unit test, which is teacher-constructed, as a part of the regular academic protocol. The teachers will then share with the researcher three unit test scores for each student: the last unit test score obtained prior to this experiment, the test score after the music treatment, and the test score after the no-music treatment.

A math tutor will be provided for any student who is in need of remediation due to the music treatment (e.g., significantly lower mathematics scores during that unit, defined as a drop of 2.0 standard deviation units from the benchmark--pre-treatment measure.) The student will be offered tutorial intervention, if so desired.

Data will be gathered from the students, who will be able to give their feedback and perceptions to the chosen music and to their reactions to the process, at the conclusion of the study. Some scaled responses will be identified by a check-system and other responses will be open-ended statements. Demographic information, including age, grade, gender, prior or current musical involvement with music lessons, music listening preferences, and whether or not the student listens to music while doing homework, will be requested at the end of the study. The parents/guardians of the students will receive a copy of the student survey (see attached) when consent/permission forms (see attached) are distributed, before the research begins. A third party, from the research team, will administer the student surveys to the students at the conclusion of the study.

As the researcher, I look forward to your response to this request, and ask that you call me or e-mail me for your initial approval and/or for questions you may have. Thank you for your consideration!

Sincerely,

Mary Roy Weiss, SSND
Mailing Address
City, State, Zip Code
Phone
E-mail address

Appendix C

Letter/Consent Form for Teachers

Dear Teacher,

You are invited to assist in helping to administer a research study for your class. Your class members and their parents will be asked to sign consent forms and assent forms to participate in the study. Upon their approval, you will be asked to let selected classical music be played as background music for your mathematics class time and mathematics test time during one unit of work (10 class periods with 25 minutes of background music, a total of 250 minutes, as well as music during one test time) within two units of work being researched in the study. The tests will be the tests that you construct as part of your regular academic protocol. At any time, your students may opt to not have their test scores used for the research study.

At the conclusion of the experimental period, after the two unit cycle, a third party will distribute and collect a student survey to be completed by the members of your class. You will also be requested to provide the last test score acquired from the last mathematics unit before the experiment began. Please direct any questions to the researcher, who will provide the selected music for your class, and who will clarify the specifics of the implementation of this study upon your consent. From among the participating teachers, two teachers will be randomly selected to receive a $100 gift card, and two teachers will be randomly selected to receive a $50 gift card.

______I am willing to have my class(es) participate in this research.

______ I am not willing to have my class(es) participate in this research.

____

(Signature of Teacher)

Appendix D

Teacher Instruction Form

Teacher Instruction Form

If your class is chosen for the study, then proceed with the following directions during the music condition of the experiment:

Choose a quality sound system for use in your classroom.

Music will be played at 60db, a standard figure for background music **(http://www.soundinstitute.com/article_detail.cfm/ID/128).**

Play music during 25 minutes of class time (approximately 12-13 minutes during instructional time and approximately 12-13 minutes during classwork time.)

Play music in this way for no more than, and no less than, 10 days during your unit of work in the music condition.

Day 1: Use 1st half of CD #1

Day 2: Use 2nd half of CD #1

Day 3: Use 1st half of CD #2

Day 4: Use 2nd half of CD #2

Day 5: Use 1st half of CD #3

Day 6: Use 2nd half of CD #3

Day 7: Use 1st half of CD #4

Day 8: Use 2nd half of CD #4

Day 9: Use 1st half of CD #5

Day 10: Use 2nd half of CD #5

Test Day: Use any CD # 1 through #5

On one of the days shortly following the test, a third party will administer a student survey during part of a class period. Please allow, at most, 10 minutes of class time for the students to complete the survey. Thank you.

Appendix E

Parent/Guardian Consent Form

Page 1 of 2
Initials ___________
*Date*______________

CONSENT FORM

Project Title	***Background Music and Cognitive Learning Effects in Mathematics with Middle School Students***
Why is this research being done?	The purpose of this research is to learn how listening to background music during mathematics classes and mathematics testing affects mathematics test scores of middle school children.
What will I be asked to do?	As a parent/guardian, you are being requested to give permission for your child/ren to participate in this research which will take place during regular classroom instruction time and testing time over a period of two units of mathematics work.
What about confidentiality?	Your child's personal information will be kept confidential. Numerical identification codes will be indicated on data forms. The students will be asked to fill out a questionnaire with this information at the end of the study: age, grade, male/female, impressions about the experiment and general student involvement with music at home and school and other venues. Password-protected computer files will be used to protect the data. The test scores and information gleaned from the questionnaire will not personally identify your child. Only the researcher will be able to link the questionnaire to your child and only the researcher will have access to the identification key. The researcher is seeking aggregate compilations of data that will further the understanding of the study.
What are the risks of this research?	One risk may be that your child will find listening to background music as a distracter to the mathematics class work or testing situation. There are no other known risks with participating in this research project.
What are the benefits of this research?	One potential benefit of this research project is improved knowledge in mathematics.
Do I have to be in this research? May I stop participating at any time?	Your child's participation in this research is voluntary. Either you as your child's parent, or your child him/herself, may not want the mathematics testing scores to be used. If anyone decides not to participate or to stop participating in this research, the researcher will not use the mathematics scores nor the survey forms as part of the research, and the students will not be penalized in any way.

What if I have questions?	This research is being conducted by Mary Roy Weiss, SSND, doctoral candidate, under the supervision of Dr. Gary Thrift in the School of Education at Notre Dame of Maryland University, 4701 North Charles Street, Baltimore, MD 21210. Sister Mary Roy can be reached at xxx-xxx-xxxx or by e-mail; Dr. Thrift can be reached at xxx-xxx-xxxx or by e-mail.

Page 2 of 2

*Initials*________
*Date*__________

Project Title	***Background Music and Cognitive Learning Effects in Mathematics with Middle School Children***	
Statement of Age of Subject and Consent	Your signature indicates that : • You are the parent/guardian of your child. • The research has been explained to you. • Your questions have been fully answered. • You freely and voluntarily choose to participate in this research project.	
Signature and Date	**NAME OF SUBJECT (CHILD)**	
	SIGNATURE OF PARENT/GUARDIAN	
	DATE	

Appendix F

Student Assent Form

This study will take place during my regular mathematics class time and my mathematics testing time. Classical background music will be played during mathematics class time and mathematics testing time during <u>one</u> of two units of work.

Only mathematics test scores during the experiment will be used in the study. The scores will remain anonymous and confidential to the researcher. My regular mathematics teacher will decide whether to include these test scores as part of the usual class marks and averages according to regular classroom procedures. I can decide not to have my test scores used in the research project.

At the end of the experiment, I will answer a questionnaire using my student code number, and will provide my impressions about the experiment and how I use music in my life.

If I have any questions, I can ask them now or have my parents or teacher call the researcher about them.

My signature below means that I have read and understood this assent form and I agree to have my test scores used in the study.

Please check <u>one</u> of the following:

______I <u>am</u> willing to listen to background music during my class/test time and to have my mathematics test scores used in this research study.

____
(Signature of student)

______I am <u>not</u> willing to listen to background music during my class/test time and to have my mathematics test scores used in this research study.

____
(Signature of student)

Parental Permission on File: ____Yes ______No Date: ________________

Signature of Researcher ________________________________

Appendix G

Student Questionnaire/Survey at conclusion of study

Student code number_______________
Date:________________________

1. Age: ___________________
2. Gender: Male_____ Female____
3. Grade level: Six_______Seven _____Eight______

4. During mathematics <u>class</u> time, I liked background music playing:
   All the time_____ Sometimes_____
   Most of the time_____ Not at all _____

5. During mathematics <u>testing</u> time, I liked background music playing:
   The entire testing time______ Part of the testing time_____
   Most of the testing time_____ Not at all during testing time_______

6. When I'm doing homework, I listen to music:
   All the time_____ Sometimes_______
   Most of the time_____ Not at all _______

7. If I <u>do</u> listen to music while doing homework, this is the music I listen to:
   ______________________________ ______________________________
   ______________________________ ______________________________

8. Please check all that apply:
   _____I like singing.
   _____I have had singing lessons.
   Years of voice lessons:____
   ______I am a member of a choir
   In school_____
   In church_____
   Other________

   _____I play an instrument.
   Name the instruments you play and how long you've had lessons:
   For example: <u>Piano</u> <u>2 years</u>
   _______________ ______
   _______________ ______
   _______________ ______

9. When background music was played in class, I felt that I… (please check all that apply)
   _____was more attentive _____was more distracted
   _____was able to concentrate more _____ did not concentrate as well
   Option:_____The background music didn't make much of a difference to me.

10. What else would you like to tell the researcher about how you experienced this experiment?
    (Please use the other side of this paper to continue to write about your experiences.)

Appendix H

Listening Chart for Teachers

CD # 1 -- 1st half (yellow) Day 1

Source/Track			Minutes.Seconds
3/11	Track 1: K. 19	Andante from Symphony No.4 in D Major	4.21
3/2	Track 2: K. 182	Andantino grazioso from Symphony No. 24 in B^b	2.51
4/5	Track 3: K. 333	Andante cantabile from Sonata No. 13 for Piano in B^b	5.06
7-3/10	Track 4: K. 370	Adagio from Oboe Quartet in F Major	3.38
12/6	Track 5: K. 551	Andante from Symphony No. 41 in C Major "Jupiter"	9.29

CD # 1 --2nd half (yellow) Day 2

2/1	Track 6: K. 467	Andante from Piano Concerto No. 21 in C Major	6.46
7-4/8	Track 7: K. 388	Andante from Wind Serenade No. 12 in C Minor	3.46
5/8	Track 8: K. 501	Andante and Variations for Piano, Four Hands in G Major	1.12
5/12	Track 9: K. 501	Andante and Variations for Piano, Four Hands in G Major (Var. IV)	1.24
2/8	Track10: K.320	Concertante Andante grazioso from the "Posthorn" Serenade No. 9 in D Major	8.36
2/4	Track 11: K. 285	Adagio from Flute Quartet in D Major	2.55

CD # 2 --1st half (green) Day 3

2/3	Track 1: K. 299	Andantino from Concerto for Flute and Harp in C Major	7.34
12/2	Track 2: K. 550	Andante from Symphony No. 40 in G minor	7.55
8/6	Track 3: K. 421	Andante from String Quartet No. 15	6.29
2/7	Track 4: K. 581	Larghetto from Clarinet Quintet in A Major	6.00

CD # 2 --2nd half (green) Day 4

5/2	Track 5: K. 448	Andante from Sonata for 2 Pianos in D Major	7.57
11-1/2	Track 6: K. 268	Violin Concerto No. 6—Un poco adagio (in E^b)	5.36
7-2/6	Track 7: K. 537	Larghetto from Piano Concerto No. 26 in D Major	5.00
9/2	Track 8: K. 183	Andante from Symphony No. 25 in G Minor	4.20
9/7	Track 9: K. 199	Andantino grazioso from Symphony No.27 in G Major	4.19

CD # 3 --1st half (orange) Day 5 Minutes.Seconds

2/2	Track 1:	K. 428	Andante con moto from String Quartet No. 16 in E^b Major	9.06
5/6	Track 2:	K. 608	Andante from Fantasia for Mechanical Organ in F minor	4.23
11-2/5	Track 3:	K. 313	Adagio non troppo from Flute Concerto No. 1 in G	9.14
4/1	Track 4:	K. 620	March of the Priests from *Die Zauberflöte*	2.45

CD # 3 --2nd half (orange) Day 6

7-2/9	Track 5:	K. 261	Adagio in E Major for Violin and Orchestra	8.24
4/6	Track 6:	K. 622	Concerto for Clarinet and Orchestra in A	8.27
10/2	Track 7:	K. 207	Adagio from Violin Concerto No. 1 in B^b Major	8.03

CD # 4 --1st half (blue) Day 7

7-4/8.9	Track 1:	K. 332	Adagio from Piano Sonata No. 12 in F Major	3.47
1/5	Track 2:	K. 247	Andante grazioso from Lodron Night Music No. 1	4.46
2/10	Track 3:	K. 205	Adagio from the Divertimento in D Major	4.08
11-2/8	Track 4:	K. 314	Andante ma non troppo from Flute Concerto No. 2	6.48
6/5	Track 5:	K. 595	Larghetto from Piano Concerto No. 27 in B^b	7.43

CD # 4 --2nd half (blue) Day 8

2/5	Track 6:	K. 296	Andante Sostenuto from Violin Sonata in C Major	5.43
11-1/8	Track 7:	K. 310	Andante Cantabile from Piano Sonata in A minor	9.32
2/9	Track 8:	K. 315	Andante in C for Flute	6.01
11-2/2	Track 9:	K. 545	Adagio from Piano Sonata No. 16 in C	4.21

CD # 5 --1st half (red) Day 9

7-1/3	Track 1:	K. 525	Romance from Eine Kleine Nachtmusik	6.43
7-3/2	Track 2:	K. 488	Adagio from Piano Concerto No. 23 in A Major	6.00
11-2/6	Track 3:	K. 491	Larghetto from Piano Concerto No. 24 in C minor	7.33
10/5	Track 4:	K. 216	Adagio from Violin Concerto No. 3 in G Major	8.02

CD # 5 --2nd half (red) Day 10

11-1/5	Track 5:	K. 271a	Andante from Violin Concerto No. 7 in D	7.56
8/3	Track 6:	K. 387	Andante cantabile from String Quartet No. 14	7.33
10/8	Track 7:	K. 364	Andante from Sinfonia concertante for violin, viola, and orchestra	10.43

Appendix I

List of CD titles for the study

1. music for The Mozart Effect-I- Strengthen the Mind
   Boulder, Colorado: Spring Hill Music (1997)

2. music for The Mozart Effect-II- Heal the Body
   Boulder, Colorado: Spring Hill Music (1997)

3. music for The Mozart Effect-III-Unlock the Creative Spirit
   Boulder, Colorado: Spring Hill Music (1997)

4. Serene & Sublime: Mozart's Most Relaxing Melodies from Mozart: A Celebration. New York: Sony BMG Music Entertainment (2006)

5. Mozart/Schubert performed by Murray Perahia and Radu Lupu
   Sony Music Entertainment, Inc. (2003)

6. Mozart Piano Concertos 20 & 27
   www.emiclassics: EMI Records, Ltd. (2010)

7. the 50 most essential Mozart masterpieces
   www.x5music.com: x5 Group AB (2011)

8. Mozart String Quartets No. 14, K. 387, No. 15, K. 421
   Cleveland, Ohio: Telarc International Corporation (1992)

9. Mozart Symphonies 25, 26, 27, 29, & 32
   London: The Decca Record Company (1991)

10. Mozart Violin concertos Nos. 1 & 3
    Scotland: EMI Records (2009)

11. the Ultimate most relaxing Mozart in the universe
    Santa Monica, California: Denon Classics (2007)

12. Wolfgang Amadeus Mozart: Symphony No. 40 in G minor, K. 550, Symphony No. 41 in C Major, K. 551 "Jupiter"
    Quebec, Canada: Madacy Music Group, Inc. (1993)

Appendix J

Student Selected Genres of Music While Doing Homework

Type of music	Percent of listening respondents
Pop	32.0
Rock	14.5
Rap	10.9
Hip Hop	9.0
Classical	8.9
Country	8.0
Alternative	5.0
Rhythm and Blues	5.0
Top Hits	1.9
Jazz	.9
Reggae	.9
Rock 'n' Roll	.3
Electronic	.3

Please note that Pop includes: Punk Pop, Korean Pop, Pop 80s, Pop Opera, Soft Pop

Please note that Rock includes: Soft Rock, Christian Rock, Indie Rock, Hard Rock, Heavy Metal, Alternative Rock, Classic Rock, Acid Rock, Punk Rock, and Post Hard Core

Please note that Rhythm and Blues includes: Blues and R & B Soul

Other categories < .1 % are: Mexican, Daft punk, Club step, Dubstep, Celtic, Folk, Broadway soundtracks, Techno, Christmas music, Hawaiian music, Parodies, Parents' music, Violin music, Lyric-less music, Video game sound tracks, New Age, Random, Acoustic songs

Appendix K

Musical Artists Listened to by Students

Number of Students	Artist
13	One Direction
8	Justin Beiber
8	Katy Perry
6	Pandora
5	One Republic
5	Taylor Swift
6	Miley Cyrus
5	Eminem
4	Lorde
3	Bring Me the Horizon
3	Mozart
3	The Neighborhood

2 AC/DC, Ariana Grande, Aerosmith, Bruno Mars, Demi Lovato, Fall Out Boy, Frank Ocean, Great Big World, Green Day, Kanye West, Lady Gaga, Luke Bryan, Macklemore, Michael Jackson, Mindless Behavior, Possibly, Queen, The Beatles, The Fray, The xx

1 The All American Rejects, 3 Day Grace, Abbama, Adele, Adventures in Odyssey, Avenged Sevenfold, B.O.B., Beethoven, Beyonce, Billy Joel, Birdy, Bless thefall, Ellie Goulding, Celine Dion, Ciara, Closing Time, Crush 40, Deadmau5, Deep Purple, Delta Ray Run, Diggy Simmons, Drake, Ed Sheeran, Elton John, End of Message, F.V. Music, Fifth Harmony, Florence and the Machine, Foo Fighters, Garth Brooks, Hunter Hayes, iivolo, Instalok, Jay Z, Johnny Cash, Jjicy J, Justin Timberlake, Daughtry, Kesha, Kiss, Lana Del Ray, Lightning Crashes, Mayday Parade, Metallica, Never Shout Never, Nicki Minaj, Of Mice and Men, Panic: at the Disco, Paramore, Pink Floyd, Reality Driven Pursuits, Rihanna, Rush Band, Selena Gomez, Shinedown, Sweet Home Alabama, The Rolling Stones, The Script, The Who, TLC, Toni Braxton, Train, Treyarch, U-13-40 Band, Viceroy, Whitney Houston

Appendix L

Sample Thematic Quotes from Students' Open-Ended Survey Question # 10

What else would you like to tell the researcher about how you experienced this experiment?

Theme 1: Calm, relaxed, soothing

1. While the music was playing, I felt more calm, also that I could concentrate better than I have before.
2. The music relaxed me and let me focus better.
3. The music chosen for this project was more soothing than the music I listen to while I work.

Theme 2: Genre, type of music

1. I felt that the classical music stimulated my brain.
2. I think they should play different types of music and not just classical music.
3. I think it could've been different music or music from different genres.

Theme 3: Blocked out, ignored it, didn't notice it

1. I did not notice the music after a few minutes of it starting.
2. After a couple of days, I did not notice the music and ended up blocking it out.
3. I think my brain just blocked out the music because I don't really remember hearing it.

Theme 4: Fun

1. I thought the experiment was fun and I enjoyed participating in it.
2. I feel like I learned math better and it was a fun and interesting experiment.
3. This was fun and different but I don't want to do it every day.

Theme 5: Wanted music longer, do this again

1. I wish we could do this more often.
2. I liked it and I want the music longer than 10 days. (smiley face added)
3. Do it for a longer time.

Theme 6: Couldn't hear it

1. Most of the time I could not hear the music very well.
2. I couldn't always hear the music. If it was louder that might help.
3. I didn't hear it, didn't realize it.

Theme 7: Pretty tired, sleepy, headache

1. I liked the music, but sometimes it made me sleepy.
2. It kind of made me drift off in my mind, and it also made me pretty tired.
3. I remember sometimes getting a headache (when listening to classical music).

Theme 8: Opinions

1. I liked it a lot and would like music to be added to the school curriculum. However, I'd like to listen to music I'm more familiar with.
2. I enjoyed it and wouldn't mind if we continued to listen to music during math class.
3. The music experiment I had was really unique. It made me enjoy math class more. I hope I could do this again sometime.
4. I didn't like it at all. It was boring and distracted me. When it came on I sighed knowing I couldn't concentrate. Especially during tests. It is not my type of music.
5. The music was annoying.
6. I don't know why but it made me feel tense, nervous and stressed out.
7. I thought this was an interesting topic.
8. Your survey is very creative and original.
9. That music was my jam.
10. It was a good experience overall.

Theme 9: Suggestions

1. Play different music!!! All of them sounded the same.
2. I would have liked to listen to more up-beat music and music with words.
3. Try a type of Reggae.
4. You could ask if you listen to music in your free time in your survey.
5. I would like to say one thing. It was great, but the only thing is I wish we could have listened to harder music like the Beatles, the Who, Led Zeppelin, etc. Other than that, it was really, really fun.

Theme 10: Personal self-reflected learnings

1. During the test, I felt more concentrated, and I think that it should be played daily.
2. When the music was the right volume it was better than when it was too loud or too quiet.
3. I like listening to it because it was relaxing and made me feel like some stress, like if I didn't fully understand the current lesson, was lifted off my shoulders to some degree.

4. I liked this study, because I always listen to music when I'm doing work. I liked the classical music, because it didn't distract me, because I didn't know the song and there were no lyrics to sing along to.
5. At first, I thought that the music was going to distract me and that it would be hard to concentrate. This was the opposite of what happened. The music helped me concentrate and encouraged me to listen to classical music while I did my homework.

Appendix M

Assessment Topics in All Eight Schools (General List)

Please note that the music and nonmusic conditions were reversed, depending on the class, so the music condition did not necessarily immediately follow the preresearch condition. The music condition may have followed the nonmusic condition.

Grade 6: Preresearch condition: Place values, addition and subtraction, fractions, decimals, percents, comparing, modeling

Music condition: Division, multiplication and division of fractions, ratio and proportion, multiplication and division of decimals

Non-music condition: multiplication, computing with multidigit numbers, computation with fractions, fractions/decimals/percents

Grade 7: Preresearch condition: Operations with integers, proportional reasoning and probability, algebraic expressions and integers, order of operations, integers, operations with integers, equations

Music condition: Operations with rational numbers, functions and graphs, solving step equations and inequalities, solving mathematics step problems, rational numbers, addition, subtraction, multiplication and division, positive and negative fractions

Nonmusic condition: Powers and roots, linear equations, decimals and equations, distributive property, basic solving of equations, factors and fractions, expressions, exponents, algebraic fractions, monomials

Grade 8: Preresearch condition: Expressing equations, functions, proportional reasoning and probability, adding and subtracting equations, linear equations solving using addition and subtraction, systems of equations, prelinear equations

Music condition: Linear equations, functions and graphs, multiplication and division of equations, solving equations and inequalities, solving multistep equalities, ratios, proportions, percents, properties of exponents, polynomials

Nonmusic condition: Equations, linear equations, integers, ratios/proportions/percents, properties of numbers, distributive properties, inequalities, systems of equations