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Impact of Music Education on Mathematics Achievement Scores Among Middle School Students

Curt Glendale Willis
Walden University

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COLLEGE OF EDUCATION

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Curt Willis

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Chief Academic Officer

Eric Riedel, Ph.D.

Walden University
2016

Abstract

The Impact of Music Education on Mathematics Achievement

Scores Among Middle School Students

by

Curt Glendale Willis

MAT, Andrews University, 1994

BS, Andrews University, 1987

Doctoral Study Submitted in Partial

Fulfillment of the Requirements for the Degree

of Doctor of Education

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January, 2016

Abstract

Music education has been shown to be related to a variety of positive outcomes, including student achievement in math. This study was conducted to explore the relationship between music education and student achievement in math. The framework for the study was Miendlarzweska and Trost's model of musical instrument training. A deidentified archival data set consisting of middle school students' (N = 116) total math scores on the Iowa Assessments was used to determine the impact of music education on students' math achievement, while controlling for students' sex and socioeconomic status. Changes in student achievement were measured by calculating math scores between the 2012-2013, 2013-2014, and 2014-2015 academic school years. The data were accessed from a private school system in the northeast United States. Results of a *t* test indicated that there were no differences in baseline scores between the group of students who received music education and the group of students who did not receive music education. Results of a regression model for 2013-2014 showed that music education was a significant predictor of math growth scores (p = .015). Results of a regression model for 2014-2015 indicated that only socioeconomic status was a significant predictor of math growth scores (p = .039). Implications for social change include improved stakeholder awareness of the value of music education for student achievement, which may motivate teachers to become advocates for music education and administrators to include music education in their curriculums. By increasing student access to music education, students may be helped to achieve to their fullest potential.

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Dedication

This doctoral study is dedicated to my wonderful family. To my late mother, Joyce Willis, for her unconditional love, unshakeable integrity, unwavering faith in God, and perennial inspiration and encouragement to complete the EdD program. To my late Father, Glenroy Willis, who always echoed incredible confidence and passion for all my successes. He taught me to trust God implicitly, love and enjoy life, and be the second father-leader in the family. To my beloved siblings, Curleen, Dawn, the late Rene, Jewel, Gem, Jael, Ernil, and Tishelle for their love, encouragement, prayers, words of wisdom, and financial assistance. Finally, all glory, honor, and praises to our Lord and Savior Jesus Christ, the Author and Finisher of our faith. Thank you Lord for allowing me to achieve this great milestone.

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I have been privileged to walk with several distinguished individuals on this doctoral sojourn, and at this time I pause to extend my heartfelt gratitude for the significant role each one played. Special thanks to my incredible and multi-talented chair, Dr. David A. Hernandez, who exceeded the expectations of his role via his valuable advisement, patience, and kindness; my second committee member, Dr. Marilyn Robb, whose caring spirit, inspiration, and scholarship are highly appreciated; and my previous chair, Dr. Kerry Burner, who provided tremendous guidance and reached out to me during my most turbulent times in the EdD program. Finally, I thank Dr. Canosa, Mrs. Judy Dent, members of CUSAC, AECBOE, Ms. Victoria Lynch, Mrs. Gloria Perry, Ms. Cynthia Poole, Ms. Shayla Little, Pastor St. Ulysse, Ms. Elaine Nieves, and Dr. Samuel Chapman for their support and encouragement.

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Section 1: Introduction to the Study

The influence of music has been shown to be far reaching in its impact on the human condition (Miendlarzweska & Trost, 2014), socially, personally, and intellectually (Hallam, 2010). With regard to intellectual function in particular, research has shown that skills developed during musical training often transfer to other skills and cognitive functions, many associated with learning (Miendlarzweska & Trost, 2014). Music training has been shown to impact student achievement (Miendlarzweska & Trost, 2014). This impact most often has been identified specifically in relation to language arts (Miendlarzweska & Trost, 2014) and math (Helmrich, 2010).

Despite evidence that music education can have positive academic outcomes for students, many schools have reduced the extent to which they offer students music education or have stopped offering students music education entirely (Beveridge, 2010). This decrease in music education has been blamed, in part, on legislation requiring accountability for core subjects to the exclusion of music (Beveridge, 2010). Researchers such as Beveridge (2010) and Gerrity (2009) have called for advocacy on the part of music education. This study is aimed at generating data that could contribute to the scholarly discussion on this topic and serve as evidence to support the advocacy of music education in schools.

Problem Statement

Many school districts in the United States have reduced or eliminated music education from their school curriculums (Beveridge, 2010). This slow decay of music education in school curriculums has been driven, in part, by high-stakes testing motivated by the No Child Left Behind Act of 2001 (NCLB, 2002; Beveridge, 2010; Gerrity, 2009). Although arts is identified as a core academic subject, mandates for demonstrating annual yearly progress only include assessments in math, language arts, and science (NCLB, 2002). As a result, school administrators have focused their attention on those three core academic subjects (Beveridge, 2010; Gerrity, 2009). The reduction and elimination of music education from school curriculums is problematic because research has shown that music education can contribute to improved academic outcomes for students (Catterall, Dumais, Hampden, & Thompson, 2012; Helmrich, 2010). This means that students in schools where no music education is offered may not be succeeding academically as well as they could be. This is potentially the case in the school division of focus in this study, where music education only is offered in 10 of the 17 schools in the division. The focus school division in this study is the northeast division of a denominational private school system in the northeast United States.

Purpose of the Study

The purpose of this study was to examine the impact of music education on students' math achievement scores, particularly their total math scores on the Iowa Assessments. Based on the literature reviewed for this study that showed music education is related to student achievement in a variety of ways, it was probable that I would find at least some connection between music education and students' math achievement scores. It was my intent to generate data that could contribute to the scholarly discussion on this topic and serve as evidence to support or refute the advocacy of music education in schools.

Nature of the Study

This study was a causal comparative study conducted using archival data. One research question with associated hypotheses was developed for this study:

RQ: Is there an association between music education and students' Iowa Assessments math growth scores, while controlling for students' sex and socioeconomic status?

H_0: There is no significant association between music education and students' Iowa Assessments math growth scores, while controlling for students' sex and socioeconomic status.

H_1: There is a significant association between music education and students' Iowa Assessments math growth scores, while controlling for students' sex and socioeconomic status.

The main independent variable was music education, and the dependent variable was students' mathematics scores on the Iowa Assessments. Additional covariates were students' sex and socioeconomic status. No human participants were included in this study. A deidentified data set consisting of middle school students' mathematics scores was used to determine the impact of music education on student achievement. The data were accessed from a private school system in the northeast United States. Multiple regression was conducted to analyze the data.

Theoretical Framework

The theoretical framework used for this study is Miendlarzweska and Trost's (2014) model of musical instrument training (see Figure 1). In the model, Miendlarzweska and Trost depict two basic relationships. The first relationship is that musical instrument training is associated with skills (outcomes) in other academic, cognitive, and social domains; the second relationship is that six variables mediate the relationship between musical instrument training and outcome skills (Miendlarzweska & Trost, 2014).

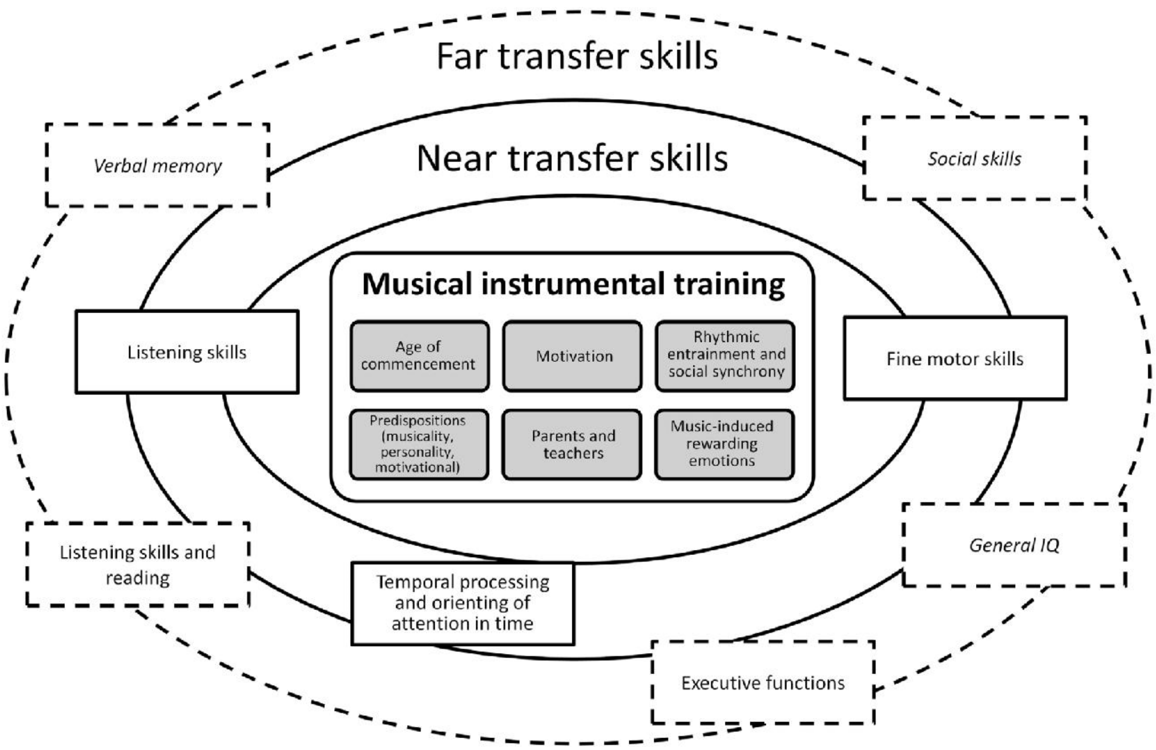

Figure 1. Miendlarzweska and Trost's model of musical instrument training. Adapted from "How Musical Training Affects Cognitive Development: Rhythm, Reward, and Other Modulating Variables," by E. A. Miendlarzweska and W. J. Trost, 2014, Frontiers in Neuroscience, 7(279), p. 5. Reprinted with permission from E. A. Miendlarzweska.

The impact of musical instrument training on outcome skills is mediated by (a) age of commencement; (b) motivation; (c) rhythmic entrainment and social synchrony; (d) predisposition (musicality, personality, motivational); (e) parents and teachers; and (f) music-induced rewarding emotions (Miendlarzweska & Trost (2014). Skills impacted by musical instrument training can be categorized as either near transfer skills or far transfer skills (Miendlarzweska & Trost, 2014). Near transfer skills are those considered to be closely related to playing a musical instrument; they are listening skills, fine motor skills, and temporal processing and orientation of attention in time (Miendlarzweska & Trost, 2014). Far transfer skills are those not considered to be closely related to playing a musical instrument; they are verbal memory, listening and reading skills, executive functions, general IQ, and social skills (Miendlarzweska & Trost, 2014).

This model is a valuable tool because it clearly depicts the extensive discussions and theories related to how musical instrument training can alter neurological processes (Miendlarzweska & Trost, 2014). The model is limited in that it does not analyze how participation in chorus or music theory education may be related to skills or other outcomes (Miendlarzweska & Trost, 2014). However, a relationship between chorus and music theory education and learning in classroom settings has been documented in the literature (Miendlarzweska & Trost, 2014). This model provides a useful starting point for a discussion of those relationships.

Operational Definitions

Math growth score: The dependent variable in this study was math growth score. This term refers to improvement on a student's Iowa Assessments total math score that occurred from one year to the next. Growth score was calculated by subtracting from the total math score of one school year the prior year's total math score.

Music education/instruction: The terms *music education* and *music instruction* are broad in scope and can be used to refer to a variety of instrumental (Hille, Gust, Bitz, & Kammer, 2011), vocal (Helmrich, 2010), or academic courses related to music (Elpus, 2013; Royal Conservatory of Music, 2015). Examples include "band, choir, orchestra, music theory, guitar, piano, etc." (Elpus, 2013, p. 6). For the purposes of this study, music education specifically will refer to band, chorus, and music theory classes.

Music(al) training: Music (al) training refers to training based exclusively on the use of a musical instrument (Merrett, Peretz, & Wilson, 2013; Miendlarzweska & Trost, 2014; Skoe & Kraus, 2013).

Assumptions and Limitations

Three assumptions were made in this study. First, it was assumed that music education was provided to students as indicated in the curriculums for band, chorus, and music theory. If the music education activities provided at the schools did not resemble the activities identified in the schools' music education curriculum, the findings in this study would be inaccurate. However, it is likely that the schools offered music education as described in their curriculums and that the results of this study do indicate the impact of music education on students' math achievement.

Second, it was assumed that the staff at the focus school administered the Iowa Assessments according to the standard protocols. If proper testing procedures were not followed, students' math achievement scores might not accurately reflect their true abilities, which would jeopardize the accuracy of the findings in this study. However, the focus school district in this study has been administering standardized tests throughout its history and strictly monitors test administration. It is most likely that the Iowa Assessment proctors followed the proper protocols for administering the tests and that the test results accurately reflected students' ability to perform the math functions they were designed to measure.

The third assumption was that the focus schools' records of students' music education were accurate and that these records were accurately paired with students' Iowa Assessments total math scores. The use of inaccurate data for analysis could have resulted in findings that do not accurately represent conditions at the focus school regarding music education and math achievement. However, the office staff who gathered the records of students' music education and paired them with students' math achievement scores are professionals who can be reasonably expected to generate accurate data.

There were three limitations noted for this study. The first limitation was that I was unable to control for students' potential music education prior to the 2012-2013 academic school year when the baseline data were collected. Because I used archival data, I was limited to the data available from the school district and could not determine if students had music education prior to 2012-2013. If students received music education prior to the 2012-2013 academic school year, the initial impact of music education on math achievement would not have been captured in the student's first year change scores. The second limitation was the use of a convenience sample. The sample was drawn from the private school system in which I am employed. Using a convenience sample was a limitation because, according to Salkind (2010), data collected using convenience samples are not generalizable to larger populations. The third limitation was that I did not include in this study covariates that have been found in the literature to mediate the relationship between education and student achievement. Variables such as structure of music training (Hash, 2011) and the type and extent of music education (Hallam, 2010) can affect the impact music education has on learning in other cognitive domains.

Scope and Delimitations

The scope of this study was limited to two variables: students' music education and students' Iowa Assessments math growth scores, and to two covariates: students' sex and socioeconomic status. Students' music education was delimited to participation in band, chorus, or music theory classes. Iowa Assessments math growth scores were delimited by growth score calculations based only on total math scores, as opposed to individual mathematics or computation scores. In order to obtain the data for my convenience sample, I delimited the sample to one cohort group that started in middle school in one private school district in the 2012-2013 academic school year. I then obtained the subsequent 2 years of data, 2013-2014 and 2014-2015, for the same participants.

Significance of the Study

This study is important because it generated data demonstrating a relationship between music education and student achievement in math. These results are supported by literature showing that skills gained through music education can transfer to learning in other domains (Hallam, 2010; Helmrich, 2010; Miendlarzweska & Trost, 2014) and that musical training is related to student achievement (Baker, 2012; Helmrich, 2010). Data from the literature coupled with data from this study could be used as evidence that music education is beneficial for students and could be used to promote social change in the focus school district. Data from this study could encourage school administrators who currently offer music education to continue to offer music education and could encourage school administrators who do not currently offer music education to do so. Results from this study may prompt teachers and parents to advocate for music education in schools.

Results from recent National Assessments of Education Progress show that, on average, students' math performance in Grades 4 and 8 is only slightly above the basic level of understanding (National Center for Education Statistics [NCES], 2015). In addition, students' average scores have declined since 2013 (NCES, 2015). These decreases were noted for students in all categories of proficiency: basic, proficient, and advanced (NCES, 2015). Furthermore, although the achievement gap between White and Black students decreased for students in Grade 4, this change occurred because scores for White students decreased (NCES, 2015). Both White and Black students' scores decreased to similar degrees for Grade 8 students (NCES, 2015). Similar deficiencies were noted for students in Grade 12, with no change in the gap between White and Black students between assessment years (NCES, 2013). Changes in these trends could be initiated through music education.

Summary

Researchers do not fully understand how music affects brain function (Miendlarzweska & Trost, 2014). They also do not understand how neurological processes triggered by engagement in musical activity can be transferred to cognitive functions in other domains (Miendlarzweska & Trost, 2014). However, researchers have identified links between music education and numerous academic, social, and cognitive outcomes (Miendlarzweska & Trost, 2014), including achievement in math (Helmrich, 2010). Despite this evidence, the inclusion of music education in school curriculums has declined (Beveridge, 2010). There is considerable agreement in the literature that this condition is based largely on mandates imposed by NCLB (Beveridge, 2010; Gerrity, 2009).

By conducting this causal comparative study to examine the impact of music education on students' Iowa Assessments math achievement scores, I have generated data that can be used to promote social change. Specifically, data generated in this study can be used to support the promotion of music education in this study's focus school district.

The remainder of this study is made up of four sections. Section 2 is a review of current literature related to music education and student achievement in math. Section 3 is a description of the study methodology. Section 4 is the presentation of the results based on the analyses I conducted to answer my research question. Section 5 is a discussion of the salient findings identified in Section 4, including a discussion of the implications of those data for social change.

Section 2: Literature Review

The purpose of this study was to examine the impact of music education on students' mathematics achievement scores. Topics related to those variables are presented in this literature review. First, factors that contribute to student achievement in math are introduced. Then topics related to learning are discussed. A complete discussion of the neurological processes involved in how people learn is beyond the scope of this study. However, a brief discussion of basic learning processes and the learning processes associated with music education is warranted. This discussion can provide a foundation of understanding for the discussion of how music education is connected to improved student outcomes in other cognitive domains, in particular math. The decline of music education and attitudes toward music education are also discussed.

The literature reviewed reflects the most current and pertinent research available on music education. Because the term music education can be used to represent engagement in instrumental, vocal, or music theory classes, I have maintained the original terminology from each study but distinguished the particular type of music education as necessary to provide clarity for the reader.

The information discussed in this section was accessed through multiple commercial and government databases. The databases used were Academic Search Premier, Google Scholar, ProQuest, eLibrary, ERIC, EBSCOhost, e-Reference Encyclopedia, and Education Research Complete. Key search terms were *music education, music connections, mathematics, curriculum, causal comparative design, at-*

risk, mathematics achievement, middle school, creativity, intelligences, ITBS, music integration, NCLB, music, and *motivation.*

Factors That Contribute to Students' Achievement in Math

The literature has indicated that music education may impact student achievement in math. This impact may be mediated by a variety of variables. Because the relationship between music education and student academic achievement in math is the focus of this study, this relationship is explored in more detail in the Student Achievement in Math section.

Researchers have found that other factors may contribute to students' achievement in math. To provide readers with a more comprehensive understanding of factors related to student achievement in math, some of the more notable factors are discussed here. Some factors appear to directly influence math achievement. Other factors are described as dependent on mediating factors. However, because none of these additional factors are variables in this study, they are presented here only briefly.

Math Anxiety

Math anxiety in female students has been linked to poor achievement in math (Beilock, Gunderson, Ramirez, & Levine, 2010). According to Beilock et al. (2010), this link is fostered by girls' belief that boys are better at performing math than girls are, a belief mediated by math anxiety of female teachers (Beilock et al., 2010). Math anxiety of female teachers did not affect levels of math anxiety or math performance for boys (Beilock et al., 2010).

Teaching Strategies

Bottia, Moller, Mickelson, and Sterns (2014) found moderate support in favor of the perspective that particular teaching strategies are related to kindergarten students' academic achievement in math. Of the 17 types of instructional practices identified, in particular, the use of group work, practice drills, hands-on learning activities, and music for teaching were found to impact student achievement (Bottia, Moller, Mickelson, & Sterns, 2014). However, students' race, household socioeconomic status, and academic readiness in math were mediating variables (Bottia et al., 2014).

Socioeconomic Status

Similar to Bottia et al. (2014), Barr (2015) found that socioeconomic status was related to math achievement. However, according to Barr, family health problems mediated this relationship. Among 9th grade students, Barr found that students from households characterized by low socioeconomic status experienced higher rates of family health problems, which directly impacted student achievement in math.

Stereotype Threats

Although no data exist on the impact of stereotype threats on performance in math for young students, stereotype threats have been found to impact performance in math for undergraduate college students (Tine & Gotleib, 2013). Stereotype threats occur when students' perceptions of stereotypical outcomes associated with demographic characteristics impact their performance (Tine & Gotleib, 2013). Although gender-based stereotype threat has not been shown to be associated with math performance, race- and income-based stereotype threats have been shown to be associated with math performance for undergraduate students (Tine & Gotleib, 2013). For both demographics, Black students and students from low-income households performed more poorly than White students and students from high-income households (Tine & Gotleib, 2013).

Learning Processes in Music Education

Neuroplasticity is the ability of neurons to react to stimuli and change (Spingath, Kang, Plummer, & Blake, 2011). Neural changes can be evident in the strengthening or growth of existing neural connections, the development of new neural pathways, or the generation of new neurons (Spingath et al., 2011). Any of these neural changes represent the process typically understood as learning (Spingath et al., 2011).

Neural changes occur differently depending on whether or not the learning is reinforced with a reward (Spingath et al., 2011). Neural change is more likely to occur when the neural change is prompted by rewards the learner interprets as positive (Spingath et al., 2011) or when the learner perceives the learning activity to be enjoyable (Hallam, 2010).

According to Pearce et al. (2013), leading researchers in the field of neuroscience have claimed that the perception and creation of music (i.e., learning music) employs multiple cognitive processes based on the musical concepts being studied. For example, timbral features of music have been found to be associated with learning only in certain areas of the brain responsible for cognitive processes, while tonal and rhythmic features of music have been found to be associated with learning in other areas of the brain as well as in areas responsible for cognitive, motor, and emotion processes (Alluri et al., 2012).

Variables Mediating Learning Processes in Music Education

The impact of music education on brain function is mediated by a variety of variables (Merrett et al., 2013). These variables impact the degree of learning through music education, and thus, theoretically, can impact the degree that music education can impact learning in other cognitive areas. These variables include sex of the student, absolute pitch, type of music training, and type of instrument played (Merrett et al., 2013). Two of the more impactful mediators of learning through music education are the extent of music training a person receives and the age when music training begins (Penhune, 2011).

The extent of music training a person receives can impact the degree to which learning occurs through music education (Wilson, Lusher, Martin, Rayner, & McLachlan, 2012). The more music training a person receives, the stronger the associated neural pathways become (Wilson et al., 2012). This condition is especially apparent when music education is considered in combination with family history of musical ability and the early age of commencement of music training (Wilson et al., 2012). Chobert, François, Velay, and Besson (2012) suggested that at least 6 months of music education was necessary before significant neuroplasticity transfer is observed.

The age when music training begins may affect the impact music training has on learning because the human capacity for experience-dependent auditory learning changes during the life span (Helmrich, 2010; Skoe & Kraus, 2013). Brainstem capacity for experience-dependent auditory learning is most sensitive between the ages of 5 and 14 and during old age (Skoe & Kraus, 2013). It is during these sensitive periods that learning will be most meaningful and enduring (Skoe & Kraus, 2013). The age when musical training begins is also related to responsiveness of the central sulcus of the brain, the part of the brain responsible for both motor and sensory learning (Li et al., 2010). Thus, a person's age when he or she begins training with a musical instrument may impact the extent of neural changes that occur in the person's brain. That neural changes associated with music training during a child's formative years are evident in later adulthood demonstrates that these changes can be long lasting (Skoe & Kraus, 2012).

Learning Transference: Music Education to Academic Outcomes

The neurological processes by which music education can impact other areas of learning are not clearly understood. However, research in the field of cognitive neuroscience may provide insight into this process. Two of the more prominent and interrelated ideas in the literature are presented here. They are the multifunctionality of brain domains and the strengthening of neural pathways responsible for learning in these domains.

Certain parts of the brain are responsible for specific functions, while other parts of the brain are multifunctional (Harold & Zatorre, 2012). It is through this capacity for multifunctionality that learning in music can be transferred to other cognitive domains (Alluri et al., 2012; Yuskaitis et al., 2015). According to Alluri et al. (2012), timbral, tonal, and rhythmic features of music are all associated with learning in areas of the brain responsible for various cognitive functions. By stimulating these areas of the brain through exposure to music, neural pathways located in this area of the brain are strengthened (Alluri et al., 2012). Because the neural pathways in these areas of the brain are developed, they may be better able to support cognitive function when learning activities in other cognitive domains require it.

Similar connections have been found to exist for other musical attributes as well. For example, pitch, a perceptual attribute of music, and speech are both processed in the part of the brain responsible for processing auditory information (Tsang & Conrad, 2011; Yuskaitis et al., 2015). Rhythm and basic auditory stimuli are processed in parts of the brain responsible for processing auditory information (Bishop-Leibler, Welch, Huss, Thomson, & Goswami, 2014). Auditory processing regions of the brain are enacted during decoding of linguistic syntax associated with the understanding and production of speech (Herdener et al., 2011) as well as with reading (Tierney & Kraus, 2013). Music education also is associated with the speed in which auditory working memory is updated in the brain (George & Coch, 2011) and strengthens neural pathways associated with selective auditory attention, a process that allows for the distinction between sounds, a person's voice in a noisy room for example (Strait & Kraus, 2011). The enhancement of neural pathways is evident in both adult musicians (Strait & Kraus, 2011) and children who receive music education (Strait, Parbery-Clark, Hittner, & Kraus, 2012). This evidence of brain multifunctionality further strengthens the music education/academic achievement link.

In some cases, a specific part of the brain, the arcuate fasciculus, for example, has been identified as being associated with the music education/academic achievement link. The arcuate fasciculus is an area of the brain that is responsible for both linguistic and musical functions (Halwani et al., 2011). By stimulating the arcuate fasciculus through music education, in particular vocal training, neural pathways located in this area of the brain are strengthened (Halwani et al., 2011). Because the neural pathways in the arcuate fasciculus have been developed, they may be better able to support linguistic function when activities require the use of this cognitive domain (Halwani et al., 2011).

Other areas of the brain have been found to be multifunctional as well. For example, the "Broca's area, premotor cortex, pre-SMA/SMA, left insular cortex, [and] inferior parietal lobe" (Schulze, Zysset, Mueller, Friederici, & Koelsch, 2011, p. 771) have been found to be responsible not only for tonal working memory used during music training but also for verbal working memory, which is used to engage in activities associated with speech. This multifunctionality is particularly relevant with regard to working memory associated with the coding of action-related sensorimotor stimuli (Schulze et al., 2011). The demonstrated relationship between tonal and verbal memory is evidence that increasing tonal working memory can help improve verbal working memory, which can be used to accomplish nonmusic-related tasks that require cognitive functioning (Schulze et al., 2011). Improved working memory in cortical areas of the brain responsible for cognition has been linked to increased attention to cognitive tasks (Pallesen et al., 2010). This connection supports the premise that music training can improve brain function in areas of the brain that are multifunctional, and in this way, music training can impact performance in other cognitive domains (Pallesen, 2010).

Not all researchers agree that isolated areas of the brain are responsible for the transference of learning in music to other cognitive domains. For example, Miendlarzweska and Trost (2014) suggested that the theory of dynamic attending can help explain how musical training can impact other cognitive functions. This concept was previously introduced in the Theoretical Framework section. Citing work from the last 30 years, Miendlarzweska and Trost explained that various brain processes associated with attention work simultaneously to recognize musical rhythms and that the repetition of this overall process of recognizing musical rhythms trains the brain to synchronize the use of these various attentional processes. As a result, the brain develops a subconscious capacity to use multiple attending processes simultaneously, a competence that can work subconsciously to accomplish other tasks in other cognitive domains (Miendlarzweska & Trost, 2014).

Mediators of Learning Transference: Music Education to Academic Outcomes

The impact of music education on academic outcomes is mediated by a variety of variables. Results of empirical studies conducted between 1967 and 2009 consistently have shown that the type of music education in which a student participates can impact the effect of music education on learning in other cognitive domains (Hallam, 2010). In addition, those results have shown that the extent to which a student participates in music education can impact the effect of music education on learning in other cognitive domains (Hallam, 2010). For example, early commencement of music education has been linked to improved verbal working memory (Hanna-Pladdy & Gajewski, 2012) and length of music training has been found to be a significant predictor of reading comprehension (Corrigall & Trainor, 2011), both far transfer skills.

The format of the music education experience also may be a mediating factor in the way music education impacts student achievement (Hash, 2011). Typically, students receive music education during elective periods; however, the students in Hash's study were pulled from academic classes to receive music education. Without a comparison group of students who received music education during an elective period, it was not possible to conclude that there was no negative effect on students' academic success as the result of decreased academic instruction resulting from being pulled out of class to receive music instruction. Based on the finding in his study, Hash suggested that the pullout format of music education may be a mediating factor between music education and resulting student achievement.

One critical mediator of the music education/student performance relationship is the degree to which the differing domains place demand on multifunctional regions of the brain (Patel, 2014). Music training has the potential to impact cognitive processes in other domains when both the music training and any second domain share a common cognitive processing region in the brain and when the demands placed on that processing region by music training are greater than the demands placed on that processing region by the second domain (Patel, 2014). This process is further mediated by the frequency of the music education, the degree to which a person feels a sense of reward from the music training, and the attention committed to the secondary cognitive task (Patel, 2014).

Characteristics of Students Who Receive Music Education

Students who receive education in the arts, including music, are more likely than their peers who do not receive music education to demonstrate a variety of positive characteristics. Students who receive education in the arts are more likely than their peers who do not receive education in the arts to read newspapers and participate in student government associations and school clubs focused on philanthropy (Catterall et al., 2012). Also, when compared to students who do not receive education in the arts, students who do receive education in the arts are more likely to volunteer (Catterall et al. 2012). In a comprehensive national study of participation in choral groups in particular, parents (*n* = 500) and teachers (*n* = 300) reported improved emotional stability and behavior for students who participate in choral groups (Chorus America, 2009). These differences can be interpreted as evidence that students who receive arts education are more civic minded than their peers who do not receive arts education (Catterall et al., 2012). In this capacity, arts education could promote good citizenship and contribute to the development of adults who are productive members of society.

Concerning students from low socioeconomic backgrounds in particular, when compared to students from low socioeconomic backgrounds who receive low levels of arts education, students from low socioeconomic backgrounds who receive high levels of arts education have better auditory and visual processing skills (Cohen, Evans, Horowitz, & Wolfe, 2011) and are more likely (a) to enroll in advanced math classes in high school (22% vs. 33%); postsecondary education (48% vs. 71%); and professionally based majors at the postsecondary level; (b) to attend a 4-year college (17% vs. 39%); (c) to earn an associate’s (10% vs. 24%) or bachelor’s (6% vs. 18%) degree; and (d) to plan to work in a professional field following completion of postsecondary study (Catterall et al., 2012).

Benefits Associated With Music

The benefits of music and engaging in musical activities are well documented in the literature (Bugaj & Brenner, 2011). Engaging in musical activities in general can elicit an extensive range of emotional responses (Loui, Bachorik, Li, & Schlaug, 2013), affect mood (Koelsch, 2014), promote creativity and imagination (Royal Conservatory of Music, 2015), and be implicitly rewarding (de Manzano, Harmat, Theorell, & Ullén, 2010; Nakahara, Fauria, Masuko, Francis, & Kinoshita, 2011). Because the creation of music typically involves multiple social functions, students who receive music education also are likely to benefit from improved social development (Koelsch, 2010; Kirschner & Tomasello, 2010). This same premise is true for students who participate in choral groups (Chorus America, 2009). In these ways, music can contribute to a person's overall well-being (Miendlarzweska & Trost, 2014).

Motor skills associated with instrument training can promote improved fine motor skills associated with complex motor processes (Spilka, Steele, & Penhune, 2010). Furthermore, skills developed as the result of training with a musical instrument have been shown to transfer to other skills and cognitive functions (e.g., Hallam, 2010; Miendlarzweska & Trost, 2014) including spelling (Hille, Gust, Bitz, & Krammer, 2011), reading (Bugaj & Brenner, 2011), and other skills and functions relevant to performance in the academic setting (Baker, 2012; Catterall et al., 2012). Music also can have a long-lasting impact on cognitive function, in particular, cognitive flexibility and processing speeds associated with cognitive functions (Hanna-Pladdy & MacKay, 2011). These benefits are especially evident for people who have participated in music training for more than 10 years over the course of their lifetimes (Hanna-Pladdy & MacKay, 2011).

Some of the benefits of art education, inclusive of music education, have been found to be especially evident among students from low socioeconomic households

(Catterall et al., 2012). When compared to students from low socioeconomic backgrounds who receive low levels of arts education, students from low socioeconomic backgrounds who receive high levels of arts education are more likely to have higher grade point averages (2.41 vs. 2.63; Catterall et al., 2012). These statistics underscore the potential for music education to close the achievement gap for students from low socioeconomic backgrounds.

Because the connection between music education and student achievement in math is the focus of this study, I discuss the connection between music education and student achievement in more detail in this section. First I discuss the impact of music education on student achievement in general. Then I discuss the impact of music education on student achievement in math specifically.

Academic Skills and Student Achievement

Music education may be positively associated with both cognitive functioning related to the academic setting and student achievement. To demonstrate the validity of this claim, results of several studies demonstrating these relationships are discussed in this section. Studies associated with academic skills are discussed first. Then studies associated with student achievement are discussed. Because student IQ is associated with student achievement, the connection between music education and IQ also is discussed in this section. Lastly, alternate perspectives are offered.

Academic skills. Music education has been found to be associated with skill in spelling (Hille, Gust, Bitz, & Krammer, 2011). In a study of 194 boys in the third grade, Hille et al. (2011) found that boys who played an instrument outperformed their peers who did not play an instrument in the top three quartiles of the testing ranges. Improved spelling performance for the boys who played an instrument was found for both general and specific spelling skills (Hille et al., 2011). Among students of early childhood age (4-6 years old) music education was found to impact verbal intelligence (Moreno, Bialystok, et al., 2011). In a study of 71 urban children from one city, Moreno, Bialystok, et al. (2011) found that even after receiving only short-term music education, 90% of the children in the sample experienced improved verbal intelligence. Moreno, Bialystok, et al. based their conclusion that music education impacts verbal intelligence on positive correlations they found between functional brain plasticity and verbal intelligence.

Music education also has been found to be associated with spatial-temporal reasoning (Rauscher & Hinton, 2011). "Spatial-temporal reasoning is the ability to visualize spatial patterns and transform them mentally over time in the absence of a physical model" (Rauscher & Hinton, 2011, p. 215). This cognitive skill is associated with the performance of math functions, especially calculating ratios and proportions, and, based on preliminary findings, may be mediated by teacher gender (Rauscher & Hinton, 2011).

During a comprehensive review of previous studies on the relationship between music training and auditory skills, Kraus and Chandrasekaran (2010) found sufficient evidence to conclude that music education improves auditory skills. This is likely because musical training provides students an opportunity to practice listening skills (Kraus & Chandrasekaran, 2010). The development of listening skills is essential for student learning because listening skills, as Baker (2012) pointed out, is a critical component of literacy. Music education also provides students the opportunity to read music, a task associated with visual cognitive processing mechanisms (Moreno, Friesen, & Bialystok, 2011). Through this opportunity, students who receive music education may develop greater visual-auditory capacity, a skill essential for reading (Moreno, Friesen, et al., 2011).

Music education also has been found to be related to academic self-concept, a personality trait associated with academic performance (Degé, Wehrum, Stark, & Schwarzer, 2014). The construct self-concept incorporates individual-, social-, and criterion-based factors (Degé et al., 2014). The relationship between music education and academic self-concept was found to be significant even after controlling for multiple variables, including gender, IQ, and socioeconomic status (Degé et al., 2014).

Student achievement. With regard to student achievement, researchers have found that music education is related to various types of measurements of achievement for diverse populations of students in different educational settings. Among a sample of Grade 8 students in Louisiana, Baker (2012) found that overall, students who received performance-based music instruction outperformed, on the Louisiana Educational Assessment Program, both students who received instruction in visual arts or dual arts as well as students who received no music instruction at all ($p < .001$). Test scores consistently were higher for students who received performance-based music instruction, when compared to the students in the other groups, regardless of the students' socioeconomic status (high-middle/low) or ethnicity (Black/White; Baker, 2012).

In Catterall et al.'s (2012) study, the researchers also reported study findings about Grade 8 students. Using data from the National Education Longitudinal Study of 1988; the Early Childhood Longitudinal Study: Kindergarten Class of 1998-1999; the Education Longitudinal Study of 2002; and the National Longitudinal Survey of Youth of 1997, Catterall et al. (2012) identified relationships between arts education and student outcomes in science and writing for students from low socioeconomic households. On average, students who received arts education scored 7 points higher on science tests and 3 points higher on writing tests (Catterall et al., 2012). That no differences were found in achievement scores for students from high socioeconomic households underscores the potential value of arts education for closing the achievement gap between students from low socioeconomic households and students from more financially stable households (Catterall et al., 2012).

Young, Cordes, and Winner (2013) suggested that participation in arts programs after school only was related to academic achievement when students had access to a musical instrument in their homes. It is likely that this outcome was evident because students who have access to a musical instrument in their homes likely would practice playing the instrument at home and, therefore, ultimately have more exposure to the effects of playing a musical instrument (Young et al., 2013). As such, students who have a musical instrument at home would be more likely to have higher levels of academic achievement (Young et al., 2013).

IQ. In addition to academic skills and academic achievement, music education may impact student IQ. Hille et al. (2011), who found that boys who played an instrument performed better on a spelling test than boys who did not play an instrument, also found that boys who played an instrument had higher nonverbal IQ scores than boys who did not play an instrument. This relationship remained significant even after Hille et al. excluded families without instruments from the analyses. Degé, Kubicek, and Schwarzer (2011) suggested that the relationship between music education and IQ is mediated by executive functions, most notably, inhibition and selective attention.

Alternate perspectives. Not all research findings support the premise that music education improves student achievement. Elpus (2013) claimed that the connection between music education and student achievement could not be substantiated even after accounting for multiple school- and individual-level mediating factors. In his study of 13,500 students who either received music education or did not receive music education, Elpus was unable to corroborate other researchers' claims of the music education/academic performance relationship even after conducting repeated analyses with various parameters. Rather, Elpus found that the most salient and reliable predictors of student achievement, measured by scores on the SAT and a standardized math test, were socioeconomic status, eligibility for special education services, and previous academic success.

Hash (2011), who studied only eighth grade band students, explored the impact of music instruction on students' overall achievement on the ACT Explore assessment. Three types of students made up the sample: students who never participated in band (n = 234), students who had dropped out of band prior to the eighth grade (n = 58), and students who had participated in pullout music instruction once a week for at least 5 years

($n = 61$). Results of group comparisons indicated that students who participated in band outperformed students in the other groups; however, there was no significant difference between the band students as a group and the highest-achieving students who never received music education. In addition, comparison of baseline scores indicated that students in the band group were more likely to be academically successful before beginning music education (Hash, 2011). Hash concluded it was more probable that higher achieving students were more likely to choose to be educated in music rather than that students who received music education experienced improvements in their academic performance. Student personality also may be a factor in students' decision to receive music education (Corrigall, Schellenberg, & Misura, 2013).

In a study to determine the impact of executive function on the relationship between music education and student IQ, Schellenberg (2011) came to the same conclusion as Hash. Schellenberg did find that students who received music education had higher IQs than their peers who did not receive music education, Schellenberg also determined that students who received music education also had more educated parents and participated in more nonacademic activities. These conditions, combined with data showing no impact of executive function on the relationship between music education and student IQ led Schellenberg to conclude that the connection between music education and student IQ was more likely to exist because students with higher IQs were more apt to participate in music education than their peers with lower IQs rather than because music education impacts student learning. Cabanac, Perlovsky, Bonnoit-Cabanac, and Cabanac (2013) also stressed that despite study results demonstrating a link between music education and academic performance, no causal relationship between the variables could be made.

Student Achievement in Math

Music education may be positively associated with student achievement in math. To demonstrate the validity of this claim, results of several studies demonstrating this relationship are discussed in this section. Based on previous research that demonstrated musicians use similar brain functions to process music and complete algebra problems, Helmrich (2010) hypothesized that students who participated in a music program, instrumental or choral, would perform better on tests of mathematical ability. Helmrich tested her hypothesis with 6,026 adolescence in Maryland using scores from the Maryland Algebra/Data Analysis High School Assessment. Helmrich found that students in the instrument group (mean difference = 13.34, $p < .001$) and the choral group (mean difference = 3.82, $p < .001$) had significantly higher algebra scores than the control groups of students who participated in no music program. Of the students in the study, Black students in the instrumental group and the choral group showed the greatest improvements over their counterparts who did not participate in any music program (mean difference = 18.87, $p < .001$ and mean difference = 9.39, $p < .001$, respectively; Helmrich, 2010).

In Baker's (2012) study, the mean math scores of students who received performance-based music instruction were 6 points higher than their counterparts who either received instruction in visual arts or dual arts or who received no music instruction at all. Math test scores consistently were higher for students who received performance-based music instruction, when compared to the students in the other groups, regardless of the students' socioeconomic status (high-middle/low) or ethnicity (Black/White; Baker, 2012).

Shin (2011) found a significant relationship between music education and academic self-concept in math for students from low-income neighborhoods. This means that after receiving music education, students perceived themselves to be more capable in math than before they received music education (Shin, 2011). Because academic self-concept in math is directly related to math achievement, these results are suggestive of an indirect relationship between music education and academic achievement in math (Shin, 2011).

The Decline of Music Education

Budget cuts in combination with lack of mandatory testing for music as a curricular subject has incentivized school administrators to focus their attention away from music education and toward tested subjects such as math, reading, and science (Beveridge, 2010). Evidence of this situation is demonstrated in work by both Gerrity (2009) and Beveridge (2010). In a study of Ohio principals, Gerrity (2009) found a decrease in music education in 43% of the schools that participated in the study (N = 179). The principals of the schools claimed that they had reduced the music curriculums in response to pressure to meet NCLB benchmarks in core subjects (Gerrity, 2009). In schools that maintain music education, some students still may not be able to participate because they may have to enroll in a remedial core subject class (Beveridge, 2010). In high-stakes testing environments, it is not uncommon for students who fail tests in mandatory testing subjects to be required to participate in remedial classwork, which typically is scheduled during the elective period in which they would have been able to receive music education (Beveridge, 2010).

Data collected by the National Center for Education Statistics (2011) do not support the conclusion that there has been a decrease in music education since the enactment of NCLB. According to the NCES, 94% of elementary schools and 90% of secondary schools offered music education during the 1999-2000 academic school year. During the 2009-2010 academic school year, no change was noted for elementary schools, and, in fact, the percentages of secondary schools that offered music education increased by 1% (NCES, 2012). These data do not support the idea that music education in public schools has decreased since the enactment of NCLB. Moreover, at the secondary level, the percentage of schools in which participation in at least one arts-related class (music, visual arts, dance, or drama/theatre) was required for graduation increased from 52% during the 1999-2000 academic school year to 57% during the 2009-2010 academic school year (NCES, 2012). Of the schools that required participation in at least one arts-related class, 30% of the schools required participation in more than one arts-related class (NCES, 2012).

Attitudes Toward Music Education

Music education has been minimized or removed from curriculums in many schools. However, evidence in the literature shows that parents and school administrators have positive attitudes towards music education. The details of several studies that demonstrate these positive attitudes are discussed in this section.

Data from an unpublished survey conducted for the Royal Conservatory of Music (2015) showed that parents have positive attitudes toward music. Parents perceived that music education (a) helps children maintain focus (93%); (b) improves creativity (92%), verbal memory (83%), speech/reading abilities (77%), IQ (75%), and overall academic achievement (82%); and (c) builds self-confidence/emotional strength (88%).

Vitale (2011) also found that parents, as well as students, nonmusic teachers, and music teachers perceived music to be beneficial. Specifically, these stakeholders perceived a link between music education and improved cognitive skills (Vitale, 2011). Students, parents, and nonmusic teachers perceived a connection between music and improved outcomes in math and science in particular (Vitale, 2011). Parents, nonmusic teachers, and teachers all perceived music education to be a critical element of society or education overall (Vitale, 2011).

Gerrity (2009) found that 93% of principals in Ohio schools had positive attitudes toward music education. Positive attitudes were considered those that were favorable, very favorable, and extremely favorable (Gerrity, 2009). Only 7% of principals had unfavorable attitudes toward music programs, and no principals were considered to have had very unfavorable or extremely unfavorable attitudes toward music programs (Gerrity, 2009). Despite the positive attitudes principals held toward the music programs, 25% of principals deemed the programs less important because music is not subject to mandated testing (Gerrity, 2009). Principals in schools with low academic ratings (emergency, watch, and continually improving vs. effective or excellent) were slightly more likely to have decreased the music programs at their schools (Gerrity, 2009). This condition likely was the result of the need to focus on tested subjects that contribute to the schools' academic ratings (Gerrity, 2009).

Summary

The literature reviewed for this study showed that learning through music education experiences occurs as the result of numerous and complex processes in the brain and that learning that occurs during music education experiences can be transferred to new learning experiences in other cognitive domains. This learning transfer is mediated by a variety of variables including type of music education to which student are exposed, the format of the music education experience, and the degree to which the differing domains place demand on multifunctional regions of the brain. Benefits of music education are many. Of primary interest in this study was the promotion of academic skills and the impact on academic achievement, specifically in math.

Section 3: Methodology

The purpose of this study was to determine the impact of music education on students' mathematics achievement scores. The details of the methodology used to make this determination are presented in this section. Specifically, this section includes a discussion of the study's research design and approach, setting and sample, instrumentation, and data collection and analyses processes. In addition, issues related to ethical research are discussed, including my role as the researcher in this study.

Research Design and Approach

A causal comparative research design was used for this study. Quantitative studies are appropriate when researchers want to conduct mathematical analyses for the purpose of identifying specific characteristics of a population or when they want to generate suppositions/test hypotheses and make generalizations about the data they have collected (Creswell, 2013). In this study, I conducted mathematical analyses in order to make suppositions about the data I collected. More specifically, I determined the impact of music education on students' mathematics achievement scores by conducting correlations.

A causal comparative study design is useful for determining the reasons a particular condition exists or phenomenon is occurring or for determining the causes associated with that particular condition or phenomenon (Gay, Mills, & Airasian, 2012). Although causal comparative research cannot be used to make definitive cause and effect statements about variables, it can be helpful for determining relationships between variables (Brewer & Kuhn, 2010). In this study, I sought to determine the relationship between music education and student outcomes as measured by Iowa Assessments mathematics scores using archival data that I did not generate through experimentation.

Data for this study were archival. Archival data are data that have been located and retrieved from archives to use for analysis (Corti, 2004). Although previously generated for explicit purposes, archival data can be used in new ways and to explore new relationships among the established data (Corti, 2004).

The data I used in this study were collected to assess student achievement. I used the data in a different way: to examine how music education might have impacted that achievement. Because music education at the school was already in place, it was necessary to use archival data to explore the potential relationship between music education and student achievement.

Setting and Sample

Data for this study were drawn from a denominational private school system in the northeast United States. The northeast division of the school system, which has schools in five states, is one of many divisions worldwide. The focus school system is made up of 17 schools, all of which serve students in Grades K-8 and some of which serve students in Grades K-12. The school's curriculum is standards-based and reflects the world view of the schools' operating religious body but also integrates national, provincial, and state standards. The curriculum includes typical core subjects such as mathematics, science, social studies, and language arts. The study of the Bible also is an important aspect of the curriculum. Music education is provided in some of the schools.

Although not mandatory at the schools that provide it, participation in music education is encouraged with incentives so that 100% participation is consistently reached.

Schools that offer music education begin offering opportunities for students as early as Grade 2, but typically, students start participating in music education at Grade 4 or 5. Music education in the focus school district is composed of chorus, band, and music theory. The choral curriculum regularly includes vocal training, which typically occurs once a week for a period of 45 minutes. During this time, students are taught the fundamentals of singing and the correct use of the voice via vocal exercises as well as how to choose music that is most appropriate for the students' vocal ranges. Students also participate in the school choir. Students who participate in band receive instruction in playing stringed, percussion, woodwind, and brass instruments and participate in the school orchestra once or twice a week for a period of approximately 30-45 minutes. In some schools, students also may take classes in music theory, which are offered once a week for 30 minutes.

Of the administrators at the 17 schools in the focus school district, administrators from 11 schools agreed to provide student data for this study. In six of the 11 schools, the curriculum included music education. In the other five schools, the curriculum did not include music education. From these 11 schools, I received data for the period 2013-2015 on 116 students with Iowa Assessments total math scores for all 3 years ($n = 116$) which I used in my analyses. I chose middle school grades because, according to the literature, nationally, middle schools have noticeably been cutting music education from the school curriculums for over a decade (Beveridge, 2010).

The sample for this study was a convenience sample. According to Salkind (2010), a convenience sample is a nonprobability sample that is chosen because it is easily accessible. An additional benefit of a convenience sample is that it is cost effective (Salkind, 2010). It is for these reasons that I chose a convenience sample in this study. The focus schools in this study were accessible to me because I am a teacher in the focus school district. One drawback of using a convenience sample is that the resulting data cannot be generalized to larger populations (Salkind, 2010). Although I acknowledge the results of this study will not be generalizable to the larger population, the study results will provide insight into the impact of music education among the schools the data represent. Based on these data, administrators from other schools in the district may be prompted to consider the value of music education at their own schools.

When considering a study's sample, it is important to consider sample size. Power analysis can be used during data analysis to determine the sample size required to detect statistical significance (Cohen, 1992). A power analysis conducted using a power of .90, an effect size of 0.15, and an alpha of .05 for three predictors in a multiple regression analysis indicated that the required sample size needed for this study was 99.

Instrumentation

The independent variable for this study was music education. The covariates were students' sex and socioeconomic status. No instrument was used to collect these data. The dependent variable in this study was the Iowa Assessments math growth score for students in Grades 7 (2014) and 8 (2015). Math growth scores were calculated for 2014 and 2015 using deidentified Iowa Assessments total math scores from 2013/2014 and

2014/2015, respectively. Total math score was chosen because its range would allow for the best demonstration of changes in scores. Archival total math scores data from 2013 (Grade 6, Iowa Assessments Level 12), 2014 (Grade 7, Iowa Assessments Level 13), and 2015 (Grade 8, Iowa Assessments Level 14) were generated originally by the focus school district using the Iowa Assessments Form E.

The Iowa Assessments

The Iowa Assessments is a group-administered, achievement-test battery that covers a range of subjects, including five aspects of language arts as well as math, science, and social studies (Hoover et al., 2011). The Iowa Assessments are developed and managed by the Iowa Testing Programs, at the University of Iowa. In addition to providing evidence of student progress over time (the test is appropriate to use for Grades K-8), the creators of the Iowa Assessments claim that it can help administrators make informed decisions related to student performance and outcomes (see Hoover et al., 2011). Because the focus of this study was the relationship between music education and student achievement in math, only Iowa Assessments math scores were considered in this study.

Math scores, according to Hoover et al. (2011), not only represent an assessment of students' ability to solve numerical problems but of their capacity for critical thinking as well. These skills are assessed using two tests: mathematics and computation, each of which are made up of subtests with varying numbers of questions at each grade/test level (Iowa Testing Programs, 2011). The mathematics test is made up of five subtests: (a) number sense and operations (18, 19, and 20 questions for Grades 6-8, respectively); (b) algebraic patterns and connections (11, 12, and 13 questions for Grades 6-8, respectively); (c) data analysis, probability, and statistics (10, 11, and 12 questions for Grades 6-8, respectively); (d) geometry (13, 14, and 15 questions Grades 6-8, respectively); and (e) measurement (13, 14, and 15 questions for Grades 6-8, respectively; Iowa Testing Programs, 2011). The computation test is made up of four subtests: (a) compute with whole numbers (10, 8, and 3 questions for Grades 6-8, respectively); (b) compute with fractions (11, 12, and 13 questions for Grades 6-8, respectively); (c) compute with decimals (9, 11, and 14 questions for Grades 6-8, respectively); and (d) algebraic manipulations (5 questions for Grade 8; Iowa Testing Programs, 2011).

Initial raw scores (correct answers) calculated for each of the nine subtests are used in conjunction with other information, such as norm- and criterion-referenced data, to calculate other scores, including grade equivalent, percentile rank, and developmental standard score (Iowa Testing Programs, 2011). Based on an equal-interval scale, developmental "standard scores are continuous across all levels and forms of a specific test" (Iowa Testing Programs, 2011). The total math score is calculated using the formula mathematics total = 0.67 x mathematics + 0.33 x mathematics computation (Iowa Testing Programs, n.d.b).

Validity and Reliability

The creators of the Iowa Assessments claimed that the instrument's trustworthiness can be based, in part, on the incorporation of over 80 years' worth of research into the development of the instrument (Hoover et al., 2011; Iowa Testing

Programs, n.d.a.). However, when conducting quantitative studies, researchers support the credibility of their findings by demonstrating they collected valid and reliable data, using a valid and reliable instrument.

Theoretically, “validity is a characteristic of the inferences that are drawn about phenomena by human agents and the actions that result from these inferences” (Rupp & Pant, 2007, p. 1033). That is, it is the use of a test for a particular purpose and the inferences drawn from the use of that test that can be validated, rather than the test itself (Sireci, 2007). This is why, typically, validity testing is conducted each time an instrument is used for a new purpose (Sawilowsky, 2007a). According to the definition of validity provided in the *Standards for Educational and Psychological Testing* (as cited in Bubany, 2007), “validity refers to the extent to which an intended interpretation of test scores is supported by evidence” (p. 1029). This definition assumes that construct validity is the only accurate assessment of validity because it can be supported by evidence related to instrument content and development as well as by empirically generated evidence of criterion-related validity (the relationship between variables typically demonstrated using correlations) represented using validity coefficients (Bubany, 2007). Construct “validity refers to the degree that a test measures what it purports to measure” (Sawilowsky, 2007a, p. 178). Validity refers to the accuracy of a measurement.

The Iowa Testing Programs (n.d.a) suggested that the validity of the Iowa Assessments can be considered with respect to the five types of evidence identified by in the *Standards for Educational and Psychological Testing:* test content, response processes, internal structure, relations to other variables, and consequences of testing. In its research guide, the Iowa Testing Programs discussed research and provided data as examples of such evidence. While the Iowa Testing Programs recognized that reliability coefficients could imply validity, it also recognized that other evidence is necessary. In this regard, the Iowa Testing Programs claimed to have employed a variety of methods for ensuring the validity of test content, including consideration of (a) current teaching practices, (b) national curriculums, (c) student populations, and (d) levels of cognitive development during instrument design and development phases as well pilot testing of all instruments.

Perhaps the strongest evidence of the validity of the Iowa Assessments has been demonstrated through results of predictive validity analysis, although this function was not a design consideration when the instrument was developed (Iowa Testing Programs, n.d.a.). Results from a number of studies in which validity was determined using correlation coefficients showed a range of scores (Iowa Testing Programs, n.d.a.). Correlation coefficients were calculated to examine the relationship between a variety of Iowa Assessment tests and other criterion variables, including scores from the Iowa Tests of Educational Development, achievement scores in subsequent grades in high school, high school grade point average, composite scores on the ACT assessment, and college grade point average (Iowa Testing Programs, n.d.a.). Scores ranged from .18 (Grade 4 predictor of grade point average in freshman year of college) to .84 (Grade 8 predictor of Grade 10 score on the Iowa Tests of Educational Development; Iowa Testing Programs, n.d.a.). The wide range of scores may have been due in part to the variability of the studies for which results were reported, in particular, lack of diversity among samples as well as small sample sizes (Iowa Testing Programs, n.d.a.). Although it was recognized that the real value of any assessment resides in the users' interpretation of its appropriateness in their particular setting (Iowa Testing Programs, n.d.a), overall, considering all the research evidence and consistent feedback from schools that use the Iowa Assessments, the Iowa Assessments are considered a valid means of measuring achievement (Iowa Testing Programs, n.d.a).

While validity refers to the accuracy of a measurement, reliability refers to a measurement that is consistently accurate. "Instrument reliability is the consistency that a test measures whatever it measures" (Sawilowsky, 2007a, p. 516). After developing Iowa Assessments Form E, the Iowa Testing Programs (2012) conducted reliability testing two times: in the fall of 2010 and in the spring of 2011. The Kuder-Richardson Formula 20 (KR-20) was used as the reliability coefficient (Iowa Testing Programs, 2012). Although various ranges of acceptable coefficient measures have been cited in the literature, makers of assessment tests have consistently disclosed KR-20 ranges between .85 and .95 or above as proof of instrument reliability (Sawilowsky, 2007b). The calculated reliability coefficients for mathematics, computation, and total Grades 6-8 are shown in Table 1. All of the KR-20 coefficients are above .85, which demonstrates the Iowa Assessments Form E is a reliable instrument with regard to measurement of mathematics, computation, and total math skills assessment.

Table 1

Reliability Data for Iowa Assessments Form E: Developmental Standards Scores for Mathematics, Computation, and Total Math (Fall 2010 and Spring 2011)

Grade/Test level	Mathematics	Computation	Total math
Grade 6 (Level 12)			
Fall	.906	.866	.933
Spring	.914	.889	.940
Grade 7 (Level 13)			
Fall	.930	.874	.946
Spring	.939	.899	.954
Grade 8 (Level 14)			
Fall	.934	.882	.950
Spring	.939	.899	.954

Data Collection and Analysis

Because the data I used in this study were archival, student demographic data and assessment scores, it was necessary to request access to these data from the school district under study. Initially, I sent a letter of request to the superintendent of the school district. Once I had permission from the superintendent to access the student scores, I contacted the principals of 11 schools in the district and requested their participation as well.

The principals of each school sent the student demographic data to the district education office where it was matched to students' Iowa Assessments total math scores using student names. An administrative assistant at the district education office then forwarded the deidentified data to me in Excel format via email.

SPSS (Version 20.0) for Windows was used to analyze the data in this study. Both descriptive and inferential statistics were calculated. For the descriptive statistics, frequencies and percentages were calculated for student demographics, and mean, standard deviation, skewness, kurtosis, and minimum and maximum values were calculated for the 2013 Iowa Assessments baseline total math score and both the 2014 and 2015 Iowa Assessments math growth scores. Growth scores were calculated by subtracting the total math score of the previous school year from the current year's total math score.

For the inferential statistics, correlations were calculated using ordinary least squares regression. The independent variable was music education. The covariates were students' sex and socioeconomic status. The dependent variable was the Iowa Assessments math growth score. Data for the three independent variables were garnered from student records by the office of education. Music education was determined based on student enrollment in chorus, band, and music theory classes and measured using a nominal scale: *yes* = Y, *no* = N. Socioeconomic status was determined using the proxy measure participation in the free/reduced-price lunch program (student records) and measured using the same nominal scale: *yes* = Y, *no* = N. Students' sex was measured using a nominal scale: *male* = M, *female* = F. The Iowa Assessments math growth scores were measured on a continuous interval scale.

Considerations for Ethical Research

As the primary investigator in this study, I was responsible for obtaining the data set and analysis of the data used in this study as well as for ensuring this study was conducted following ethical research practices. I am a teacher in the focus school district; however, because I used only archival data, there was no interaction with human participants. This means that my position as a teacher in the focus school district had no potential for influencing participation in my study. Also, before collecting any data, I sought and received approval to conduct my study from Walden University's Institutional Review Board (#06-23-15-0072950) as well as from the district superintendent. Data I received were deidentified; therefore, there was no risk of violation of participants' rights or exposure of participants' identities. However, I did keep all data associated with this study either on my password protected computer or in a locked filing cabinet, both of which were in my home office.

Summary

A quantitative causal comparative research design was used for this study. Data used in this study were archival. Specifically, through the school district's office of education, I accessed deidentified demographic data (students' sex and socioeconomic status) and Iowa Assessments total math scores for students in middle school for the 2013 (Grade 6), 2014 (Grade 7), and 2015 (Grade 8) academic school years. Total math scores were determined based on nine subtests. For this study, I used the total math score data to calculate growth scores for 2014 and 2015. Descriptive statistics were calculated for the demographic data, and both descriptive and inferential statistics were calculated for the Iowa Assessments math growth scores.

Section 4: Results

In this section, I present the results of my data analysis. First, I present the descriptive statistics for the student demographics as well as for the 2013 Iowa Assessments baseline total math score and both the 2014 and 2015 Iowa Assessments math growth scores. Then I present the inferential statistics for the regression analyses of Iowa Assessments math growth scores.

Descriptive Statistics

Data from 116 students were included in the analyses for this study. The descriptive statistics for these students are presented in Table 2. The majority of students represented in this study did not receive music education (n = 72, 62.1%). All students in schools in which music education is offered participated in music education of some sort. This means that the students represented here as not receiving music education did not receive music education because no music education was offered at their schools. Although six schools offered music education compared to five schools that did not, there were fewer students who received music education than students who did not. The reason for this anomaly is that there were more students who attended schools that did not offer music education than there were students who attended schools that did. This condition helps explain why there were more male students who did not receive music education (n

= 40) than there were male students who did receive music education (n = 24) and, similarly, why there were more female students who did not receive music education (n = 32) than there were female students who did receive music education (n = 20).

Nonetheless, males and females were approximately equally represented in both the group that received music education and the group that did not.

Table 2

Descriptive Statistics - Participant Profile

	Music		No music		Total
Variable	*n*	%	*n*	%	*N*
Total	44	37.9	72	62.1	116
Gender					
Female	20	38.5	32	61.5	52
Male	24	37.5	40	62.5	64
Free/reduced-price lunch					
No	42	40.8	61	59.2	103
Yes	2	15.4	11	84.6	13

Of the students represented in this study, only 11% received free or reduced-price lunch, which suggests that 89% of the school population is at least middle class. This would be expected because the students in this study were attending private schools. It is reasonable to assume that if parents could afford the tuition for the private school, they would not likely be eligible to receive free or reduced-priced lunch. Additionally, there were scholarship opportunities and discounted tuition rates available to students who were from low socioeconomic backgrounds, which might explain the attendance of students who were eligible for free or reduced-price lunch.

Baseline total math scores and growth scores calculated after the first and second years of music education are presented in Table 3. The results indicated that students who received music education had a higher mean baseline score ($M = 215.66$, $SD = 22.05$) than students who did not receive music education had ($M = 210.32$, $SD = 20.69$). Mean growth scores for 2014 and 2015 also were greater for students who received music education ($M = 13.57$, $SD = 12.60$, and $M = 22.45$, $SD = 11.90$; respectively) when compared to students who did not receive music ($M = 8.15$, $SD = 10.69$, and $M = 19.38$, $SD = 13.23$; respectively).

Inferential Statistics

Before conducting an analysis to determine if there were significant differences in Iowa Assessments math growth scores between students who received music education and students who did not receive music education, I conducted a t test to determine whether there was a significant difference in baseline total math scores between students in the two groups. The mean 2013 Iowa Assessments total math score for students who received music education was 215.66 ($SD = 22.05$), and the mean score for students who did not receive music education was 210.32 ($SD = 20.69$). The results of a two-tailed, independent groups t test indicated that there was no significant difference in mean scores between the two groups—$t(114) = -1.316$, $p = .191$. With this evidence, I proceeded to conduct regression analyses on the growth scores for 2014 and 2015.

Table 3

Baseline Total Math Scores and Growth Scores Data After Year 1 and 2

Variable	*N*	*M*	*SD*	Skewness	Kurtosis	Range Min.	Range Max.
			Total math scores				
2013 Iowa Assessments							
Music education	44	215.66	22.05	0.04	-0.57	167	261
No music education	72	210.32	20.69	0.48	-0.57	173	255
			Growth scores				
2014 Iowa Assessments							
Music education	44	13.57	12.60	0.24	0.58	-22	50
No music education	72	8.15	10.69	0.21	0.28	-18	40
2015 Iowa Assessments							
Music education	44	22.45	11.90	-0.38	0.30	-8	48
No music education	72	19.38	13.23	0.01	0.28	-10	51

Note. *N* = 116.

To conduct the multiple regressions, I entered the three independent variables in two blocks. In the first block, I entered the demographic variables of students' sex and free and reduced-price lunch using the Stepwise entry method. These two variables temporally preceded the third independent variable, music education. Additionally, the regression model containing these two additional demographic variables (i.e., covariates) besides the independent variable of interest (i.e., music education) was exploratory in nature. The Stepwise method is appropriate to use when generating an exploratory model (Field, 2005), since there was no clear evidence in the literature that might suggest interaction effects between students' sex or free and reduced-price lunch and music education.

In the second block, I used the Enter method to introduce the main independent variable, music education, during the second step of the analysis. Because music education was the variable of focus for hypothesis testing, the Enter method was appropriate to force the variable to remain in the model. Results of these analyses are presented in Table 4.

Table 4

Multiple Regression Coefficients for Music Education and Socioeconomic Status on Iowa Assessments Math Growth Scores for 2014 and 2015

Independent variable	*B*	*SE B*	β	*t*	*p*
2014 growth score[a]					
Music education	5.42	2.20	.23	2.47	.015
2015 growth score[b]					
Music education	3.98	2.43	.15	1.64	.104
Free/reduced-price lunch	8.37	3.74	.021	2.24	.027

[a] $R = .23$, $R^2 = .05$, adjusted $R^2 = .04$, $F(1, 114) = 6.11$, $p = .015$.
[b] $R = .24$, $R^2 = .06$, adjusted $R^2 = .04$, $F(2, 113) = 3.34$, $p = .039$.

Results of the first regression model for 2014 growth score indicated that music education was a significant predictor of Iowa Assessments math growth scores $F(1, 114) = 6.11$, $p = .015$. This variable accounted for 4% (adjusted $R^2 = .04$) of the variance in the Iowa Assessments math growth score for 2014. Neither students' sex nor free or reduced-price lunch were significant predictors of Iowa Assessments math growth scores.

Results of the second regression model for 2015 growth scores indicated that at least one of the variables in the two-variable model, socioeconomic status and music education, was a significant predictor of Iowa Assessments math growth scores $F(2, 113) = 3.34$, $p = .039$. This means that taken together, socioeconomic status and music education accounted for 4% (adjusted $R^2 = .04$) of the variance in the Iowa Assessments math growth score for 2015. Of the two variables in the overall model, only socioeconomic status was a significant predictor of Iowa Assessments math growth scores ($p = .027$).

Summary

Descriptive data of the 116 students for whom archival data were retrieved indicated that the majority of students did not receive music education ($n = 72$, 62.1%). Of those students who received music education, 45.5% were male and 54.5% were female. Only 11% of the students received free or reduced-price lunch. Mean baseline scores for total math and growth scores for 2014 and 2015 were higher for students who received music education.

Results of the *t* test indicated that there was no significant difference in mean baseline total math scores between students who received music education and students who did not receive music education. Results of multiple regression analyses indicated that only music education was a significant predictor of Iowa Assessments math growth scores for 2013-2014. For the 2014-2015 school year, only socioeconomic status was found to be a significant predictor of Iowa Assessments math growth scores. Based on these results, the alternate hypothesis, that there is a significant association between music education and students' Iowa Assessments math growth scores while controlling for students' sex and socioeconomic status, was accepted.

Section 5: Discussion, Conclusions, and Recommendations

The impetus for this study was a concern over the continual decline of music education offered to students in schools, both public and private, throughout the United States. This concern was based on the literature that showed a connection between music education and student achievement in math. This concern also led me to consider the connection between these two variables in the private school setting in which I am employed. I also questioned how students' sex and socioeconomic status might be related to the two main variables. To explore these possible connections, I conducted a causal comparative study using archival data of student enrollment in music education and Iowa Assessments math growth scores.

Results of *t* tests indicated that there were no significant differences in baseline Iowa Assessments math scores between students who received music education and those who did not. Two multiple regression models were tested to determine the relationships between the variables. Results of the regression for the first model indicated that only music education was a significant predictor of Iowa Assessments math growth scores $F(1, 114) = 6.11$, $p = .015$. Results of the regression for the second model indicated that only socioeconomic status was a significant predictor of Iowa Assessments math growth scores $F(2, 113) = 3.34$, $p = .039$.

Interpretation of Findings

Results of this study indicated that there was an association between music education and student achievement in math, in particular, student achievement on the Iowa Assessments math test. This finding was evident for only the 2013-2014 school year. In general, this result is supported in the literature. Researchers have found that when compared to students who receive no music education, students who receive music education have greater academic-related skills (Baker, 2012; Degé et al., 2014; Hille et al., 2011; Kraus & Chandrasekaran, 2010; Moreno, Bialystok, et al., 2011; Rauscher & Hinton, 2011) and higher levels of academic achievement (Baker, 2012; Catterall et al., 2012; Degé et al., 2014; Hille et al., 2011; Young et al., 2013). A connection between music education and student self-concept in math, which is connected to academic achievement in math, also has been found (Shin, 2011). Although no researchers in the current literature reviewed for this study specifically used math scores on the Iowa Assessments to determine the relationship between music education and student achievement, they did use valid measurements of math achievement. Helmrich (2010) used scores from the Maryland Algebra/Data Analysis High School Assessment, and Baker (2012) used scores from the mathematics portion of the Louisiana Educational Assessment Program. Shin (2011), who measured self-concept in math and cited its connection to academic achievement in math, used the Self-Description Questionnaire.

As indicated in Miendlarzweska and Trost’s (2014) model of musical instrument training, it is possible that students’ math scores improved because they experienced improvement in near and far transfer skills. For example, it is possible that music education helped improve students’ listening skills (Kraus & Chandrasekaran, 2010), verbal memory (Schulze et al., 2011), executive functions (Degé et al., 2011), and general IQ (Hille et al., 2011), all skills which might help students learn better in their math classes.

The impact of other factors on students' math performance in this study must be considered. The processes involved in translating experiences and learning gained through music education to other cognitive domains is complex. Researchers have identified a number of variables that could impact the processes involved in translating experiences and learning gained through music education to other cognitive domains. Thus, it is possible that improvement in students' performance found in this study may have been the result of many factors, including the length of time students received music education (Hallam, 2010). Because I was not able to account for music education students may have received prior to the collection of baseline data in the 2012-2013 school year, it is possible that students may have received more music education than I was able to account for. Type of music education also may impact the degree to which music education impact student achievement in other cognitive domains (Hallam, 2010). It is possible that the variety of options for music education considered in this study (band, chorus, and music theory) contributed to the findings in this study.

Results also indicated that socioeconomic status was related to student achievement in math. This finding was only observed for the 2014-2015 school year. Results in the literature have shown that socioeconomic status was related to student achievement in math (Bottia et al., 2014) as well as better auditory and visual processing skills (Cohen, Evans, Horowitz, & Wolfe, 2011) and overall academic achievement and outcomes (Catterall et al., 2012). However, no comparison was made in this study between students from low- and high-income households, so these findings from the literature do not help to explain why the first year's regression model did not identify socioeconomic status as a significant predictor of math achievement. The student scores used in this study were collected for the same students over the three year period the data represented. Although it is possible that students experienced changes in their socioeconomic statuses, it is not likely that enough students experienced such changes so that one year would show the impact of socioeconomic status on math achievement but the other year would not. Young et al. (2013) suggested that socioeconomic status may be a factor of student participation in music education because financial constraints might keep families from being able to purchase an instrument for their children. However, this is not the case at the study site. Not only do students have the option to participate in chorus or music theory classes, students who wish to participate in band and do not have an instrument are provided one to use during the band period. While students who do not have an instrument at home would be restricted with regard to the extent of practice time they could accumulate (Young et al., 2013), and the extent of music practice may impact the degree to which music education can impact achievement (Hallam, 2010), I did not explore this connection in this study. Perhaps further study in this area will help explain this anomaly.

Implications for Social Change

The diversity of topics discussed in the literature review conducted for this study underscores the complexity of the nature of the music education/academic achievement relationship. Processes related to (a) how learning occurs, (b) how learning occurs during music education, and (c) how learning that occurs during music education is transferred to learning experiences in other cognitive domains must be considered when examining the relationship between music education and student academic achievement not only in math but for all academic and nonacademic subjects alike. That these processes are complex and often not well understood compound the difficulty in studying the relationship between music education and student achievement in math.

Regardless of the challenges of studying the relationship between music education and student achievement in math, every new study on this topics contributes knowledge to the field in some capacity and, through this contribution, gains value. Although this study was limited by the use of a convenience sample and the potential impact of both students' prior experience and mediating factors on the relationship between music education and student achievement in math, this study is valuable. Through this study, I may impact social change in critical ways. In particular, I may prompt dialog and action among stakeholders which may prompt the implementation of music education in schools. Ultimately, student access to music education could help improve student outcomes, especially for minority students.

Not all schools at the study site offer students music education. The lack of opportunity for students to participate in music education is problematic because, as shown in the literature, when compared to students who receive no music education, students who receive music education have improved academic-related skills (Baker, 2012; Degé et al., 2014; Hille et al., 2011; Kraus & Chandrasekaran, 2010; Moreno, Bialystok, et al., 2011; Rauscher & Hinton, 2011) and higher levels of academic achievement (Baker, 2012; Catterall et al., 2012; Degé et al., 2014; Hille et al., 2011; Young et al., 2013). Recognizing the potential for music education to improve academic outcomes for students, researchers and music advocates (e.g., Baker, 2012; Kraus & Chandrasekaran, 2010) have expressed the need for stakeholders to reassess the role of music education in school curriculums. By sharing the results of this study with stakeholders at the study site, I may educate those stakeholders as to the value of music education for students and raise awareness of the need to take action. As a result, the results of this study may prompt dialog among students, parents, teachers, administrators, and community members who may then begin to work together to generate change in the school district.

By conducting this study, I have generated data that demonstrate there is a significant connection between music education and student achievement in math particularly for students in six of the district schools in this study that provide music education. Using these data, I may strengthen the conviction of school administrators who provide music education in their schools with regard to the value of doing so. Also, I may encourage school administrators who do not provide music education in their schools to do so. If all schools in the school district provide music education for their students, it is likely that student achievement will improve for students who currently do not receive music education and students who currently receive music education may continue to gain the benefits associated with music education.

Moreover, the impact of music education on academic achievement has been found to be especially relevant for ethnic minority students (Helmrich, 2010), while the impact of music education on self-concept in math, a mediating factor of math achievement, has been found to be especially relevant for students from low-income households (Shin, 2011). Black students and students from low-income households typically perform more poorly than White students and students from high-income households, respectively (Tine & Gotleib, 2013). Based on this insight, increasing opportunities for all students to receive music education may offer a means to close the achievement gap for minority and low-income students.

As a result of this study, teachers may be made aware of the potential they have to create change in their schools by advocating for music education. Teachers may work together to present a unified voice to promote the inclusion of music education at their schools. Teachers, through such advocacy, may become a driving force of change at the study site and ultimately help all students achieve to their fullest capacity.

Recommendations for Action

Despite the inconsistencies in the literature regarding the ways in which music education can impact learning and the potential for multiple variables to mediate the impact of music education on learning in other cognitive domains, the literature clearly shows a connection between the two concepts. Based on this understanding, researchers have supported the endorsement, restoration, and proliferation of music education in schools.

Although terminology in NCLB (2002) identified arts as a core academic subject, mandated subject testing to demonstrate annual yearly progress does not include assessment of the arts. However, in the 5 years prior to this study, the executive branch of the government has begun to demonstrate support for including arts as an integral part of a student's education. Specifically, in 2010, the United States Department of Education

(USDOE) presented “A Blueprint for Reform,” a plan for the reauthorization of NCLB that was focused on improving the overall quality of education students receive. One main strategy for accomplishing this goal is to provide students with a complete education, one that includes study in the arts (USDOE, 2010). In 2015, the Senate’s version of the reauthorized Elementary and Secondary Education Act, Every Child Achieves Act of 2015 (ECAA), and the House of Representative’s version, the Investing in Student Success Act of 2015, were passed by both houses and moved to a congressional conference committee so the two versions can be merged for presentation to President Obama to sign into law (Congress.gov, 2015). Like NCLB, ECAA (2015) also identifies art as a core subject but does not require mandatory state assessment for the subject. For this reason, advocacy for music education must be supported.

Gerrity (2009) claimed that the survival of music programs depends on the efforts of music advocates who must implement initiatives to promote relationships between parents and communities and through these relationships, convey the value of continued music education for students. Cole (2011) made similar suggestions regarding teacher engagement with families and the community as a means of advocating for music education. As such, I recommend that music educators in the schools in the focus school district that have music programs form a task force to advocate for the continuation of music programs in the schools where they exist and the implementation of music programs where they are lacking.

Beveridge (2010) called upon music educators to lobby their school administrators and legislators to consider testing in music programs. Inclusion of music in high-stakes testing would likely elevate its perceived value by school administrators and other stakeholders and ensure a place for music in every school's curriculum. For this reason, I recommend that the task force of music educators in the focus school district advocate for testing of music as part of a core curriculum.

It is possible that support could be generated for the endorsement, restoration, and proliferation of music programs in schools. However, without adequate financial support, music programs will not be able to be developed or sustained. Beveridge (2010) suggested that training music educators to apply for grants and federal funding was a first step in rebuilding a school budget capable of supporting a music program and appropriate testing of that program. I concur with this perspective and suggest that steps be taken in the focus school district to train music educators in this capacity.

Recommendations for Further Study

Based on the limitations noted in this study, I offer several suggestions for further study. This study was limited by my inability to control for students' potential music education prior to the 2012-2013 academic school year when data I used for baseline data were collected. My inability to control for this variable was a limitation because the extent of a person's music education can impact the degree of learning that occurs as the result of that music education (Wilson et al., 2012). In turn, the degree of learning that occurs as the result of that music education, theoretically, can impact the extent of learning transfer to other cognitive domains through near and far transfer skills (Alluri et al., 2012; Hallam, 2010; Halwani et al., 2011; Miendlarzweska & Trost, 2014). Therefore, it is important to consider students' prior music education experiences when analyzing the relationship between music education and students' academic outcomes. Because it is possible that my study results did not capture the full impact that music education may have had on the students in my study, I recommend that this study be repeated to control for this covariate. Data on students' prior music education could be generated using a survey that could be distributed to students and/or parents.

This study also was limited by the sampling method. In part because I used a convenience sample, I was unable to generalize my data to larger populations of students. Because insight about how music education impacts student learning could be valuable to administrators in various academic institutions at the state and local levels, I suggest further study be conducted using larger samples of students from across the United States.

Many variables may impact the degree of learning transfer that occurs between learning acquired in the music education setting and learning acquired in other academic settings. These variables include gender, absolute pitch, type of music training, and type of instrument played (Merrett et al., 2013) as well as the structure of music training (Hash, 2011), the extent of music training a person receives, and the age when music training begins (Penhune, 2011). Excluding students' sex, these variables were not considered in this study. For this reason, I suggest further research be conducted to determine how these variables may impact the music education/math performance outcomes for students at the study site. Additional demographic variables also could be considered.

Conclusion

Skills developed as the result of training with a musical instrument have been shown to transfer to other skills and cognitive functions (Hallam, 2010; Miendlarzweska & Trost, 2014). Because the creation of music typically involves multiple social functions, students who participate in music programs are likely to benefit from improved social development as well (Koelsch, 2010). Engaging in musical activities also can elicit an extensive range of emotional responses (Loui et al., 2013), affect mood (Koelsch, 2014), promote creativity and imagination (Royal Conservatory of Music, 2015), and be implicitly rewarding (de Manzano et al., 2010; Nakahara et al., 2011). In these ways, music can contribute to a person's overall well-being (Miendlarzweska & Trost, 2014) and help young people develop into educated citizens (Baker, 2012).

Various forms of music education have been found to be associated with improved academic performance when compared to no music education (e.g., Baker, 2012). In some cases, these outcomes have been noted specifically with regard to academic performance in math (Baker, 2012; Helmrich, 2010). Furthermore, improved academic outcomes connected to music education have been shown to be consistent across socioeconomic and ethnic boundaries, and in fact, potentially more impactful for students from low socioeconomic households (Baker, 2012). It is through these relationships that music education may have a positive impact on the lives of all students, but in particular, it may offer a means of closing the achievement gap for students from low income and minority households who currently lag behind their peers with regard to academic outcomes (Baker, 2012). Although school efforts to improve student outcomes can be successful when they are focused on improving teaching methods (Hiebert & Morris, 2012), teacher productivity (Adelman & Taylor, 2011), and building school/community partnerships (Sheldon, Epstein, & Galindo, 2010), based on the literature and the data generated in this study, the potential for music education to be used as a means of improving student achievement should not be overlooked. Researchers must continue to explore and better understand the relationship between music education and student achievement, and parents and teachers should be encouraged to take active roles in advocating for music education in their schools. In these ways, stakeholders can ensure that all students are provided the opportunity to receive music education and all its academic and social benefits.

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