Title
Differences in Mathematics Scores Between Students Who Receive Traditional Montessori Instruction and Students Who Receive Music Enriched Montessori Instruction

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Montessori educators and parents are pondering the kind of education our children need to become responsible and productive members of a global society. In order to create the kind of futuristic thinking necessary to cope with our ever-changing world, Pitman (1998) suggests that higher order thinking processes deserve attention now, and an arts-rich curriculum can provide a vehicle for creative problem solving and motivation. Sadly, the value of music in educating the young child is not being recognized, and despite the amount of literature available regarding the effect of music instruction on academic achievement, little has been written on different Montessori music pedagogies and their effectiveness. The potential to learn is never greater than at the moment of birth, and what children learn in the first five years of life forms the foundation for all subsequent educational development (Olsho, 1984). Olsho believes that early experiences are crucial to the developing architecture of the young brain, and research indicates that music plays an important role in the brain development of a child. Because neural connections are responsible for all types of intelligence, a child's brain develops to its full potential only with exposure to the necessary enriching experiences in early childhood. Young children need to develop the foundation for their listening and singing music vocabulary, just as they develop the foundation of their listening and speaking language

vocabularies long before entering school. A child's loss of opportunity during this time cannot be corrected, and, unfortunately, no amount of compensatory education at a later time will be able to offset this handicap completely (Gordon, 2003).

The Montessori method was conceived as an indirect approach to learning, presenting a comprehensive view of the child (Davenport, 1987). Montessori regarded the classroom as a laboratory for observing children and testing and retesting ideas and aids to their growth. She approached education as a scientist and pursued her ideas with an open mind, always with strong respect for the child as an individual. The method was designed to develop the whole personality of the child at a natural rate of progress, and thus free the potential for self-development within a prepared environment. The Montessori curriculum did not place restraints on the student's ability and provided manual and physical activity through use of concrete and abstract experiences to help gain mastery of oneself and environment. The materials allowed the child to explore the world through various senses and develop confidence and competence while working from simple to the more complex (Havis, as cited in Hainstock 1997).

Montessori embedded music in her approach with a variety of stimuli, such as listening, singing, playing, body expression, and, above all, by creating special sets of materials (Miller, 1999). These

materials, the Bells and Tone bars, designed with the collaboration of Signorina Macheroni, a music specialist, are elementary age appropriate. After having innovated a methodology for working with children with disabilities, Montessori started her Casa Dei Bambini in 1907 in Italy. In the 1950's American educator Nancy Rambush led a movement of renewal, and Montessori education spread as an independent school movement. Montessori was influenced by the works of Rousseau, Pestalozzi, and Froebel and incorporated their ideologies into her own developing and expanding theories. She modified the sensory teaching materials of Itard and Seguin and produced the Montessori didactic materials (George 1964).

Montessori's ultimate goal was the return of the child to a state of his or her true normal way of being, which she named the "normalized child," with the qualities of spontaneous self-discipline, love of order and constructive activity, attachment to reality and complete harmony with the entire environment. It was to this end that her vast array of materials was developed (Hainstock 1997).

With the recognition that schooling should enhance the development of creative and responsible citizens, it is necessary to consider how such development takes place and provide rich opportunities for learning for all students (Landsberg, 1997; Eisler, 2000). The arts are most effective when they are connected with the

rest of the school curriculum and when students are allowed to explore topics from both an artistic and academic perspective. Through connection with other participants, the arts become a central part of the learning experience, drawing upon the content of other disciplines and adding depth and quality to the learning process. There is a growing body of evidence to suggest every day that music education has a beneficial ripple effect through the rest of a child's academic and social life and that music should not be any more optional than English or mathematics (Haroutounian, 2002). A review of the extant literature suggests that: a) learning through the arts can benefit the "whole" child through its positive impact on reading, mathematics, writing, self-esteem, and brain development; b) academic achievement scores are significantly higher for those students studying music; c) attending a Montessori program from the approximate ages of 3 to 11 predicts significantly higher mathematics and science standardized test scores in high school (Gartner & Kerzner-Lipsky, 2002); and d) Montessori produces a more academically accomplished child (Clifford & Takacs, 1991). What, then, is the potential for the child when Montessori includes a music- enriched curriculum?

As Montessori faces the challenges of the future with an opportunity and responsibility to change, early childhood music education continues to grow during a never-ending search to improve.

As we face the challenges of the future, this is truly the time to explore how research and practice reflects the wider world of early childhood education. Montessori children are achieving higher percentile scores on mathematics tests than non Montessori children (Clifford & Takacs, 1991), and Montessori children receiving music-enriched Montessori instruction are achieving higher percentile scores on mathematics tests than those receiving traditional Montessori instruction (Harris, 2005). One can only imagine the possibilities across the curriculum for those children receiving music-enriched Montessori instruction. The present study clearly shows that it is time to develop a new model for Montessori music education that will demonstrate the value of an arts-based comprehensive approach and serve as a practical blueprint for all the Montessori classrooms globally.

SIGNIFICANCE OF THE STUDY

It is believed that early experiences are crucial to the developing architecture of the young brain, and research indicates that music plays an important role in the brain development of a child (Gordon 2003). Montessori programs (18 months to 5 years) have grown considerably over the past decades, and with this growth have come concerns about outcomes, especially academic ones. This study offers quantitative evidence that could help Montessori and early childhood educators recognize the value of music enriched instruction for the

young child, and implementing the instructional designs used in this study could lead to higher levels of student achievement in mathematics. This is significant, because these instructional designs improve students' mathematics scores. A grasp of proportional mathematics and fractions is a prerequisite to mathematics at higher levels, and children who do not master these areas of mathematics cannot understand more advanced mathematical concepts that are critical to higher order thinking.

The decision to support music cannot be made without knowing music's effect on academic achievement and its contribution to a student's education. As the quantity, quality, and availability of empirical studies increases, Montessori schools will be able to make a stronger connection between their design decisions and the evidence of "what works."

REVIEW OF THE LITERATURE

In the history of education in North America, children are receiving more music lessons in more schools than ever before. There are many curricula to choose from, with Orff, Jaques-Dalcroze, Kodaly, Suzuki, Education Through Music, Kindermusik, Music Learning Theory, and Music for Young Children the most widely used. The extant literature regarding the effect of music instruction on academic achievement, the relationship between mathematics and music and

the effect of a Montessori education on academic achievement reveals four recurrent themes: 1) the effect of music on brain functions; 2) music students and academic growth; 3) the relationship between music and mathematics; and 4) Montessori students and academic growth.

The Effect of Music on Brain Functions

The role music plays in the education of the child is the focus of much discussion in education today, and this environment influences the child who grows up surrounded by music. Research by Olsho (1984) showed that, during the early months and years of life, the child's brain expanded at a pace that was never matched in later years, and early experiences were believed to be crucial to the developing architecture of the young brain. Research results showed that babies studied at two to four days of age who had been exposed to a melody repeatedly while their mothers were pregnant exhibited changes in heart rate and movements when the same melody was presented after birth. Also, fetuses of 29 to 37 weeks' gestation age showed specific behavioral responses to tunes played earlier in pregnancy. In both experiments, behavioral responses were specific to the tune to which they had been exposed. These results indicated that the learning and remembering of a melody occurred not only before birth but actually before or at the beginning of the third trimester (Hepper, 1991). Classical music played at a rhythm of 60 beats per

minute, which is equivalent to that of a resting human heart, encouraged creative and intellectual development for the unborn child (Verny, 1981).

Further studies showed that even very young children learned music, especially if they were engaged and involved in active participation (Upitis & Smithrin, 2001). Research by Hodges (2000) demonstrated that the first three years in a child's life was the time when music was used to stimulate the development of nerve connections among brain cells necessary for optimal cognitive development. Research by Rauscher and Shaw (1998) emphasized the causal relationship between early music training and the development of the neural circuitry that governs spatial intelligence. Their studies indicated that music training generated the neural connections used for abstract reasoning, including those necessary for understanding mathematical concepts. Music was also being used in the treatment of Attention Deficit Hyperactivity Disorder (ADHD). Music therapists often work with preschool children. Jackson (2003) conducted a survey to ascertain the music therapy methods being used for children with an ADHD diagnosis, how effective this treatment was perceived to be, and the role that music therapy treatment played in relation to other forms of treatment. The results of the survey indicated that music therapists often utilized a number of music therapy methods in the treatment of children with ADHD.

Research supported the theory that, as music had a positive effect on the development of the brain, the earlier in life the young child was exposed to music, the sooner this effect took place. Roehmann & Wilson (1988) reported that Houston of the Foundation for Mind Research had said that children without access to an arts program were actually damaging their brains. They were not being engaged in non-verbal modalities that helped them learn skills like reading, writing, and mathematics.

Music Students and Academic Growth

The literature suggested that music education was vital to individual development; that the competencies learned in one art form were in some sense generic and transferable to other participants (Brademas, 1995); and student participation in music activities had a positive effect on many things from academic achievement to self-discipline (Morrison, 1994). Educators used music instruction to enhance academic achievement and mental discipline (Upitis & Smithrin, 2001), and evidence existed suggesting that focused listening to music facilitated learning to read, probably by increasing children's awareness of speech sounds, which was important in learning to "sound out" words (Butzlaff, 2000). Music, specifically song, was one of the best training grounds for babies learning to recognize the tones that added up to spoken language.

Using music to train and prepare the ear was also important during the early grades, when children started to transpose sounds into letters. While learning to read, music enhanced the students' ability to perform the skills necessary for reading, listening, anticipating, forecasting, memory training, recall skills, concentration techniques and speed-reading. A reading program in New York dramatically improved reading achievement scores by including music and art in the curriculum (New York City Board of Education, 1980). These findings supported the view that music education facilitated the ability to read.

It was also found that music students out-performed non-music students on achievement tests in reading and mathematics in a study of medical school applicants. Sixty-six percent of music students who applied to medical school were admitted, the highest percentage of all groups, while students who studied music scored higher on both the verbal and mathematics portions of the SAT than non-music students (College Entrance Examination Board as reported in *Symphony*, Sep-Oct 1996).

Further research suggested that music should assume a place in the regular school curriculum, as it showed a positive effect on academic achievement. "Music and the arts were vital to the development and expanse of the human intellect, which in turn resulted in superior academic and career performance" (Oddleifson as

cited in Kelstrom, 1998). A child may use the ability for logical thinking that was developed in the music class to solve problems quite unrelated to music, and it became clear that music had a profound influence upon the academic life of a child and deserved equal status within the curriculum (Sloboda, 2001). The studies cited here presented a compelling argument in favor of the implementation of long-term developmental music programs for all students, not just those with an obvious aptitude and interest.

Relationship between Music and Mathematics

A study of 500,000 students in 45 countries showed that the United States was below average in mathematics, Further, a study titled “Musical training improves a child’s ability in spatial-temporal reasoning, which is important in mathematics and science education” (Grandin, Peterson & Shaw, 1998) suggested that music education be present in schools, preferably starting in preschool, to develop “hardware” for spatial temporal reasoning in the child’s brain. The absolute crucial role of spatial temporal reasoning in learning difficult mathematics and science concepts must be explored and exploited.

A New York City program called LEAP (Learning through an Expanded Arts Program) used art and music to teach academic skills. Simple mathematical concepts, such as odd and even, counting, addition, multiplication, sets and fractions were integrated throughout the musically enriched lessons (Dean 1992). As students developed

the rhythms for their songs, they began to think in multiples of four. They realized that if they had sixteen beats of music, they then had four sets of four beats. Students also grasped the concept of odd and even as the groups were subdivided into smaller units for particular steps or musical rounds (Dean, 1992). There were similar brain processes at work in developing a strong sense of musical pitch and the understanding and use of numbers. Pitches in a musical scale and numbers increased from step to step and from lower to higher. The representations were different, but they required a similar way of understanding and using information (Gardiner, Fox, Knowles, & Jeffrey, 1996). Music taught and reinforced basic mathematical concepts that were otherwise difficult to grasp for some students (Geoghegan & Mitchelmore, 1996).

The research team, Rauscher & Shaw (1997), exploring the link between music and intelligence, reported that music training – specifically piano instruction – was far superior to computer instruction in dramatically enhancing children's abstract reasoning skills necessary for learning mathematics and science. The new findings were the result of a two year experiment with preschoolers. What Rauscher and Shaw emphasized was the causal relationship between early music training and the development of the neural circuitry that governs spatial intelligence.

It is more than a coincidence that mathematics and music were noted for their crossover talents. For example, the musical scale was similar to a neat logarithmic progression of frequencies. There were also similar connections between patterns of notes and patterns of numbers. Music involved ratios, regularity, and patterns, all of which paralleled mathematical concepts, and, while music was viewed as a separate intelligence, there was a high correlation between mathematics and music. Reading music required an understanding of ratios and proportions. Arithmetic progressions in music corresponded to geometric progressions in mathematics; that is, the relation between the two was logarithmic (Marsh, 1999). These findings indicated that music uniquely enhanced higher brain functions required for mathematics, chess, science, and engineering. Because neural connections were responsible for all types of intelligence, a child's brain developed to its full potential only with exposure to the necessary enriching experiences in early childhood (Hargreaves & Davis, 2000).

Montessori Students and Academic Growth

Many Montessori schools evidenced high achievement levels. Such results, though impressive, could be difficult to interpret for a variety of reasons: high socioeconomic backgrounds; parental influence; etc. A study comparing the academic outcomes of two groups of students who graduated from high schools in the Milwaukee

Public Schools during the years 1997-2001 indicated that one group had completed fifth grade in Montessori, while the other group had not attended Montessori. The Montessori sample, which consisted of 201 students, found that five to seven years after the Montessori students had exited the Montessori programs and enrolled in traditional public schools, their mathematics scores were superior. Significant finding in this study supported the hypothesis that Montessori education had a positive long-term impact. In essence, attending a Montessori program from approximately 3 to 11 years-old predicted significantly higher mathematics and science standardized test scores in high school. In this context, the fact that the Montessori students had significantly higher Mathematics/Science scores suggests a substantive impact of their Montessori experience (Morgan, 1978).

Morgan's 1978 research on the effect of Montessori materials hypothesized that certain aspects of the concept of number, as explained by Piagetian theory, could be accelerated by the Montessori mathematics experiences. A second hypothesis was that Montessori children would perform better on a preschool test of arithmetic skills and concepts than children in a traditional nursery school. The children from three Montessori and three traditional nursery schools were individually administered an Arithmetic Test. The results showed that the Montessori children were significantly superior in seriation and numeration tasks. However, without a description of the curriculum in

the traditional schools, Morgan's results did not prove that the superior performance of the Montessori children was due to the Montessori curriculum alone (Boehnlein, 1998).

Students in Montessori middle schools reported more positive motivation and experience than a matched sample of students from traditional middle schools (Rathunde & Csikszentmihalyi, 2003). Five Montessori schools from the United States participated in the study encompassing all social class levels. Rathunde (2001) followed up with an article that put Montessori's rich understanding of the prepared environment in tandem with contemporary thought in both education and developmental psychology. These studies supported the view that Montessori education at both the preschool and elementary levels benefited the child academically (Boehnlein, 1998).

Traditional Montessori Curriculum: The philosophy and curriculum of the Montessori method is based on the work and writings of the Italian physician, Maria Montessori. The Montessori method of preschool education is unique in its ability to educate the child from birth (Hainstock, 1997). It attempts to develop the child's senses, academic skills, practical life skills, and character and is one of the world's oldest early childhood curriculum models. The teachers carefully prepare program settings, filling them with Montessori didactic materials, which are designed to encourage children to learn on their own (Havis 1997). The "Casa" classroom consists of

Montessori children between the ages of three to five years who remain with the same Montessori teacher for a three year time frame. Older children help teach those younger to perfect their own skills, while younger children learn by observing the behavior and interest modeled by older students (Montessori, 1964). Montessori built on the work of Itard and Sequin to develop a child-centered approach to education that became known as the Montessori method. She brought to early childhood education the belief that each child develops from within as an individual; and that a child must be free to select and use materials with a minimum of adult interference for as long as desired. Montessori designed didactic materials to build the foundation for reading, writing, and arithmetic. She encouraged the use of child-sized materials, furniture, tables and chairs. Montessori advocated a change in the role of the teacher from a shaper of behavior to an observer of child directed activities in an unhurried environment that was suited to the needs of the child. Elements of the Montessori method and adaptations of Montessori materials are used widely today in early childhood programs throughout the world. Montessori provided insight into, and respect for, the ways in which young children learn (Montessori, 1964).

The traditional Montessori curriculum is based on a three year program and concentrates on the Practical Life, Sensorial, Language, Mathematics, and Cultural (including music) areas of development.

The Montessori bells and tone bars are used as a sensorial based exploration that leads to the writing and reading of music (Miller, 1999). Music instruction is left to the discretion of the classroom teacher whose musical knowledge and confidence level may be limited, thus hindering the effectiveness of the instruction. Little development has been made in the areas of the curriculum specific to music.

The following question was examined for this study: Are there statistically significant differences in the mathematics achievement scores of Montessori students who receive traditional Montessori instruction and students who receive music-enriched Montessori instruction?

DESIGN AND METHODOLOGY

A sample of 200 Casa students within the jurisdiction of a Montessori School board located in Southwestern Ontario was selected for the study. The Montessori School was a licensed school, with an American Montessori International trained Directress and teachers. Casa students were between the ages of three and five years, with gender somewhat evenly distributed all students were in the process of completing the total Montessori three year curriculum. The school was an established Montessori program that met recognized affiliation standards. Authenticity of a Montessori program specified minimum expectations in the following areas: 1) the teacher held a recognized Montessori diploma; 2) the classroom was fully equipped in all basic

areas, and the curriculum areas were supplemented by handmade materials appropriate to the class; 3) the class consisted of mixed ages of children three to six years of age; 4) the school day was a minimum of two and one-half to three hours daily for five days per week for nine months; 5) the classroom aide remained for the full term and functioned as an aide; and 6) the full Montessori curriculum was available to the child for extended, uninterrupted individual and small group work time (Boehnlein, 1998). All participants were randomly selected by age as defined in the table of random numbers (Gay & Airasian, 2000) and placed in one of two groups. The participants came from advantaged homes and were for the most part homogenous with respect to socio-economic status.

The researcher, an experienced Montessori teacher; and music specialist, used the Test of Early Mathematics Ability 3 (TEMA-3) assessment for this study (Ginsburg & Baroody, 1998). This test is intended to provide useful information on the strengths and weaknesses of three to eight year-olds' mathematic ability and was individually administered to each child by the researcher, with a starting point determined by the child's age. Examples of questions asked ranged from a) asking the child which of two pictures had the most objects, such as the case of two pictures, one showing a star and the other showing five stars; b) asking the child to count the stars on

each page; and c) asking the older age group the number of stars on each page. “If two were removed, how many stars remain?”

Reliability of the TEMA-3 test is discussed in the Mental Measurements Yearbook of test reviews, which were complementary to the test as a useful measure of children’s mathematical knowledge and thinking. The reviewers of the TEMA-3 approved of the addition of the Assessment probes and Instructional Activities. Coefficient alpha reliability estimates and standard errors are reported at each level. The median reliability estimate is .95 and the median standard error is 3. Reliability is estimated at .97, based on a sample of 46 children and corrected for restriction of range. This same sample was retested after two weeks, and the correlation, corrected for restriction of range, was .93. In the present study, the data that were collected from the assessment were the students’ quantitative scores and were used as the dependent variable to determine if the independent variable, music instruction, had any effect on students’ mathematics test scores. Test administrators and scorers were given the required training, materials and standard procedures used in testing and scoring to control for data collector bias and to ensure scoring reliability.

MUSIC-ENRICHED MONTESSORI INSTRUCTION

In the early years, when the foundation of musical knowledge is nourished, it is important that the young child receive music sessions weekly. The length of the class period is not as important as the

frequency; two or three 20 to 30 minute weekly sessions with Casa age children is more valuable than one 40-minute session (Choksy, 1986). This newly developed music-enriched Montessori instruction (Harris, 2004) is administered by an experienced Montessori teacher who is also an early childhood music specialist. It provides a child-centered musical environment to facilitate development in all curriculum areas, while enabling the child to learn fundamental music skills (Harris, 2005). Creative movement develops individual expressiveness and coordination, while music skills are refined, using group activities and hands-on Montessori materials. Composing integrates aural and written skills and gives children a sense of ownership. Finally, rhythm ensemble develops coordination, beat, and inner hearing and nurtures self-confidence and communication skills. It builds a solid foundation of understanding and enjoyment of music, while allowing the child to explore and develop his or her own strengths in a variety of musical areas (Gordon, 2003).

Incorporating the leading approaches and philosophies that influence early childhood music and movement in education today, this music program was sequenced to teach concepts of pitch, dynamics, duration, timbre, and form. It accented the positive, while refining the young child's listening, vocal, fine and gross motor skills. Musical concepts were taught at the child's learning level, and emphasis was

placed on accuracy of basic skills to provide a solid foundation for further musical growth.

The first step in exploration of music is the experience of silence. Silence is defined as the absence of sound and a motionless environment. From there, the introduction to, and recognition of, the smallest stimuli is the basic principle for the training of the senses moving on to the reaction to external stimuli. The next step is to make a distinction between sounds beginning with the larger sounds and greater differences through the almost imperceptible of sounds. The progress proceeds to the different timbres of sounds, from environmental sounds, to the human voice, to musical instruments, and then to distinguishing specific tones on the musical scale.

In the typically busy, everyday human activities of the 21st century, the opportunities to experience silence are indeed extremely rare. One needs to consciously create moments of silence and share these moments with the child. Sitting quietly, breathing quietly, inviting the child to do likewise, and observing the sounds created by every tiny move--a sigh or moving the foot just a little for comfort--all make noise. The child becomes aware of the differences between quiet, supposed silence, and absolute silence, where nothing, absolutely nothing, moves. Gradually, with the settling of complete silence on the part of the child, the external environmental sounds, such as the chirping bird or the ticking clock, become more

accentuated. To develop one's senses, it is necessary to develop the ability to evaluate the smallest differences in various stimuli and continue to practice and sharpen the senses.

Simply put, while developing the repertoire of songs, the teacher can speak to the children and say that this is her "indoor voice," or "talking voice." and then ask the children to echo the same sound and volume. Following the talking voice is the "whispering voice," the "shouting" or "outdoor voice," and the "inner hearing voice" (tonal memory). Once the children are familiar with, and have practiced, the steps just mentioned, the teacher may introduce singing in rounds, *ostinato.* Excellent songs for this demonstration are "Scotland's Burning" and "Row, Row, Row Your Boat." *Ostinato* should be used only with songs that the children are very familiar with.

Let us now begin with song and voice, the most accessible and natural of all instruments. Children's songs should lie within the comfortable singing range of the child, i.e. within one octave above Middle C (Phillips, 1992), and include songs for singing, moving, playing, listening etc. A repertoire of songs will build over time to provide an excellent source of music to work with. The basis of the music-enriched Montessori instruction was singing where it was the teacher's role to introduce melodies that were matched to children's abilities (Harris, 2005) and the most effective method of teaching melody was teacher modeling. Repetition of easy tunes strengthened

children's singing voices. By keeping the music simple, children were able to focus their attention on pitch, melody, and rhythm, and progress became more accurate with the passing of time (Gordon, 2003). From a physiological perspective, since children's voices are not ready to handle difficult melodies, professional musicians recommend songs that fit a six to seven note range (Choksy, Abramson, Gillespie, & Woods, 1986; Forrai, 1990).

This music-enriched Montessori instruction continues through the child's musical developmental stages and builds a solid foundation of understanding and enjoyment of music, while allowing the child to explore and develop his or her own strengths in a variety of musical areas. It provides a child-centered musical environment to facilitate development in all curriculum areas, while enabling the child to learn fundamental music skills (Harris, 2005).

Montessori programs would benefit from enhancing Montessori's philosophy with a quality music methodology, expanding on the present treatment of classroom music to include daily group "music and movement" sessions (if possible), enhanced with weekly piano lessons, to provide the child with every opportunity to develop his whole being. The introduction of modern technology has opened a window for music instruction, and the ramifications for the future are only beginning to be realized. Keeping in mind that the goal in early childhood education is to cultivate the child's own natural desire to

learn (Montessori, 1916), Maria Montessori would carefully “follow the child” and encourage other educators likewise. As a visionary whose innovative ideas were so unconventional for her time (Montessori, 1948,) she would perhaps embrace a music-enriched Montessori curriculum.

DESIGN AND PROCEDURES

This study was an experimental design using a two-group post-test comparison (Gay & Airasian, 2000). All children were from middle to upper middle class homes and were accepted to the study as they applied. A pre-test was not necessary because of the large sample size, the comparison based on age, and the participants’ socio-economic homogeneity. The convenience sample was 200 children from a Montessori School in Ontario. Permission was sought and granted from the University of Windsor Research Ethics Board, as well as the participating Montessori Board of Education by a Letter of Permission (see Appendix A). Permission was also sought and granted from the Directress of the participating Montessori school by means of a Letter of Information (see Appendix B). The participants were provided with the opportunity to participate in the study and were given a package that contained a Letter of Information (see Appendix C) that provided a thorough explanation of the study and a detailed Letter of Consent (see Appendix D). To be eligible to participate, participants had to return signed consent forms from their parents

within one week; all students returned the forms. Once the parental consent forms were returned the students were grouped according to age, comprising of three, four and five year-olds. Using the Table of Random Numbers from the test (Gay & Airasian, p.552-555), each age grouping was randomly assigned to one of two groups: either the control group that had experienced music-enriched Montessori instruction or the experimental group that had received traditional Montessori instruction. The final distribution between the two groups was a result of two students from the experimental group and eight students from the control group being reassigned to an afternoon program in order to accommodate student's school time scheduling needs. The experimental group received a treatment consisting of 3 half-hour weekly sessions in music instruction for six consecutive months, after which both groups were post-tested. The experimental treatment was an "in-house" music-enriched Montessori program that was sequenced in order to teach concepts relating to pitch, dynamics, duration, timbre, and form, as well as skills in moving, playing, listening, singing and organizing sound. The comparison control group received traditional Montessori instruction based on a three year program that concentrates on the Practical Life, Sensorial, Language, Mathematics, and Cultural (including music) areas of development and does not include a specific music curriculum. The instrument used to measure mathematical achievement was the Test of Early Mathematics

Ability-3 (TEMA-3) developed by Ginsburg and Baroody (1990). The test covered 1) concepts of relative magnitude, 2) counting skills, 3) calculation skills, 4) knowledge of conventions, and 5) number facts (reviewed by the American Educational Research Association, the American Psychological Association, and the National Council on Measurement in Education 1999). The post-test scores of both groups were then compared (see Tables 2 and 3). Comparisons of the groups' mathematics scores were analyzed.

LIMITATIONS OF DESIGN

Many Montessori schools evidence high achievement levels. Such results, though impressive, can be difficult to interpret for a variety of reasons. These schools may contain large proportions of children from high socioeconomic backgrounds who might be expected to show strong academic achievement regardless of type of schooling. It is also difficult to rule out the influence of parental motivation, in that Montessori schools may attract families who are particularly committed to, and involved in, their children's education. Not administering a pretest was the decision of the researcher, based on the large sample size; comparison by age; the participants, for the most part, homogenous with respect to socio-economic status; the assumption all students were academically at an age-appropriate similar level at the beginning of the study; and the fact that all children in the study attended Montessori school. The combination of random assignment

and the presence of a control group provided a control for internal invalidity, and the absence of mortality did not prove to be a threat (Gay & Airasian, p.377).

ANALYSIS OF THE DATA

The results of the data analysis that were used to address the research question developed for this study is presented in this chapter. The children in the study were divided into two groups; experimental and control. The experimental group received music enriched Montessori instruction consisting of three half-hour weekly sessions in music instruction for six consecutive months. The experimental treatment was an “in-house”’ music enriched Montessori program designed from appropriate early childhood educational pedagogies. The control group received traditional Montessori instruction based on a three year program and concentrated on the Practical Life, Sensorial, Language, Mathematics, and Cultural (including music) areas of development. The children’s ages were summarized using frequency distributions. To test the hypothesis, a 2 x 3 factorial analysis of variance was used to determine if a statistically significant difference existed between proficiency achievement of students receiving traditional Montessori instruction and those receiving music-enriched Montessori instruction. The independent variables were group membership and age of the children (three, four, and five year olds). The dependent variable was raw scores on the TEMA-3. All decisions

on the statistical significance of the findings were made using an alpha level of .05. Children in both groups were post tested on the TEMA – 3.

The children ranged in age from three to five years. Table 1 presents a cross tabulation of their ages by group membership.

Table 1 - *Cross tabulation: Age by Group Membership*

Age	Group Membership				Total	
	Experimental		Control			
	Number	Percent	Number	Percent	Number	Percent
Three years	38	38.8	35	38.0	73	38.4
Four years	30	30.6	31	33.7	61	32.1
Five years	30	30.6	26	28.3	56	29.5
Total	98	100.0	92	100.0	190	100.0

The largest group of students (n=73, 38.4%) was the 3-year-olds. This number included 38 (38.8%) in the experimental group and 35 (38.0%) in the control group. Of the 61 (32.1%) 4-year old children, 30 (30.6%) were in the experimental group, and 31 (33.7%) were in the control group. Among the 56 (29.5%) 5-year old children at the time of the study, 30 (30.6%) were in the experimental group, and 26 (28.3%) were in the control group, as indicated in the Age of Students by Group Membership (see Appendix E).

The research question developed for this study determined if there were possible differences in the mathematics achievement scores of Montessori students who had received traditional Montessori instruction and students who had received music-enriched Montessori instruction?

A 2 x 3 factorial analysis of variance was used to determine if a statistically significant difference existed between the experimental and control group on their raw scores on the TEMA-3. The dependent variable in this analysis was scores on the TEMA-3, with group membership used as the independent variable. Table 2 presents results of this analysis.

Table 2 - *2 x 3 Analysis of Variance – TEMA – 3 Raw Scores by Group Membership*

Source of Variance	Sum of Squares	DF	Mean Square	F	Sig
Group	29548.56	1	29548.56	526.31	<.001
Age	3345.63	2	1672.82	29.80	<.001
Group x Age	2057.05	2	1028.52	18.32	<.001
Error	10330.35	184	56.14		
Total	45281.59	189			

The main effect of group membership was statistically significant, indicating a difference in mathematics achievement between the experimental and control group, $F(1, 184) = 526.31$, $p < .001$. The result of this analysis of variance is presented on the Levene's Test of Equality of Error Variances (see Appendix F).

The second main effect, age, also produced statistically significant differences in mathematics achievement, $F(2, 184) = 29.80$, $p < .001$. The interaction between group and age was statistically significant, $F(2, 184) = 18.32$, $p < .001$.

Based on these findings, it appears that children differed relative to the type of Montessori instruction, music enriched or traditional, and

age, 3, 4, or 5-years old. The result of this analysis is presented in Post Hoc tests (see Appendix G).

To further examine these findings, descriptive statistics were obtained for each of the groups. Table 3 presents results of these analyses.

Table 3 - *Descriptive Statistics: TEMA – 3 Raw Scores by Group Membership*

		Number	Mean	SD
Group				
	Experimental	98	142.58	3.52
	Control	92	118.30	12.52
Age				
	Three	73	135.10	9.21
	Four	61	130.49	15.59
	Five	56	125.63	19.02
Group x Age				
	Experimental x Three Years	38	143.02	2.49
	Experimental x Four Years	30	140.00	2.26
	Experimental x Five Years	30	140.60	4.70
	Control x Three Years	35	126.49	5.14
	Control x Four Years	31	117.42	11.04
	Control x Five Years	26	108.35	13.80

The students in the experimental group (M = 142.58, SD = 3.52) had significantly higher mathematics achievement outcomes than students in the control group (M = 118.30, SD = 12.52). These findings are presented on a Profile Plot (see Appendix H). Based on this finding, it appears that students who received music-enriched Montessori instruction had higher levels of mathematics achievement than students who received traditional Montessori instruction.

When compared by age group, 3-year old students (M = 135.10, SD = 9.20) had higher scores than either the 4-year old children (M = 130.49, SD = 15.59) or the 5-year old children (M = 125.63, SD =

19.02). These findings indicate that 3-year old students had higher mathematics achievement than children in the other two age groups as presented on the Estimated Marginal Means of math score (see Appendix I).

The mean scores for the interaction indicate that children in the experimental group at all three age levels had higher scores than children in the control group. These descriptive statistics results are presented in Appendix J. Among children in the experimental group, the 3-year-old children (M = 143.02, SD = 2.49) had the highest scores, followed by 4-year-old children (M = 140.00, SD = 2.26) and 5-year-old children (M = 140.60, SD = 4.70). Similar findings were obtained among the control group children, with 3-year-old students (M = 126.49, SD = 5.14) having the highest scores. The 4-year-old children (M = 117.42, SD = 11.04) had higher scores than the 5-year-old students (M = 108.35). The result is presented on the Mathematical Achievement by Group (see Appendix K).

Based on these findings, the null hypothesis of no difference is rejected. It appears that participation in music-enriched Montessori instruction contributes to mathematics achievement at all three age levels, with the youngest age 3-year olds having a higher score than the 4-year-olds, who had a higher score than the 5-year olds. What, then, is the potential for the “whole” child upon completion of the Montessori full 3-year term?

THE NEED FOR FUTURE RESEARCH

The primary responsibility of schools undertaking comprehensive school reform was creating programs that resulted in improved student achievement, with one of the most important tasks in this process the choosing of highly effective reform strategies, methods, and programs that were grounded in scientifically based research (Boehnlein, 1998). Positive results in favor of Montessori are useless if the research does not adhere to accepted professional standards. In Boehnlein's 1987 review of the literature of a total of 84 studies on the Montessori method, it was evident in some of the studies that the researcher had not been a trained Montessorian; researchers who did not understand the integrated curriculum model in Montessori missed valuable data or drew incorrect conclusions from their data. According to experienced Montessorians, it took at least five years to build a normalized and fully functional Montessori class where the mixed-ages functioned well as a community of learners. The classroom environment needed to meet Montessori standards, and the children needed the complete a three-year preschool program for the fullest aspects of the curriculum to be experienced (Boehnlein, 1988). This study, which meets the above criteria, raises the question: "Would even greater differences be seen between programs, if the children receiving music-enriched Montessori instruction had a three-year music education period"?

The students in the experimental group had significantly higher mathematics achievement outcomes than students in the control group. Thus, it appears that students who received music-enriched Montessori instruction had higher levels of mathematics achievement than students who received traditional Montessori instruction. These findings indicate that three-year old students had higher mathematics achievement than children in the other two age groups (see Appendix K).

The findings are significant, because a grasp of proportional mathematics and fractions is a prerequisite to mathematics at higher levels, and children who do not master these areas of mathematics cannot understand more advanced mathematics critical to high-tech fields. Moreover, music lessons involve a multiplicity of experiences that could generate improvement in a wide range of activities. This study offers quantitative results that could help Montessori and early childhood educators identify the value of music enriched instruction for the young child and implement the instructional designs used in this study to lead to higher levels of student achievement in mathematics. The studies cited here present a compelling argument in favor of the implementation of long-term developmental music programs for all students, rather than limited to those students with an obvious aptitude and interest (Hargreaves, 1994).

As the quantity, quality and availability of empirical studies increase, Montessori schools will be able to make a stronger connection between their design decisions and the evidence of “what works.” The extensive research showing the improved academic achievement levels of children studying music, the positive long-term benefits of Montessori education on academic achievements levels of students, and this study showing the positive effect of music on Montessori student’s mathematics scores, raises the question of the impact of music on the “whole” child.

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APPENDICES