EXPLORING THE DEVELOPMENT OF MATHEMATICS PATTERNING SKILLS AND CONCEPTS IN YOUNG CHILDREN WHO EXPERIENCE INTEGRATED MUSIC AND MATH LESSONS

A Dissertation Presented to the
Faculty of the College of Education
University of Houston

In Partial Fulfillment
of the Requirements for the Degree

Doctor of Education

by

Carolyn Eve Wade

August, 2011

ACKNOWLEDGMENT

This dissertation is dedicated to all of my teachers:

Mom and Dad, you are my first teachers and you continue to guide me with your wisdom. You teach me to always do my best and to take responsibility when I don't. You tell me that I can accomplish anything I choose, as long as I am willing to put in the necessary work. Most importantly, I know that no matter what, I always have your support. All children should be so fortunate as to receive the unconditional love my parents give so freely.

Linda Nelson, you are an inspiration. Little did I know that my fifth grade teacher would have such an impact on me. You make children love learning through exciting, creative, and hands-on activities. Thank you for helping me get my first teaching job and for encouraging me to become a teacher.

Rudy Villarreal, you are a no-nonsense teacher who believes his students are capable of the very best. You gave a very shy girl her voice and believed she could sing even when she thought she couldn't.

Pat Bonner, you are a dedicated champion of students who demands respect for self and others. Your tireless quest for excellence in each of your students makes you the ultimate superhero.

Gary Patterson, you are a passionate, artistic teacher who taught me the beauty of music. Singing with you was a lesson in the Godliness of music.

Carole Nelson, you are a nurturing, beautiful teacher who gives the gift of self and encourages her students to stand tall in their own shoes.

Nita Copley, you are my first math teacher. You gave me the keys to connection and relationship, without which, there is no learning.

Amelia Hewitt, you are a patient and understanding teacher and friend. You taught me that respect for others means spending time and paying attention.

Nicole Andrews, you are a cheerleader and an advocate who taught me that perseverance and hard work will open doors.

Teresa Edgar, you are a kind hearted teacher whose compassion and understanding helped me navigate this path.

Margaret Watson, you are a wonderful professor who taught me to look beyond the words on the page to understand the true logic behind the thinking.

Linda Wade and Jon Monteith, you are amazing parents and grandparents who lovingly guide our family with your fun-loving zest for life. Thank you for the outstanding support, endless babysitting help, and unconditional love. I love you.

Carol Kershaw and Bill Wade, you are loving parents and grandparents who believe your children and grandchildren are capable of whatever is in their hearts. Thank you for your advice and understanding. I love you.

Jen and Craig, you are loyal, affectionate siblings who taught me that the details always matter. Your constant support and energy are infectious, and I love you.

Rachel, Jesse, and Brandon, you are the reason I want to learn. Everything you do fascinates and inspires me. You are perfect and beautiful and deserve only the best that life has to offer. I love you.

Grandma, I am taking care of number one girl. I love you.

Chris, you are my calm. You taught me that words have deep power and should be used carefully. You have given me the gifts of love, family, and realized dreams. Your commitment to life is uplifting and a blessing to all. I love you.

To all of you, thank you for these lessons. I promise to hold all of them in my heart and to try my best to teach them to others.

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Wade, Carolyn. “Exploring the Development of Mathematics Patterning Skills and Concepts in Young Children Who Experience Integrated Music and Math Lessons” Unpublished Doctor of Education Dissertation, University of Houston, August 2011.

Abstract

Research touting the positive effects of music instruction on mathematical ability is abundant. Specifically, studies have shown a causal link between listening to music and spatial temporal reasoning (Rauscher, 1994), receiving music lessons and spatial-task performance (Hetland, 2000), and music instruction and spatial cognitive abilities (Costa-Giomi, 1999). This growing body of research presents a platform upon which future studies may stand. While studies have shown the positive effects of music education on mathematics ability for students of varying ages, the result of early mathematics and music education is beneficial (Bryant-Jones, Shimmins, &Vega, 2000). In addition, many studies focus solely on the effect of music on spatial-temporal reasoning or spatial task performance. Therefore, the proposed study explores how mathematics patterning skills and concepts develop when pre-kindergarteners experience mathematics and music lessons. Since both mathematics and music present pattern generation within their learning outcomes and standards, this connection will be part of the proposed exploration. Support for combining separate disciplines comes not only from Rauscher’s studies, but also from national organizations such as NAEYC, NCTM, and MENC that promote integrated and developmentally appropriate curriculum.

The research question for the study was: How are mathematics patterning skills and concepts developed when young children experience integrated mathematics and music lessons? The participants were 11 pre-kindergarteners, aged four and five, who enrolled in pre-kindergarten at a private preschool in a suburb of a major metropolitan city. The children were taught 8, 20 minute mathematics and music lessons for two weeks. Using qualitative methods, data was collected using four “windows of observation” (adapted from Clements and Sarama, 2009) and provided a comprehensive analysis of pre-kindergarteners’ patterning abilities. These four windows included: performance tasks from thePerformance Task- Pattern Path Assessment, focused observation, video-taping, and metacognitive fieldnotes. The researcher analyzed the Performance Task Pattern Path Assessment by color coding the developmental levels of the children. The remaining three sets of recorded data were analyzed by highlighting and coding recurring themes in the data collected. Commonalities and points of interest among the data were examined and discussed according to themes generated.

The researcher found that Child 1 and Child 3 showed no change from the pretest to the posttest (both easily completed the color and shape pattern tasks and Child 3 also correctly completed the rhythmic pattern tasks). Child 2, Child 4, and Child 5, did have a change from the pretest to the posttest. All three demonstrated change in the same categories. Each had a change in the “Pattern Fixer”, “Pattern Extender”, and “Pattern Unit Recognizer” sections. Child 2 also showed a change in the “Numeric Patterner” section.

The researcher also found that during the music and math lessons, each of the 5 children created a color and shape pattern-ABABA and AABBAABB-and read the patterns in rhythm. Additionally, each of the children (with the exception of Child 4) created a unique pattern during the lessons. The 7 themes generated from the observation before the lessons, metacognitive fieldnotes, and video-tape recording of the lessons included, “The children have a natural interest in music”, “The Use of Instruments as Non-Musical Toys Before Music and Math Lessons”, “The Children’s Natural Interest in Music was Piqued During Music and Math Lessons”, “Non-

Pattern Sounds Created by the Children", "Pattern making with color and shape", "Reading patterns in rhythm with one-to-one correspondence", "Unique pattern making".

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CHAPTER I

INTRODUCTION

The process of deciding on a topic for my dissertation has truly been a journey. Originally, like with many other undertakings, I just wanted to pick something convenient and simple. The problem this time was that I kept thinking of these fabulous lesson ideas for mathematics and music. I mulled over these ideas several months, until I took a class in which I was required to write in a journal. It took several weeks before I felt comfortable writing, and I often felt very removed from my words. During class one day, the professor asked that we take time to write in our journals. I had just been thinking about my music and mathematics lessons and began writing my ideas on paper. Even after the allotted time was over, I continued to write. Worse than that, the professor had moved on to new topics and all I could think about were my lessons. Later that evening when I sat down to write a new entry, I reflected on my feelings. I noticed that I had a surprising emotional response every time I thought about the lessons. I had tears in my eyes and a choked feeling in my throat as I wrote. I cared about these lessons because they came from a part of me that wants music to have a place in my life again.

A similar emotional response occurred several weeks later at the beginning of a new semester in another class with the same professor. Again, the class was asked to keep a journal. This time, however, the journal had to focus solely on topics related to education and program areas. I had trouble writing without using class readings as prompts, but I did find common underlying themes running through each entry. I noticed that many of my deeply held beliefs concerning education had come from my own experiences as a student. More than that, many of my most passionate feelings stem from negative memories of myself as a mathematics student.

I spent my life as a student trying to escape mathematics. My father recognized this and warned me profusely that mathematical concepts build upon one another and that avoidance of class work would only come back to haunt me. Although his advice led me to worry about my mathematics studies from grade school through graduate school, none of that worry prompted me to learn much about the substance of mathematical concepts. Instead, I spent my time becoming an excellent student of memorization techniques. I could memorize countless steps and formulas to pass mathematics classes by the skin of my teeth, but it always felt like cheating somehow. I hated myself for being too lazy to learn. Interestingly, however, it is my fear and avoidance of mathematics that has influenced many of my teaching practices.

My journal is full of entries about impatient teachers frustrated with my lack of understanding, my embarrassment over failures, and thoughts of ways my experiences could have been different. My earliest memories of mathematics class began at ate four when I could not understand a lesson taught with Cuisenaire Rods. I was not allowed to play at recess with the other children until I understood the lesson. The teacher yelled at me until I cried and I remember feeling terribly confused. I knew I was not stupid, but it was as if the teacher spoke a different language. I feared mathematics so much that I worried about first grade mathematics when I was in kindergarten, a pattern that followed me from year to year. By the time I was in second grade, I was behind. My teacher tried helping by making me use a number line for subtraction, but the embarrassment in front of my friends was too much to bear. From then on, I learned how to fake my knowledge of mathematics with quick fixes and fast memorization. I was a whiz at multiplication tables and formulas and my self-esteem in mathematics sank lower and lower. I was truly haunted by my lack of understanding and constantly afraid my teachers would uncover my secret.

Interestingly, I held a similar secret in my musical life, but it manifested itself in a different manner. Music has always been a part of my life, but never in a comfortable way. Unlike, mathematics, I always felt certain of my musical abilities, but I could never reconcile a place for music in my life. I remember singing as loudly as I could during group music time in nursery school hoping a teacher would hear me and tell me how wonderful I was, but I was too shy to ever sing alone. More than that, I almost always held back in every endeavor so as not to call attention to myself, but secretly hoped someone would notice me. By the time I reached middle school, I gained enough confidence in my abilities to sing, but nearly had nervous breakdowns before every performance. It never mattered how much praise I received, or how much attention I drew, I was terribly frightened and uncomfortable while singing. Though I appreciated the identity music gave me, I had trouble believing that I was worthy in the role of a singer because I never worked for my success.

When it was time for high school, there was no question that I would attend the performing arts school. If I ever had trouble identifying myself as a singer, it really became a problem in high school. The school was competitive and I rose to the occasion because I knew I could, but I also knew I never really had to try. Those thoughts never seemed to prompt me to work harder, but did cause me to doubt my true abilities. As the thoughts of inadequacy became more frequent, my fear of failure became stronger. Compounding the problem was the fact that though I could not truly accept the identity of a musician, being a singer was the only part of me that I could recognize. My teachers became disappointed with my progress by my junior year and told my parents that I had the talent, but needed to learn to be assertive. My lack of assertive behavior came from my feelings of inadequacy and was exacerbated by the guilt that I felt for not working as hard as I should. My lack of effort caught up with me by my senior year and I never realized the big plans my teachers had for me. Though I loved high school, I left with many feelings of regret that stemmed from a sense that I was missing something.

I chose a school in Texas over a prestigious music conservatory for college and felt in many ways that I had let myself off the hook. I thought music school in Texas would be easy and I would slide through. Not only was I mistaken, but I also met with the first major failure of my life. By college, I hated the identity of being a singer and did everything I could to avoid that association. I also hated myself more than ever for not practicing and working hard. This culminated in my failing qualifying juries my junior year because I literally went into the jury room unprepared and forgot the words to an aria. My teacher understandably had no sympathy for me and explained that I had better shape up for next time. I knew that there was not going to be a next time because failing juries would push me a semester behind my expected graduation date. I felt sorry for myself and cried, but secretly felt relief. A few weeks later as I drove my future husband to take the LSAT exam, it occurred to me that I could take the LSAT too. Nothing like this had ever occurred to me because I was always going to be a singer. I felt such incredible joy over this prospect, that I changed my major to political science and planned for law school.

Political science was wonderful. I needed to work even less at that than I did at music to be successful and I even enjoyed my classes in a way that I never enjoyed music classes. I began to have stomachaches, however, during my senior year when it came time to take the LSAT. Again, I had not prepared. I skated by and gained entrance into law school, but the stomachaches continued. I knew deep down that I had no desire to be a lawyer, but I loved the idea of being a lawyer. The interesting thing is that my close family and friends questioned my decision and asked why I chose something that seemed so antithetical to my personality. I had the answer to that question, but was too afraid to admit it. Lawyers are smart and special and I wanted people to think I was smart and special the way I thought people saw me when I sang. The problem was, like singing, law takes hard work and I lacked the desire to put forth that kind of effort. I only lasted a year in law school before I was put on academic probation. I had matured by this point beyond where I was when I failed my college juries and I knew that I had made a serious mistake in attending law school. With the encouragement of my family and my fifth grade teacher, I took a job as a substitute at an elementary school and loved every minute of it. I loved everything from the sounds in the halls, to the familiar smell of crayons, and the sight of apples in September, pumpkins in November, snowflakes in January, and flowers in May. I struggled with the idea of becoming a teacher because it lacked the prestige of other professions and I thought I would lose the respect of my peers when I made the change. That lack of maturity came from the fact that I was still searching for an identity and felt that I was missing something.

I never worked as hard as I did my first year as an alternative certification teacher. I barely had time to breathe that year much less recognize the tremendous amount of time and effort I was exerting into my new profession. The reason I did not see this was because I enjoyed myself so much. I loved being a teacher. The pure joy and satisfaction that I experienced permeated my entire life. I talked about my children and issues in my classroom and in education constantly. Soon, any misgivings I had about becoming a teacher disappeared and I signed up for more and more classes. The most surprising thing to me was that I had no intention at the time of earning a master's degree; I truly felt the desire to gain more knowledge so I could better serve the needs of my children. As I accumulated more and more hours, I decided that I might as well earn a degree. As the newness of teaching wore off and I had more time to reflect, I knew that I enjoyed teaching, but recognized that something was still missing.

Part of that missing link was filled when I met my major professor because mathematics had always been an elusive subject for me and one of the few areas in my life where, as a child, I could memorize what I needed to know, but knew that I understood very little of the subject matter. Like music, any success I enjoyed in mathematics seemed empty because of my lack of effort and true knowledge. My inadequacies in mathematics followed me into teaching where I was more aware than ever that I had very little knowledge. I discovered that I was missing the basic foundations in mathematics and began a process of growth that year. I watched my professor teach mathematics to young children and secretly learned it myself. The years I spent questioning the way I learned mathematics and believing there were other ways mathematics entered the universe aside from formulas and multiplication tables were finally over. My epiphany was that mathematics exists everywhere, not just in textbooks. The teacher's job is to uncover that mathematical world for children through play and careful guidance. The confidence that I gained from my new understanding of mathematics was wonderful because I tackled a fear I held nearly my entire life. Still, this confidence did not fill the hole that I was experiencing as a teacher and a person.

I have come to realize that there are endless possibilities when it comes to tasks at hand, but there is always the possibility of just skating by with the barest of effort. There is also always the possibility of doing the kind of work that fills a hole in the fabric of your being. I cried when I wrote those mathematics and music lessons because they are giving me the chance to fill a hole that was left uncovered a long time ago. I knew that I was missing something even through my joy of teaching, but until I took the time to reflect and understand the missing pieces, I always had a nagging in my heart. The fact that I can write lessons that include mathematics and music brings great relief and satisfaction to me. It is as if my education has come full circle. Whereas I experienced a great disconnect among subject areas throughout my schooling, classes at the doctoral level have afforded me the opportunity to truly examine gaps in my knowledge without fear. Teaching mathematics with confidence and bringing music into the classroom is something I feared because I knew I lacked true knowledge and had not taken the time nor expended the effort to rectify my deficits. Journaling, close self-examination, and hard work have opened a new path ahead of me. I can now enter the realm of music and mathematics without trepidation as I have put forth a great deal of effort in this inquiry.

The inquiry begins with my candidacy based on quantitative findings about the relationship between musical patterning lessons and mathematical patterning abilities in pre-kindergarten children entitled "The Effect of Music Lessons on Pre-Kindergartener's Patterning Concepts" (Wade, 2009). In that study, I created math lessons using music concepts based on rhythm to teach pattern. These lessons were taught to a pre-kindergarten class in an urban, public school. The pre-kindergarten class was randomized and equally split to create two groups. One group received the lesson treatment given by me while the other group received a general lesson given by the classroom teacher over a period of six days. The children in both groups took a pre-test before the intervention and a post-test after the intervention. While that candidacy/quantitative study had inconclusive results, I suggested that a qualitative look at the children's patterning behaviors may yield insight as to the depth of knowledge a pre-kindergartener may hold (Wade, 2009). I made these suggestions based on her personal notes about the children's behaviors, which indicated that the children had more expansive knowledge than the pre-test and the post-test measured. The children easily created ABAB and AABBAABB patterns with the musical note manipulatives because they were color-coded. After I played the sample ABAB pattern, most of the children were able to replicate the sound of the ABAB pattern and retained this skill in subsequent instruction sessions. Similarly, when the AABBAABB pattern was played, most children easily replicated this rhythm in later sessions both through the use of manipulatives and through use of rhythm. I worried that the children would become bored when, by the fifth day of the lesson, most of the children could easily repeat the ABAB and AABBAABB patterns after hearing them played. However, I also noticed that, despite being able to repeat the patterns after hearing them played, it was unclear whether the children could translate the visual patterns represented by the manipulatives into aural patterns using rhythm. It is possible that the children simply memorized the aural patterns and regurgitated what they heard. In effect, the children may have had trouble making the connection between the visual representation of the patterns using manipulatives and the aural patterns to be played. In addition, the musical note manipulatives were of limited color variety thereby restricting the complexity of the patterns that could be visually represented. Therefore, in later lessons, I allowed the children to play with the instruments independently of the manipulatives. I next noted that the complexity of the musical patterns created by the children without the use of manipulatives far exceeded the AABBAABB patterns created with the manipulatives. Furthermore, because of the limitations of the pre and post test, I could not measure the breadth of knowledge the children exhibited through the lessons. During the lessons, I also noted that the lessons afforded the children an opportunity for musical exploration which could not be fully communicated through quantitative methods alone. The manifestations of the knowledge were unique for each child and seemed to grow from organic experiences with the environment which included music, interactions with the lessons and me, and interactions with each other. The natural setting of the classroom was fertile ground for observation as the children were comfortable in their environment and unaware of my gaze. Additionally, I noted that the opportunity to study this exploration during the lessons may yield greater insight into the multi-faceted connection between music and mathematics. Because of the many questions involving the connections between mathematics and music, the inquiry is primarily exploratory and a qualitative investigation is indicated. Through qualitative methods, I would have the ability to expound upon the behaviors of the children and their individual reactions to the lessons by creating four windows of data generation which include performance tasks, focused observation, video-taping and metacognitive field notes. The proposed study will employ these four windows of qualitative methods to offer a more comprehensive analysis of pre-kindergarteners' patterning abilities.

The emphasis in the proposed study on math, music, and pre-kindergarten is a ripe area for discovery and has become stronger over the past several decades. Longitudinal studies such as the High/Scope Perry Preschool Project helped posit the benefits of an early education and brought this finding to the attention of the nation (Schweinhart, 2003). Many states, including Texas, responded by allocating funds to publicly educate preschool-aged children. In Texas, House Bill 72, enacted May1985, mandates pre-kindergarten for high-risk children. Students eligible for public pre-kindergarten must meet one of six criteria set forth by the bill and subsequent amendments to the bill. The child must be at least three years of age and

- unable to speak and comprehend the English language;
- educationally disadvantaged;
- homeless;
- a child of an active duty member of the armed forces of the United States;
- a child of a member of the armed forces who was killed or injured in the line of duty; or
- a child who is or ever has been in the conservatorship of the Department of Family and Protective Services following an adversary meeting.

Even with these limiting factors, prekindergarten enrollment continues to grow. There were 224,335 children enrolled in pre-kindergarten in the state of Texas for the 2010-2011 school year, an increase of 23,806 students over the enrollment in the 2008-09 school year (http://www.tea.state.tx.us/index.aspx?id=2147487020&menu_id=814). As enrollment grows, so does the need for research in early childhood education.

The National Council of Teachers of Mathematics (NCTM) created standards for teaching mathematics to pre-kindergarteners based on the idea that children form attitudes and concepts about mathematics before they reach school age (http://www.nctm.org/about/content.aspx?id=12590). Another nationally-recognized organization, the National Association for the Education of Young Children (NAEYC), endorses mathematics education for pre-kindergarten aged students, and also encourages an integrated approach to curriculum that includes the teaching of the arts and music. The notion of an integrated curriculum is further bolstered by brain research that supports the link between mathematics achievement and music education. While there is a plethora of studies that tout the effects of music education on mathematics achievement, studies are lacking as to the specific mathematical concepts that may be enhanced through the teaching of music.

Need for the Study

In the preschool years, children reap tremendous benefits from both a mathematics education and a music education. Mathematics education of young children has gained significant importance as studies show that early intervention may improve mathematics academic achievement (Starkey, Klein, & Wakeley, 2004) The researchers further illustrate this point in their recent study of preschool-aged children in which the intervention used is closely aligned with NCTM standards and children's mathematics scores increased (Starkey et al., 2004).

Like mathematics education, it is critical that music education also begin in the early years. According to the National Association for Music Education (MENC, 2004), music education should commence in preschool. Furthermore, students who do not receive music instruction before first grade operate at a great disadvantage to those who do receive instruction.

These findings are also supported by brain research that links mathematics and musical knowledge (Costa-Giomi, 1999). Because the preschool years are a critical learning period for young children, and the benefits of early intervention for mathematics and music are measurable, a practical connection between these two disciplines should be explored.

Statement of the Problem

Research touting the positive effects of music instruction on mathematical ability is abundant. Specifically, studies have shown a causal link between listening to music and spatial temporal reasoning (Rauscher, 1994), receiving music lessons and spatial-task performance (Hetland, 2000), and music instruction and spatial cognitive abilities (Costa-Giomi, 1999). This growing body of research presents a platform on which future studies may stand. The participants in these studies range in age from preschool through adulthood. A study by Bryant-Jones, Shimmins, and Vega (2000) supported early training in both mathematics and music. These studies have focused mainly on the effect of music on spatial-temporal reasoning or spatial task performance. The proposed study explores how mathematics patterning skills and concepts develop when pre-kindergarteners experience mathematics and music lessons. Since both mathematics and music present pattern generation within their learning outcomes and standards, this connection should be part of the proposed exploration. Support for combining seemingly separate disciplines comes not only from Rauscher's studies, but also from national organizations such as NAEYC, NCTM, and MENC that promote integrated and developmentally appropriate curriculum.

Purpose of the Study

The proposed study, therefore, will examine the use of integrated, developmentally appropriate music and mathematics lessons as a means through which mathematics learning may be enhanced. Lessons will be crafted specifically to address the following NCTM content standards:

In prekindergarten through grade 2 all students should:

- recognize, describe, and extend patterns such as sequences of sounds and shapes or simple numeric patterns and translate from one representation to another;
- analyze how both repeating and growing patterns are generated; and
- use concrete, pictorial, and verbal representations to develop an understanding of invented and conventional symbolic notations.

The lessons will also align with the following MENC standards:

Content standard 2--all students should:

c. create short pieces of music, using voices, instruments, and other sound sources; and

d. invent and use original graphic or symbolic systems to represent vocal and instrumental sounds and musical ideas.

Further, the lessons will be created for use in a pre-kindergarten classroom and employ developmentally appropriate practice promoted by NAEYC. While previous studies explored the relationship between mathematics and music by having students listen to music or receive music lessons(Hetland, 2000; Rauscher, 1994), this study will use hands-on musical activities that encourage mathematical play. These activities will employ music as a means to teach the discrete mathematical concept of patterning. The purpose of this study is to explore how mathematics patterning skills and concepts develop when pre-kindergarteners experience mathematics and music lessons.

Research Question

How are mathematics patterning skills and concepts developed when young children experience integrated mathematics and music lessons?

CHAPTER II

REVIEW OF LITERATURE

The purpose of this study is to explore the connection between mathematics and music before, during, and after instruction in the prekindergarten classroom. The review will discuss the national mathematics guidelines as set forth by the National Council of Teachers of Mathematics (NCTM), the specific guidelines concerning patterning, and the importance of quality mathematics instruction in the classroom that employs developmentally appropriate practice (DAP). The review will then address the connection between music and mathematics as it relates to NCTM standards, DAP guidelines, and National Association for Music Education (MENC) music education standards. Further, brain research that supports the effect of music education on a person's spatial-temporal reasoning abilities will be introduced. Finally, the research will be summarized and examined with respect to the relationship between mathematics and music.

NCTM Content Standards

Patterning is part of the larger concept of algebra in mathematics and also aids in a child's understanding of number concepts (NCTM, 2000). NCTM has specific guidelines for pre-kindergarten through second grade including the following statements:

> In pre-kindergarten through grade 2 all students should:

- recognize, describe, and extend patterns such as sequences of sounds and shapes or simple numeric patterns and translate from one representation to another;
- analyze how both repeating and growing patterns are generated; and
- use concrete, pictorial, and verbal representations to develop an understanding of invented and conventional symbolic notations.

These guidelines state that students should learn to recognize, extend, create, describe, and analyze patterns. Patterns may even be explored through the use of musical notation, a form of a conventional symbolic notation (Copley, 1999).

The Importance of Pre-Kindergarten Programs

Pre-kindergarten programs have become increasingly prevalent over the past few decades. Many people may credit the High/Scope Perry Preschool Study as having inspired the increase, as the study illustrates the positive long-term effects of a quality preschool program (Schweinhart, 2003). The participants included 123 low socio-economic status (SES), African-American 3- and 4-year-old children living in Ypsilanti, Michigan, who were at risk of failing in school. The children were identified for participation in the project through the area's census, local referrals, or neighborhood canvassing strategies. The children were further identified as low SES through answers parents gave as to their number of years of schooling, number of people living in the household as compared to the number of rooms in the house, and occupational levels. Children who met the criteria and scored between 70 and 85 on the Stanford-Binet Intelligence Test were chosen for participation in the study. The students were matched according to the IQ scores, the average SES, average intellectual ability, and percentage of male and female students. The children were then randomly divided into two groups. One group participated in a high-quality preschool program and the other group did not participate in any program. Data was collected annually on the students from the ages of 3 to 11, and then at ages 14, 15, 19, 27, and 39-41. The findings of the study include the achievement of higher levels of education for those enrolled in the preschool program as well as fewer arrests, higher economic status, and longer commitment to marriage. The High/Scope curriculum includes many areas of study and considers each of the areas to be key learning experiences for children. Mathematics concepts such as classification, number, seriation, space, and time are considered important components of the program (Schweinhart, 2003).

Another longitudinal study that supports the long-term effects of a preschool program followed students from preschool through sixth, seventh, and eighth grades. The study took place in four Head Start programs in Louisville, Kentucky. One hundred twenty-four children from disadvantaged households were randomly assigned to either one of four different types of pre-kindergarten programs for a total of fourteen classes, or were assigned to no program at all. Ninety percent of the children were African-American; more than half of the children were from single-parent households; and ninety percent of the children were from low SES households. The children were given the Preschool Inventory (PSI), the Stanford-Binet Intelligence Test, and, at the end of first and second grades, the California Achievement Test. The results showed that in their sixth-, seventh-, and eighth-grade years, children who participated in the Montessori preschool program had higher achievement levels in reading and mathematics (Miller & Bizzell, 1983) as compared to the three other preschool programs, or no program at all.

A Pre-Kindergarten Program that Employs a Mathematics Curriculum

Miller (1983) and Schweinhart's (2003) early studies support the idea that pre-kindergarten may have positive and lasting effects on children's academic achievement. Later studies look at specific program factors that may improve children's content area scores.

In 2004, Starkey, Klein, and Wakeley conducted a study to assess the effects of early intervention on mathematics knowledge. The researchers found a disparity between the informal mathematics knowledge of preschool-aged children from low-income households when compared to children from middle-income households. The results showed significant gains for both the low-income and middle-income students in mathematical concepts. The participants included 163 preschool-aged children, 88 girls and 75 boys, eligible for pre-kindergarten in the state of California. 80 children were from low-income families; 37 of those children participated in the treatment and 43 of the children received no treatment. Eighty-three children were from middle-income families; 41 of the children received the treatment and 42 of the children received no treatment. Thirty-two percent of the children in the low-income group were African-American, 13% were Caucasian, 41% Latino, and 14% interracial or other. 10% of the middle-income group were African-American, 63% were Caucasian, 7% Latino, and 20% interracial or other. Thirty-eight percent of parents in the low-income families had earned a high school diploma or less, while 16% had earned a bachelor's or graduate degree. One percent of middle-income families had earned a high school diploma or less, 11% had some higher-level education, and 82% had earned a bachelor's or graduate degree. The low-income children attended either a Head Start classroom or a California State Preschool classroom. The middle-income children either attended a private, nonprofit preschool or a preschool at a public university. Control groups were used in each of the income levels. The Child Math Assessment was administered for the pretest and posttest (Starkey et al., 2004).

The intervention used is of particular interest because of its alignment with NCTM standards, and includes concepts such as number, reasoning, spatial sense, geometry, patterning and unit construction, measurement, and logical relations. NCTM, the organization which educators hold as the authority of mathematics instruction, states that children come to school with some knowledge of mathematics gained through interaction with the environment. With consideration of children's prior knowledge, and the importance of a strong mathematical foundation for children in pre-kindergarten through second grade, NCTM strongly encourages the use of mathematics programs which are sensitive to developmental differences in children and rich in opportunities for active learning (2000). Following NCTM guidelines, the intervention in the Starkey, Klein, and Wakeley study (2004) (1) was modified depending on a child's skill level, (2) targeted specific mathematical skills, and (3) was presented as games in small groups. Teachers were encouraged to set up mathematics centers in their classroom and to allow children time on the computer for math-related activities. Teachers were given assessment sheets to monitor the children's progress. One lesson was presented each week and children practiced the lessons twice a week (Starkey et al., 2004).

The findings of this study have important implications. While each group's scores rose in comparison to those of the control groups, the low-income children's scores made greater gains and were similar at the end of the year to the middle-income students' scores (Starkey et al., 2004).

Developmentally Appropriate Practice (DAP) and Mathematics

Similar studies to Starkey, Klein, and Wakeley's (2004) also report significant gains in mathematics achievement in preschool classrooms, but include the component of developmentally appropriate practice (DAP). NAEYC is the organization which early childhood educators recognize as the authority on best practices in the young child's classroom. It is also the accrediting organization for early childhood programs in the United States. DAP refers to three major ideas: age appropriateness, individual appropriateness, and cultural appropriateness. Age-appropriate curricula consider a child's developmental level when activities, materials, and learning experiences are planned. Individual appropriate practice considers each child's unique interests and abilities during the planning and implementation of classroom activities. A culturally appropriate environment is sensitive to children's respective cultures and uses culturally relevant and meaningful activities for instructional purposes (Bredekamp & Copple, 1997).

While NAEYC does not officially support any one curriculum model, it does offer guidelines and recommendations for early childhood educators. DAP promotes active learning by the children. Children are not seen as passive receivers of information, as handed down by the all-powerful teacher. The teacher should encourage an environment in which children actively seek knowledge through interaction with others and with the classroom environment, including investigation of manipulatives, books, technology, or other materials. Further, a teacher who incorporates DAP in the classroom understands that children learn through play (Bredekamp & Copple, 1997). NAEYC supports the idea that play is the vehicle through which children learn, but also notes that teachers must plan for play, monitor play, and provide opportunities for new learning during play (Bredekamp & Copple, 1997).

The use of play also promotes implementation of an integrated curriculum. In its list of appropriate practices, NAEYC encourages teachers to make connections across the curriculum and various disciplines when planning lessons. Teachers are also encouraged to facilitate students' inquiries into subject matter that incorporates many content areas. As teachers guide children in these investigations, they are mindful that the students' personal interests should drive the query (Bredekamp & Copple, 1997).

The following studies illustrate the use of developmentally appropriate practices when implemented with a math curriculum, and the resulting effects on mathematics achievement.

The first study analyzed the effects that the Pre-Kindergarten Early Intervention Program (PKEI) had on a fourth-grade reading and math standardized exam in the state of Florida. The PKEI is Florida's state supported pre-kindergarten program, which adheres to developmentally appropriate practices. Children qualify for the pre-kindergarten program if their family's income falls below the federal poverty line. In addition, children who qualified for the study began kindergarten in a Florida public school in 1993, remained in that public school system for the next five years, and had not participated in Florida's Pre-Kindergarten Program for Children with Disabilities. The study sample included 75,025 students. Of the sample, 41.6% of the population was African-American, 22.6% was Hispanic, and 35.8% was Caucasian. In addition, 51.0% of the population was male, and 49.0% of the population was female (Roth, Carter, Ariet, Resnick, & Crans, 2000).

For the purposes of the present study, only the math outcomes will be discussed. The sample of students tested in mathematics totaled 54,899. Students were separated into groups according to whether they had participated in PKEI. African-American, Hispanic, and female students who had participated in PKEI had greater odds of testing into either the first-, second-, or third-highest math test score categories than students who did not participate in the PKEI (Roth et al., 2000).

As in the study by Roth et al. (2000), research done by Perry (1999) presents results that illustrate the positive effects of a developmentally appropriate pre-kindergarten curriculum on mathematics achievement scores. This study took place in rural West Virginia and included a population of 80 students, all of whom were between the ages of four and six at the time of the study. The only qualification for attendance in the pre-kindergarten program was age; however, 85% of the population served by the school participating in the study qualify for free or reduced lunch. The students in this low SES area are considered at-risk (Perry, 1999).

This study contained two experimental groups whose members attended pre-kindergarten and two control groups whose members did not attend pre-kindergarten. The difference between each of the experimental groups, on the one hand, and the control group, on the other hand, was the year the children attended the program (Perry, 1999).

The research question attempted to determine whether children who attend a DAP pre-kindergarten program exhibit better math readiness skills and higher math achievement scores than do children who do not attend pre-kindergarten. Children in the first experimental group set were tested using the Slosson Kindergarten Readiness Test and the children in the second experimental group set were tested using the Metropolitan Early Childhood Assessment Program. Both group set one and group set two showed significant differences between the experimental group and the control group, indicating that a DAP pre-kindergarten mathematics program positively affects the readiness skills and mathematics achievement of the students (Perry, 1999).

Developmentally Appropriate Practice as it Relates to Music

Developmentally appropriate practice applies not only to content areas and social aspects of a pre-kindergarten program, but also to the arts Music time is often an important aspect of the pre-kindergarten curriculum and usually includes singing and moving to the music (Kostelnik, Soderman, & Whiren, 2004). Not only does NAEYC encourage an integrated approach to curriculum, but it also encourages learning through and with the arts. For example, in the discussion of appropriate practices, making connections from mathematical patterning to music is considered an appropriate practice. NAEYC explicitly states that children should have, "daily opportunities for aesthetic expression and appreciation through art and music" (Bredekamp & Copple, 1997).

In a qualitative study by Miranda Martina (2004), the effects of developmentally appropriate practices in the instruction of a general music class were observed along with the implications of the use or non use of DAP. The researcher used ethnographic strategies such as observations, artifacts, and interviews to gather data. Three classrooms were observed: two classes were full day, and one class was half day. There were three observations per month and 90 observations in the total study. The data were coded using five main DAP topics: (1) creating a caring community of learners, (2) teaching to enhance development and understanding, (3) constructing appropriate curriculum, (4) assessing children's development and learning, and (5) establishing reciprocal relationships with families (Martina, 2004).

The researcher found that the use of DAP in the general music classroom facilitated good relationships between teachers and students, awareness of students' individual needs, and an active learning environment. The researcher also found that the more consistently DAP procedures were used, the more engaged the students were in classroom activities (Martina, 2004).

Spatial-Temporal Reasoning Abilities and Music

Recent brain research on the effect of music on spatial-temporal reasoning abilities may further highlight the possible link between mathematics and music.

Researcher Frances Rauscher hypothesized that music and spatial task performance are causally related (Rauscher, 1994). 79 undergraduate students participated in the five-day testing period and were paid thirty dollars for their participation. Students were tested using 16 Paper Folding and Cutting items and 16 Memory items adapted from the Stanford-Binet Intelligence Scale for spatial reasoning and subsequently divided according to score to one of three groups (silence, mixed, and Mozart). In the following four days, one group sat for ten minutes of silence and then were given 16 new Paper Folding and Cutting items to complete. The Mozart group listened to ten minutes of a Mozart sonata and was also given 16 new Folding and Cutting items to complete. The mixed group's listening changed each day through day four and included listening to minimalist music, an audiotape of a spoken story, and British style dance (trance) music. On day five, the mixed group was split in half, 13 people each, and one group had silence while the other listened to the Mozart sonata. After each day's activities, this third group also completed 16 new Paper Folding and Cutting items (Rauscher, 1994).

The analysis of the groups showed that the Mozart group's spatial reasoning abilities improved from day one to day two and from day two to day three. This outcome supports the idea that listening to a Mozart sonata enhances spatial reasoning (Rauscher, 1994).

Another study by Rauscher (1994) that works in conjunction with the above study investigated whether early music training enhances spatial-task performance. Thirty-three 3- and 4-year-old children, from Los Angeles County preschools, participated in the study. The children were divided into two groups. The first group of 19 children, the experimental group, received the treatment. The second group of 14 children, the control group, received no treatment. The intervention included eight months of 10- to 15-minute private keyboard instruction plus daily 30-minute group singing sessions. Spatial reasoning was tested using the Wechsler Preschool and Primary Scale of Intelligence-Revised and the Stanford-Binet Intelligence Scale. Some areas tested included object assembly, geometric design, and block design. The researcher found that the students who received the music training scored higher on the object assembly task than the control group. None of the other areas tested improved after the music lessons. This strengthens the findings and eliminates the Hawthorne Effect, the notion that the students who received music lessons scored higher because they were receiving extra attention (Rauscher, 1994). Rauscher's findings have been dubbed "The Mozart Effect".

Other researchers have attempted to replicate Rauscher's study, but have failed. Hetland (2000) proposes that failures were due to mistakes in the replication process. In her study, Hetland analyzed the spatial task performances in groups of people divided similarly to Rauscher's groupings. The first group of 889 subjects was the silence group. The second group of 535 subjects listened to classical music and then a relaxation tape. The third group of 397 subjects heard silence and then the relaxation tape. The fourth group of 92 heard silence and then noises. The fifth group of 404 heard silence followed by non-enhancing music. The sixth and final group heard relaxation tapes and non-enhancing music. Hetland was able to replicate Rauscher's findings that there is a "Mozart Effect". She also concluded that music that enhances spatial temporal reasoning is not necessarily Mozart's music, but possibly many kinds of complex music such as Mozart's (Hetland, 2000).

Another study that supports Rauscher's findings included thirty preschool children, ages three and four, from a private Montessori school in a Midwestern city. Fifteen children were in the experimental group and fifteen children were in the control group. From October through April of the school year, children in the experimental group were given twenty-four weekly lessons on song bells and were encouraged to practice singing and playing songs at home. The children were pretested and posttested using the WPPSI-R's spatial temporal tasks and the researchers found a significant gain in spatial temporal reasoning in children who received the musical training. The researchers also believe that, based on theirs and others' findings, researchers should work with educators and parents to improve the music education of young children (Gromko & Poorman, 1998).

Studies of longer duration have also shown an improvement in the spatial cognitive abilities of children. A study of fourth-graders who received three years of piano instruction showed an increase in the students' cognitive abilities after two and three years of instruction (Costa-Giomi, 1999).

Further, there is brain research that reports actual differences in the brains of professional musicians as opposed to non-musicians. In one study, researchers used the MRI to look at brain images of musicians with perfect pitch and brain images of musicians and non-musicians without perfect pitch. Those musicians with perfect pitch exhibited "stronger leftward planum temporale asymmetry" (Schlaug, Jancke, Huang, & Steimetz, 1995).

Another study showed that, after just one year of violin training with four- to six-year-olds, the left hemisphere of children's brains looked different than the children's brains who did not receive any training (Fujioka, Ross, Kakigi, Pantev, &Trainor, 2006).

Brain research has also shown that areas of the brain activated during musical performance are different than the areas of the brain that are activated during speech production. In this body of research, investigators monitored brain function as musicians performed sight-reading activities and keyboard exercises. Researchers found that the part of the brain activated during musical activities was not necessarily the same as the parts of the brain that are activated during speech production. This indicates that musicians with certain types of brain damage that affect speech may still be able to perform musically.

Brain research also links musical training in early childhood to academic gains in mathematics. In a study by Schmithorst & Holland (2004), 15 adults, seven of whom had musical training in early childhood, and eight of whom had no musical training, were randomly selected from a population of college-educated adults. The participants were given several mathematical tasks to complete, including addition and subtraction of fractions. While the tasks were being completed, the subjects' brain function was monitored. Adults with musical training showed activation of different parts of the brain than the non-musicians. The parts of the brain that were activated in the musicians are linked to "proficiency in the processing of shape information" (Schmithorst & Holland, 2004) which may be due to the subjects having had experience reading and interpreting musical notation. The researchers encourage further study of the link between mathematical ability and musical training (Schmithorst & Holland, 2004)

Music Education in the Early Childhood Classroom

With the support of music education by NAEYC, as well as studies supporting the effects of musical training on spatial-temporal reasoning and other mathematics abilities, and the idea that music time is often an integral aspect of the pre-kindergarten curriculum, it is important that standards for music education are addressed. MENC provides content standards for music education, including singing and playing instruments, creating music, responding to music, and understanding music (MENC, 2006).

For the purposes of this study, the Content Standard Two, a content standard for creating music, will be used. The standard states that children:

c. create short pieces of music, using voices, instruments, and other sound sources; and

d. invent and use original graphic or symbolic systems to represent vocal and instrumental sounds and musical ideas.

These standards may be linked to mathematics education and patterning. Because music may follow both simple and complex patterns, there are many opportunities to link these two disciplines.

In a recent study of sixteen students in a second-grade classroom and sixteen students in a fourth-grade classroom in Chicago, Illinois, where eighty-nine percent of the students qualified for free or reduced lunch, there were low math achievement scores. Researchers proposed that the reduction of music class time might be part of the cause for the low test scores (Bryant-Jones et al., 2000). Thus, the second- and fourth-grade students participating in the study engaged in a variety of musical activities designed to boost math achievement scores. Activities included listening to music by Mozart for ten minutes daily, watching School House Rock videos, and participating in teacher-made songs in the music classroom. The initial inquiry and data collection occurred in a nine-week period, during which investigators found that math scores on teacher-made exams went up. These exams were similar to formal exams given by the district. The research was extended to a 16-week period because of increased scores on the district mathematics exams. Specifically, researchers found that students retained information learned through songs and students also made connections among the music instruction, fractions, and patterning (Bryant-Jones et al., 2000).

Another study conducted by Sang Kim, a doctoral student at the University of Houston, questioned the effect of music instruction on pre-kindergarteners' mathematics abilities (Kim, 1999). The participants included 98 pre-kindergarten students in four preschool classrooms in a large urban school district. The research design employed was a pretest-posttest control group format that contained two experimental groups and two control groups. The treatment consisted of twenty-five minute integrated music/math lessons twice a week for twenty weeks, including vocal instruction as well as lessons in mallet percussion. A control group received no music instruction during the same period. This collection of lessons integrated math concepts such as counting, classification, patterning, sequencing, and seriation and music concepts such as steady beat, principles of tempo, principles of dynamics, principles of rhythm, accents, underlying beats, simple versus compound duple meter, principles of melody, principles of timbre, and repetition versus contrast forms. While Kim's research could not reject the null hypothesis, it does open the door to further inquiry and study. Kim notes that the instrument used to measure mathematics ability (Test of Early Mathematical Ability/TEMA-2) was inconsistent with the content and format of the treatment and therefore caused the insignificant outcome. Kim further suggests that a study using an integrated curriculum and a measurement tool designed to test ability within an integrated curriculum setting may yield significant results (Kim, 1999). Additionally, Kim's research sought an answer as to whether integrated mathematics and music lessons had an effect on children's mathematical abilities. The scope of this research was extremely broad in both mathematical and musical concepts and did not seek an in-depth study of specific mathematical concepts.

The integrated curriculum is based on the idea that subject matters cannot be effectively taught or understood in isolation. Howard Gardner, the author of *Frames of Mind: The Theory of Multiple Intelligences* and *The Disciplined Mind*, explains through his research that human beings have many different types of intelligences and that it is through these intelligences that people acquire knowledge. Some of the intelligences include verbal-linguistic, bodily-kinesthetic, musical, and visual-spatial intelligence (Gardner, 1983). He further explains that these intelligences may be viewed as "multiple entry points to understanding" and that instruction which is based on the idea that each individual has his own unique method by which he learns, may involve several different areas or disciplines. Educators move Gardner's theory into practice by employing many different disciplines and methods that integrate subject areas in an effort to best educate individual students (Gardner, 2000).

Rhythm

Musical intelligence is included as one of Gardner's entry points and the integration of music into the curriculum may make an impact in the classroom. Because rhythm—"an ordered recurrent alternation of strong and weak elements in the flow of sound and silence in speech" (Mirriam-Webster, 2010)—is an integral part of music, the characteristics of rhythm and its link to human understanding is a focus of several studies. Rhythm has been found to be a uniquely human characteristic; people exhibit a natural ability to combine rhythm, movement, and sound (Sacks, 2007). In a study conducted by Dr. Oliver Sacks, catatonic patients who had little to no response to the outside world became responsive when music was used as a therapy (Sacks, 1973). Further, human beings are able to understand musical patterns upon hearing them and can then anticipate a recurring beat (Levitin & Cook, 1996). This musical patterning can be quite complex in nature even when observed in young children and may be linked to mathematical patterning abilities (Wade, 2008).

Math Patterning Trajectories

Patterning is a skill that may be generalized to many different subject areas and can influence the way children understand the world around them. Patterns may be perceptual, numerical, arithmetical, or spatial and the ability to recognize these patterns and others may bring order to a seemingly disjointed set of numbers or objects. However, the relationships between patterns and the ability to recognize patterns goes beyond simple ABAB patterns children learn and create. The use of letters, numbers, movement, or musical notation as representations of pattern may be the beginnings of a child's algebraic understanding. While mathematics patterning—pattern extension and replication—is commonly taught in preschool programs, teachers may not understand the depth of this subject area nor the complex nature of patterning. They may therefore miss optimal teaching moments when children are fully engaged in pattern play (Clements & Sarama, 2009). In the book *Learning and Teaching Early Math: The Learning Trajectories Approach*, Clements and Sarama explore the idea that children actively learn through play and can be guided in their mathematics learning through learning trajectories. The trajectories include a mathematics goal, the developmental path children may travel while reaching that goal, and activities that will facilitate movement through the mathematical development. A teacher who uses this approach is aware of a child's age and mathematical developmental level and is ready when key learning moments present themselves. The teacher facilitates learning that builds on a child's pre-existing knowledge and moves the child through the stages of mathematical development using the learning trajectories (Clements & Sarama, 2009). Many activities and tasks are suggested for moving the children through the developmental stages, including musical patterning using rhythm. This task may help children recognize the smallest unit or core of a pattern (Clements & Sarama, 2009).

Transfer of Knowledge

In accordance with the use of an integrated curriculum, comes the idea of transfer of knowledge from one circumstance to a second circumstance. In 1989, Salomon and Perkins reexamined the notion that cognitive skills are not context specific. The researchers suggest two types of transfers of knowledge: near transfer and far transfer. Near transfer is a person's ability to apply skills acquired in situation A to solve a very similar issue in situation B. Far transfer is a person's ability to apply skills acquired in situation A to solve an issue in situation B that is similar in content to A, but different in context (Salomon & Perkins, 1989).

A study of 45 third-grade students from an urban elementary school found that a treatment designed to teach skills related to one subject area could be transferred to solve a problem in a second subject area (Basile, 2000). The students were divided into two groups, an experimental group and a control group, each of which was instructed by the same teacher on the topic of habitats in nature. The control group watched videos and answered prompts designed to reinforce rote knowledge, while the experimental group engaged in active learning which encouraged the use of the scientific method to solve problems. After two weeks, the groups were presented with a problem that challenged the children to create a habitat for third-grade students in space. This exercise required far transfer of knowledge into the new context of space. Both groups were tested for near and far transfer of knowledge and the students in the experimental group were able to transfer knowledge to the far transfer situation (Basile, 2000). The encouraging results of this study support the hypothesis in the present study that children will transfer knowledge of pattern in the context of music to the context of mathematics.

Sang Kim's study explored a similar hypothesis (the effect of music instruction on pre-kindergarteners' mathematic abilities), but could not show near or far transfer of knowledge (Sang, 1999). While Sang's hypothesis is similar to the present study's hypothesis, it is not the same. The hypothesis in Sang's study is very broad and encompasses many mathematical concepts, while the scope of the present study is much narrower and focuses directly on the mathematical concept of pattern. Further, while Sang suggests that the assessment method employed in the study may not have adequately tested the children's knowledge, the assessment in the present study aligns specifically with the concept of pattern.

Summary

This review has discussed the national mathematics standards and provided explanation as to the meaning of the selected content standard. Next, studies supporting the role of pre-kindergarten programs and their positive impact on the academic achievement of students are explored (Miller & Bizzell, 1983; Schweinhart, 2003; Starkey et al., 2004). More specifically, when preschool programs employ mathematics as part of the curriculum, studies provide evidence that children's mathematic achievement scores increase. Additionally, studies cited suggest that developmentally appropriate practice regarding mathematics instruction also raises test scores (Perry, 1999; Roth et al., 2000). Within this context of developmentally appropriate practice, the NAEYC supports the idea of an integrated curriculum, or carrying knowledge across many disciplines including music. Because brain research has linked musical abilities with mathematical abilities, many researchers tout the effects of music on mathematics achievement (Hetland, 2000; Gromko & Poorman, 1998; Rauscher, 1994). In another study, the researchers show that a math lesson can be taught through music. The subjects are older elementary school students who learned mathematical concepts through songs and listening to classical music (Bryant-Jones et al., 2000). The studies cited whose participants are pre-kindergarteners show that spatial-temporal reasoning abilities can be improved by listening to music or by receiving music lessons (Gromko & Poorman, 1998). Further, a study investigated the effect of music lessons on pre-kindergartener's mathematics abilities, but did not concentrate on pattern and did not yield significant results (Kim, 1999). Lastly, support for the use of an integrated curriculum and the teaching of skills that may be carried across the disciplines is found in the study that promotes the idea of far transfer (Basile, 2000). While the preceding studies explore relationships between music and mathematics, some even with young children, none specifically focus on the pre-kindergarten child, music, and mathematics patterning. The proposed study would focus on whether the specific mathematics concept of pattern can be learned through music lessons in a pre-kindergarten classroom.

CHAPTER III

METHOD

The purpose of this study was to investigate pre-kindergarten children's mathematical patterning knowledge as it related to musical patterning. The research question was: How are mathematics patterning skills and concepts developed when young children experience integrated mathematics and music lessons? This chapter discusses the research design, sample, data sources, data collection and procedure, and data analysis of the study.

Research Design

This is a qualitative study which used four sources of data. A qualitative study is one in which a researcher observes individuals in a natural setting to gain understanding of the individuals' constructs and then analyzes the information collected using analytic induction (Gall, Borg, & Gall, 2003). Data generation occurred in four phases: performance task, observation, videotape, and metacognitive field notes. Each phase was intended as a window into the children's activities. While four separate windows were created and analyzed individually, the culminating analysis by the researcher fused the four windows into one large picture window by which children's behaviors were examined.

Sample

The study included pre-kindergarten children from a private, religiously-based preschool located in a suburb of a large metropolitan area. All of the children in the classroom were either four or five years old and lived in the surrounding area. Because this was a private school, parents who enrolled children paid tuition. The school serves children from the age of 18 months through pre-kindergarten. The curriculum adopted by the preschool is called High Reach. Children in the school also participated in physical education, art, and music classes throughout the week. The school day began at nine in the morning and instructional time ended at noon. The total enrollment for the 2010-2011 school year was 30 children. The enrollment of the pre-kindergarten class was 11 children. Five children from the pre-kindergarten class were randomly chosen for the sample in the study.

Data Sources

The following is a chart explaining the four sources of data in the proposed study:

Table 1

Four Data Sources

Data Source	How are Data Generated?	How are Data Collected?	When is the Data Collected?	How will it be Analyzed?
Performance Task- Pattern Path Assessment (adapted from Clements and Sarama, 2009)	Children will perform 14 tasks (7 with objects and 7 with music)	Checklist (yes/no) of Learning Trajectories (Clements and Sarama, 2009)	1-2 days before the lesson begins 1-2 days after lessons are finished	Qualitative analyses based on four data sources
Observation of Play Centers	Musical instruments will be placed in play centers for use by subjects	Observe patterning behaviors in music and math	Two weeks before lessons begin	Generate any additional themes that may occur before formal study begins
Video Recording	Video will be focused on subjects during lesson	Observe video one time for each subject and compile field notes	During the eight lessons	Qualitative analyses based on the four data sources
Journal Field Notes	Metacognitive response to lesson	Phrases will be coded that correspond to generated themes	Written after each lesson	Qualitative analyses based on four data sources

The four sources of information were the performance task, classroom observation of play centers, video recording, and journal field notes. The first data source, the performance task, included the Pattern Path Assessment (adapted by Clements and Sarama, 1999) and required the children to perform seven tasks with objects and seven tasks with musical instruments. The second data source, the observation of play centers, included the observation of the pre-kindergarteners playing with musical instruments in an area set up in the classroom as a music center. The third data source, video recording of the math and music integrated lessons, occurred during the lessons taught by the researcher. The fourth data source, the journal field notes, occurred after the lessons were taught by the researcher and included the researcher's reactions to the lessons.

Data Generation and Procedure

Two weeks prior to the math and music integrated lessons taught by the researcher, musical instruments were placed in one of the centers in the pre-kindergarten classroom. The researcher observed the children's play for 15 minutes during centers time. The researcher recorded any observation of patterning behaviors exhibited by the children, whether in music or mathematics.

After this observation, the researcher returned to the classroom to conduct a series of eight lessons that integrated music and mathematics. The lessons were taught to all 11 students and were videotaped in order to record all of the children's actions. At the end of the series of lessons, the video was reviewed by the researcher. While all of the children in the class participated in the lesson, five randomly chosen children in the class were the focus of the in-depth study. Mona Matthews and John Kesner employed a similar method of observation in their 2003 study. Six students were the focus of a qualitative study done by Hatch and Barclay (2006) in which a class of 16 children were observed and videotaped (as cited in Spodek & Saracho, 2006). Similarly, a qualitative study in which students were observed and videotaped also randomly chose five students on whom the study would focus from a larger pool of students (Wein, 1996). Notes were written by the researcher about the behaviors of the five children in the random sample from the class. The researcher compiled the notes and looked for recurring themes throughout the notes. The themes that were generated from the notes were analyzed by the researcher.

Table 2

Mathematics and Music Lessons Sequence

Lesson	Math Concept	Instrument
1	Introduction to music, notes, and rhythm	All instruments
2	Check for understanding of rhythmic pattern	Drums
3	ABAB pattern	Shaker eggs
4	ABAB pattern	Rhythm sticks
5	Review ABAB pattern Introduce AABBAABB pattern	Bells
6	Review ABAB pattern Create AABBAABB pattern	Castanets
7	Review ABAB pattern and AABBAABB pattern	Wooden blocks
8	Children create a pattern of their choosing	Children choose a favorite instrument

The lessons were based on standards for music education and mathematics education as set forth by MENC and NCTM. The MENC standards (2006) include guidelines for singing and playing instruments, creating music, responding to music, and understanding music. The lessons focused directly on Standard 2, a content standard for creating music. Children:

c. create short pieces of music, using voices, instruments, and other sound sources; and

d. invent and use original graphic or symbolic systems to represent vocal and instrumental sounds and musical ideas.

The NCTM standards included in the lessons are the following: In pre-kindergarten through grade 2 all students should:

- recognize, describe, and extend patterns such as sequences of sounds and shapes or simple numeric patterns and translate from one representation to another;
- analyze how both repeating and growing patterns are generated; and
- use concrete, pictorial, and verbal representations to develop an understanding of invented and conventional symbolic notations.

There were eight lessons which focused on creating patterns using musical instruments. Each day, the students practiced creating rhythmic patterns using a different percussion instrument. The materials for the lessons included foam half notes and quarter notes with magnets on the back, cookie sheets on which the foam notes were placed, and various percussion instruments. The eight lessons began on day one with introductions of materials and concepts as well as playtime with the materials, modeling of ABAB patterns, and creation of ABAB patterns. The lesson on day two reviewed the previous day's lesson and allowed for more play with the materials and creation of ABAB patterns. Each successive day began with a review, time for play with a new instrument, time for each child to create and play patterns, time for the introduction of more complex patterns, and ended with a group pattern played altogether. Day eight reviewed all patterns and ended with the performance of the group's favorite pattern.

Data Collection and Procedure

The following was completed prior to the collection of data:

- approval by the University of Houston Committee for the Protection of Human Subjects;
- approval from the Congregation Beth El Preschool;
- approval from the principal at Congregation Beth El Preschool; and
- approval from parents of the students via signed consent forms.

The pre-school consists solely of pre-school classrooms. There is only one pre-kindergarten class at the school. Parental Letters of Consent were distributed to the parents of the children in this classroom. All of the children in the class obtained parental consent and gave their own assent to participate in the study. The study was four weeks in duration and began with the placement of musical instruments in the play center in the classroom on the first Monday of the study.

The data was collected using a Performance Task-Pattern Path Assessment (adapted from Clements and Sarama, 2009). The researcher used a checklist that consists of the Learning Trajectories (Clements and Sarama, 2009). The chart below explains the developmental stages of patterning behaviors.

Table 3

Performance Task Pattern Path Assessment Levels

Age (years)	Developmental Progression	Instructional Tasks
2	Pre-Explicit Patterner	Teacher emphasizes patterns in songs, stories, dances
3	Pattern Recognizer	Teacher counts in patterns, discusses patterns while observing environment, finds patterns in children's clothing
4	Pattern Fixer, Pattern Duplicator, Pattern Extender, Pattern Duplicator	ABABAB Teacher shows geometric patterns, shows a strip of paper with a pattern and describes it, children duplicate pattern, extend pattern
5	Pattern Extender	Children extend ABBABBAB patterns creatively, with pattern strips, by stringing beads
6	Pattern Unit Recognizer	Children can identify the smallest unit of a pattern using cube towers and by using rhythm instruments to create a pattern
7	Numeric Patterner	Children observe, copy, create

	patterns that grow (geometric and numeric

This was the checklist used by the researcher which is based on the Learning Trajectories (Clements and Sarama, 2009).

Table 4

Performance Task Pattern Path Assessment Checklist

Developmental Progression	Task	Yes	No	Notes
Pre-Explicit Patterner	Child sings at least 3 verses of “Old MacDonald”			
Pattern Recognizer	Child counts with researcher emphasizing even numbers			
Pattern Fixer, 1.Fixer 2.Duplicator (AB) 3.Extender (AB) 4.Duplicator (ABBABB)	1. Child “fixes” geometric pattern on a strip where one is “missing” 2.Child duplicates the geometric strip pattern 3.Child extends AB pattern 4.Child duplicates ABBABB pattern in a different location than the			

	model
Pattern Extender	Child extends an ABBABB pattern on a strip
Pattern Unit Recognizer	1.Student is shown an ABBABB pattern and can identify the “core” of the pattern 2.Student can create a rhythmic pattern
Numeric Patterner	Child creates a growing geometric pattern using blocks

In addition to the task performance checklist, the researcher collected data using the field notes in the classroom two weeks prior to the start of the eight lessons. Musical instruments were placed in the pre-kindergarten classroom and the researcher sat in the back of the room and quietly observed as the children played. Although only the five sample children’s behaviors were the focus of the study, the observation took place during normal class time and with the participation of the entire class. This “natural context” in which students were observed afforded insight into organic interactions among and between students and the objects used for play (Wein, 1996). The researcher noted any play that incorporated musical or mathematical patterning

A third data collection source was the video recording of the lessons taught to the pre-kindergarten class by the researcher. The video camera was placed in the classroom and focused on the researcher and the class during each of the eight lessons. The researcher reviewed the video one time for each of the five subjects and compiled field notes based on those viewings.

A fourth data collection procedure was journal field notes written by the researcher immediately following the completion of the lessons each of the eight days. These notes were the researcher's metacognitive response to the lessons as they were taught. At the end of the eighth day of lessons, the researcher reread the notes and highlighted phrases that corresponded to the themes previously generated from the observation. These phrases were color coded and later compiled with color coded themes from the video recording.

Data Analysis

After the data was gathered, the analysis began with the Performance Task Assessment. The students' performance was recorded on Table 4, Performance Task Pattern Path Assessment Checklist. This table was organized according to developmental patterning levels and was color coded according to those levels.

The second set of data, field notes written during the fifteen minutes the researcher spent in the classroom observing the children in play centers, was analyzed next. The researcher typed the field notes, then highlighted and coded them according to themes that recurred in the note taking.

Similarly, notes taken during the review of the lesson video, the third data source, were reread and coded according to recurring themes.

The final set of notes written by the researcher immediately following the lessons were also typed, reread, and coded according to the recurring themes.

The researcher then analyzed all four coded sets of data. Commonalities and points of interest among the data were examined and discussed according to themes generated.

CHAPTER IV

RESEARCH FINDINGS

Four data sources were used in this study to answer the research question, How are mathematics patterning skills and concepts developed when young children experience integrated mathematics and music lessons? The four data sources were: 1) Pattern Path Assessment (Pre- and Posttest), 2) observations before the lessons, 3) metacognitive fieldnotes during the lessons, and 4) observations of videotaped recordings of the lessons. This chapter discusses the results from the Pattern Path Assessment Pretest and Posttest taken by the 5 randomly selected prekindergarten children. Additionally, the 7 themes generated by the observational results (observation before the lessons, metacognitive fieldnotes, and video-tape recording of the lessons) are listed according to theme.

Analysis of Pattern Path Assessment

The Pattern Path Assessment, one of the four data sources in this study, was given to 5 out of the 11 students in the prekindergarten class. Three of the 5 students' patterning performances changed from the pretest to the posttest. The scores on the pre- and posttests as well as the changes are represented in Table 5. A specific description of each of the tasks as they relate to the developmental progression is represented in Table 6.

Table 5

Performance Task Pattern Path Assessment Results

Developmental Progression*	Child 1		Child 2		Child 3		Child 4		Child 5	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Pre-Explicit Patterner (1 task)	1	1	1	1	1	1	1	1	1	N/A**
Pattern Recognizer (2 tasks)	2	2	2	2	2	2	2	2	2	N/A**
Pattern Fixer, (8 tasks)	5	5	1	7	8	8	3	7	4	8
Pattern Extender (2 tasks)	1	1	0	2	2	2	2	1	1	2
Pattern Unit Recognizer (3 tasks)	1	1	0	1	1	1	0	1	0	1
Numeric Patterner (2 tasks)	1	1	1	0	2	2	1	1	1	1
Total	11	11	5	13	16	16	9	13	9	12

*See Table 6 or the developmental task description
**Student was too nervous to complete these tasks

Table 6

Description of Performance Tasks used as Assessments for the Pattern Developmental Progression

Developmental Progression	Task
Pre-Explicit Patterner	Child sings at least 3 verses of “Old MacDonald”.
Pattern Recognizer	a. Child counts with researcher emphasizing even numbers b. Repeat singing m3
Pattern Fixer, Fixer	a. Child “fixes” geometric pattern on a strip where one is “missing”. b. Child fills in missing beat in a rhythmic pattern.
Duplicator (AB),	a. Child duplicates the geometric strip pattern b. Child duplicates the rhythmic pattern clapped by researcher.
Extender (AB),	a. Child extends AB pattern b. Child extends clapped AB pattern
Duplicator (ABBABB)	a. Child duplicates ABBABB pattern in a different location than the model b. Child duplicates ABBABB pattern clapped by researcher
Pattern Extender	a. Child extends an ABBABB pattern on a strip b. Child extends ABBABB pattern clapped by researcher
Pattern Unit Recognizer	a. Student is shown an ABBABB pattern and can identify the “core” of the pattern b. Student can identify a 3 note pattern c. Student can create a rhythmic pattern
Numeric Patterner	a. Child creates a growing geometric pattern using blocks b. Child can sing Old MacDonald using a growing pattern format

The pretest and posttest were given to the five children chosen at random from the eleven total children in the prekindergarten class. The children were tested individually in a room down the hall and separate from the regular classroom. The charts display the number of tasks completed correctly in the pretest and in the posttest.

It is important to note that the manipulatives used in both the pretest and the posttest were the same. They were small button manipulatives of the same color, but different shapes. They were not; however, the same manipulatives used for the music and math lessons in the classroom which were manipulatives of different shape and color. None of the music and math lesson manipulatives were used to test the children. In addition, with the exception of the “create a rhythmic pattern” task, the tasks the children completed in the tests were not the same activities taught in the music and math lessons.

The results of the Pattern Path Assessment are described by each child and by each developmental progression.

Child 1

Child 1 showed no change from the pretest to the posttest. The child easily completed the color and shape pattern tasks, but was unable to complete the rhythm pattern tasks on either the pretest or the posttest.

Child 2

Child 2 showed a change from the pretest to the posttest in the “Pattern Fixer”, “Pattern Extender”, and “Pattern Unit Recognizer” sections. Child 2 also showed a change in the “Numeric Patterner” section in which the score decreased from 1 task completed to no tasks completed.

Child 3

Child 3 showed no change from the pretest to the posttest. The child easily completed the color and shape pattern tasks and Child 3 also correctly completed the rhythmic pattern tasks.

Child 4

Child 4 showed a change from the pretest to the posttest in the “Pattern Fixer”, “Pattern Extender”, and “Pattern Unit Recognizer” sections.

Child 5

Child 5, showed a change from the pretest to the posttest in the “Pattern Fixer”, “Pattern Extender”, and “Pattern Unit Recognizer” sections.

Child 2, Child 4, and Child 5 showed change in the same categories. Each had a change in the “Pattern Fixer”, “Pattern Extender”, and “Pattern Unit Recognizer” sections. Child 2 also showed a change in the “Numeric Patterner” section.

Pattern Fixer

Child 2 and Child 4 were presented with a pattern of like colors, but different shaped buttons in which one button was missing. The children had to choose the correct missing piece from a large pile of same colored buttons and place it on the sentence strip. Child 2 and Child 4 were unable to complete this task on the pretest. Both chose random shapes from the pile. On the posttest, both children were able to identify the missing piece and place it correctly on the sentence strip.

Child 2 and Child 4 were presented with an ABAB pattern on a sentence strip and were asked to duplicate the pattern using the same button manipulatives below the original pattern. Neither child was able to complete this task on the pretest. Both children were able to correctly complete the task on the posttest.

Child 2 and Child 5 were asked to duplicate a clapped ABAB rhythmic pattern. Neither child was able to complete this task on the pretest, but both children successfully clapped the pattern on the posttest.

Child 2 was asked to extend an ABAB pattern presented using manipulatives on a sentence strip and was unable to perform the task. However, the child was able to extend the pattern on the posttest.

Child 2 and Child 5 were asked to listen to an ABAB clapped rhythmic pattern and were asked to extend the pattern. The children were unable to complete this task on the pretest, but were successful on the posttest.

Child 2 and Child 4 were asked to duplicate an ABBABB pattern. The children were presented with a sentence strip upon which buttons of the same color, but different shapes were placed in an ABBABB pattern. The children were then asked to duplicate that pattern in a different location away from the original pattern. Neither of the children was successful on the pretest, but both were able to duplicate the pattern on the posttest.

Child 5 was asked to duplicate an ABBABB pattern clapped rhythmic pattern and was unable to complete this task on the pretest. However, the child was successful on the posttest.

Pattern Extender

Child 2 was presented with an ABBABB pattern of like colors, but different shaped buttons placed on a sentence strip and was asked to extend the pattern on the strip using a pile of like colored buttons on the table. The child was unsuccessful on the pretest, but was able to complete the task correctly on the posttest.

Child 2, Child 4, and Child 5 were each asked to extend an ABBABB clapped, rhythmic pattern and were unable to complete the task on the pretest. However, each of the three successfully completed the task on the posttest.

Pattern Unit Recognizer

Child 2, Child 4, and Child 5 were each asked to create a rhythmic pattern on the pretest by clapping a rhythm. None of the three were successful on the pretest, but all three children were able to create a rhythmic pattern on the posttest.

Numeric Patterner

Child 2 was asked to sing, “Old MacDonald Had a Farm” using a growing pattern. Each of the animals chosen was added on to the growing list as the child sang. The child was able to complete this task correctly during the pretest, but was unsuccessful during the posttest.

Analysis of the Observational Results

The next part of the analysis stems from the three remaining data sources: observation before the lessons began, videotape of the lessons, and metacognitive field notes. After the data collection, notes were compiled and recurring themes were color coded and analyzed. The seven themes generated were: “The children have a natural interest in music”, “The use of instruments as non-musical toys before music and math lessons”, “The children’s natural interest in music was piqued during music and math lessons”, “Non-pattern sounds created by the children”, “Pattern making with color and shape”, "Reading patterns in rhythm with one-to-one correspondence", and "Unique pattern making".

The children have a natural interest in music

During the two weeks prior to the math and music lesson instruction, observational notes were complied about the children's behaviors when a bucket full of instruments was placed on the floor in the classroom for fifteen minutes during centers time. The researcher stated, "I have not announced the fact that I brought this new bucket of instruments, nor introduced the children to the contents of the bucket." Some children exhibited a curiosity toward the bucket, but did not play with any of the instruments: "A child from the computer area came over and looked at the bucket of instruments but left"; "One child picked up an instrument, examined it, and threw it back in the bucket"; and "The instruments are placed close to the dramatic play center, and one boy keeps walking back and forth between the dramatic play center and his role in it and the instrument bucket. He leans over occasionally and looks in the bucket but doesn't touch anything". These instances all occurred on the first day of observation. In the subsequent days of observation, some of the children would approach the bucket and try the instruments. The researcher wrote, "Children have congregated around the instruments. They are trying out several different kinds including the castanets, drums, tambourines, and cymbals". On Days 8, 9, and 10, groups of children tried playing with many of the instruments: "One child picked up the cymbals and is banging them together in a random pattern. She walks over to the computer kids and shows them. This captures the attention of the other two dinosaur girls and they say, 'Let's get some instruments!'"; "Three children have approached the music box and are testing out some instruments.

Two boys are using the castanets and the girl (she has not previously played with the instruments) is banging the cymbals"; and "The lead…taps the mallets together like a rock star and directs the second boy to do the same. He does and then the first boy says, 'GO!' They both hit the drum as fast and as loudly as they can". Additionally, as the observation days wore on, Child 5, showed a recurring interest in the instruments. On Day 7 of the observation the researcher noted, "This child was one of the very few who played with the instruments almost every day."

<u>The use of instruments as non-musical toys before music and math lessons</u>

While the children displayed a natural interest in the bucket of instruments, some began using the instruments as playthings disregarding the musical aspect of the object. This behavior began on Day 3 of the observation when the researcher wrote, "I am starting to think that like most classroom toys and tools, without proper introduction and modeling for the children, they do not know how to use the toys and what purpose they may serve." The researcher made note of this behavior the next day stating, "This child is using the instruments to play store. She is buying the instruments and giving money to the girl with the cash register. The children do not seem to be interested at all in using the instruments to make music." This instance was just the beginning of a play episode during which the children involved incorporated many of the instruments into the stock of a store which sold the instruments. The game expanded to include more children and gradually disintegrated into each of the children choosing new play areas. One child took interest in a game on the top of one of the drums, "The girl continues to try and work with the maze on the drum, but has not tried to use the drum as a drum." Eventually, the children completely lost interest in the instruments and the researcher observes, "The instruments remain unused even though they were placed right next to the area where most (eight children) are playing." During several of the later observation days, this trend continued as the researcher noted: "Whereas before today the instruments would at least be used as props for play, today no one has even glanced at the instruments"; "They are even stepping over them to play in areas next to them on the floor"; "One of the girls is the one who has been regularly playing with or examining the instruments, but so far, she hasn't even looked at them"; "No one is interested in the instruments" ;and "A child almost trips over the instruments and the aide says, 'Watch out!'"

The children's natural interest in music was piqued during music and math lessons

After the music and math lessons began, the children showed interest by making connections between music and their knowledge. The researcher used the technique of appealing to the prior knowledge of the children by asking the class each day what song they would like to sing while they tapped the beat. The class would brainstorm song ideas together and chose songs with which they were familiar. The researcher wrote on the first day of lessons, "Child 5, who also happens to be the child that showed the most natural interest in the instruments during the observation days, piped up excitedly and said she was going to sing her sister's favorite song." During the second day of lessons, the researcher noted, "Most remembered that it (the song that had been previously chosen by the class as the opening song) was "Twinkle Twinkle Little Star" and were enthusiastic about this." As the lessons progressed into the fourth day and the children began creating patterns on the cookie sheets and performing them for the class, the interest level increased further. The researcher made note of this over the course of the remainder of the lessons: "A child approached me while I was setting up to tell me that today was the day they were going to make their own patterns on the cookie sheet. I was so happy to see that there was a lot of excitement about this"; "Child 5 is becoming extremely self-confident and loves to perform for the other children. I am enjoying watching each of them grow. Even the teacher commented on how well they are all doing"; "They (the children) easily warm to the idea of creating their own patterns and are happy to try new ways to pattern"; "They were very eager to perform their creations"; and "They would get so excited that some of them went a little wild with their rhythms without regard for the fact that it had to be repeated. It was like they were trying to outdo each other with more and more elaborate rhythms." The enthusiasm and interest carried through the last lesson when the children were given free rein to play anything they chose and the researcher noted, "The pattern making has become a favorite activity for the class as they seem to like being able to play something and perform for the rest of their peers" and a child stated, "Ms. Carolyn, I really like music class!"

The theme of interest level surfaced again for four out of the five children who were randomly selected as the focus of the study in the notes from the tapes of the lessons:

- Child 1 "…stays interested through all 11 children's welcome." and "The child is watching intently."
- Child 2 "The child eagerly follows directions and listens intently to my instruction."
- Child 3 "This child exudes confidence and enthusiasm."
- Child 5 "I (the researcher) change the pattern on the cookie sheet to AABBAABB and this child reads loudly (over the other children) in rhythm and confidently.

While creating a pattern on the cookie sheet the child is proud and exclaims, 'I made a different one!'"

Non-pattern sounds created by the children

The first theme that emerged from the patterning portion of the observation was non-pattern sounds created by the children and most of the non-pattern sounds were made during the classroom observations which occurred before the lessons began. The researcher noted when the instruments are used as percussive instruments and that many of the rhythms played are irregular and non-repeating:

- "One child is beating randomly on the drum."
- "One child has found the cymbals and is beating a random rhythm and another boy is beating a random rhythm on the tambourine".
- "One girl took the drum from the bucket over to where the other girls are reading. She beat a random rhythm and seems to be trying to involve the other 2 girls."
- "One child has a shaker and is randomly shaking it."
- "The child has cymbals and is hitting them together in a random rhythm."
- The (child) beat a random rhythm on the drum and left for the dramatic play center."
- "He is making up some inconsistent rhythms with the feet of the mammoth he's holding and is listening to the sounds he is making."
- "He is beating a random rhythm using the mallets attached to the drum."

- “The girl with the cymbals is banging them together in a random rhythm as hard as she can. She then picks up the tambourine, abandons that and looks for another instrument. She is back to the cymbals and is banging them loudly. The rhythm seems to be slow, slow, fast, fast, fast (it is not a regular beat), but then the children complaint that she is too loud and she stops.”
- “The boy with the dinosaurs is back and is banging a random rhythm again on the drum with the dinosaur feet. He then picks up the jingle bells, examines them, and randomly bangs on the drum again.”
- “The same interested girl is beating on the drum (another random rhythm). She continues for awhile seeming to enjoy the sound she’s making.”
- “One child picked up the cymbals and is banging them together in a random rhythm.”
- “They have the sticks and jingle bells and are beating them in random rhythms.”
- “She plays a short random rhythm on those instruments and several more.”
- “She digs in the box and very quickly tries out each instrument including the drums. There doesn’t seem to be any pattern.”
- “He is leading the other boy in beating a random rhythm on the drums.”
- “They both hit the drum as fast and as loudly as they can.”

Some of the random rhythms occurred during the lessons and were written about in the metacognitive notes:

- "However, the child really wasn't creating any patterns."
- "Some understood and did quite well, but others had trouble and were unable to come up with good repeating patterns."

More notes about random rhythmic patterning were compiled during the video tape viewing:

- Child 1 "I have the children each create a pattern using their instrument. The child is unable to do this and randomly shakes the maraca."
- Child 1 "The child tried, but was unable to create any patterns that repeated."
- Child 4 "The child is asked to play a rhythm on the drum, but just plays a random succession of beats."
- Child 4 "The child is unable to play a pattern when asked to do so. The child just plays a series of random beats."

Pattern making with color and shape

The next theme that came from the patterning portion of the observation was pattern making with color and shape. This type of patterning first occurred during the lessons and continued through the remaining lessons and observation. The researcher took notes about when patterns were created and what kinds of patterns were created:

- "Every child easily created an ABAB pattern. I was not surprised by this as I have found that this skill is drilled excessively in preschool."

- “Most of the children chose the AABBAABB pattern and only a few were unable to do this.”
- “This child successfully created an AABBAABB pattern and was able to easily play it.”
- “The most interesting is Child 4 who could not even create a pattern last week and is now creating them. This child was not able to create patterns on the pretest.”
- “Child 2 has really come a long way in the past week and was able to create a pattern and read it with no problem.”
- “Child 3 finds this consistently easy.”
- “Only Child 1 did not make a pattern.”
- “Child 5 made an ABBABBA pattern and read it correctly with ti and ta.”
- “Child 2 made an ABAB pattern and easily read it with ta and ti.”
- “Child 4 is really coming along. It has taken a little longer, but this child does a lot of observation and it has paid off. This child confidently created an ABAB pattern and read it with a steady beat instead of the correct beat. I am still extremely impressed with the progress of Child 4 in only a week and a half.”
- “Child 3 created an ABBABBA pattern and easily read it in with the correct beat values using ta and ti. Every lesson seems easy for this child. There has not been any struggle since the beginning of the lessons.”

- “Many of the children who created either the ABAB or AABBAABB patterns were able to correctly read the patterns using ta and ti.”
- “Child 1 did not make a pattern. This has been an ongoing issue and I chose to intervene again.”
- “Two other children, including Child 3 created new and different patterns.”
- “There was no pattern on the cookie sheet, just random notes placed.”
- “The child was able to create this pattern on the cookie sheet and could read it in tempo.”
- “Children are asked to create ta ta ti ti ta ta ti ti and child is told to make the notes look like the other children’s 2 times because the child did not make any pattern.”
- “The child is asked to create this pattern on the cookie sheet, tries quickly, but is incorrect.”
- “The child does not create a pattern when given the opportunity. Instead, the child randomly places the notes in a line and begins to read them.”
- “1 have to intervene with Child 1 and remind the child that a pattern has to repeat. I give examples and the child creates a pattern. The child ends up creating a unique pattern (ta ta ti, ta ta ti) and is able to read it in tempo!”
- “The child easily creates an ABABA pattern and is able to read it in tempo.”
- “The child quickly and easily creates an ABAB pattern on the cookie sheet.”

- "The class creates AABBAABB patterns on the cookie sheet. This child (Child 2) groups the like colors together in a line, but self corrects after watching the others."
- "The child (Child 2) easily creates an ABABA pattern on the cookie sheet, but reads it in an even, steady beat."
- "The child (Child 2) quickly and easily creates an AABBAABB pattern."
- "The child (Child 2) quickly and easily creates another AABBAAB pattern on the cookie sheet."
- "The child (Child 3) very quickly and easily creates an ABABA pattern on the cookie sheet and is able to read it in tempo. This is very easy for this child."
- "Child 3 created this pattern: ABBAABBA and played it almost perfectly."
- "Child 3 easily and quickly creates an AABBAABB pattern on the cookie sheet."
- "Child 3 again creates a pattern that has not been introduced (AAABBAAABB)."
- "Child 3 creates an AABAABAA pattern."
- "The end creation (Child 3) is an ABBABBA pattern."
- "Child 4 slowly creates an ABABA pattern on the cookie sheet."
- "Child 4 creates an ABABA pattern fairly easily and checks neighbor's sheets to make sure the pattern is correct."

- "Child 4 creates an AABBAABB pattern on the cookie sheet fairly quickly and with minimal checking on others' sheets."
- "Child 4 creates an ABABA pattern."
- "Child 4 quickly and easily creates an AABBAABB pattern without checking any other child's cookie sheet."
- "Then, Child 4 creates an AABBAABB pattern."
- "Child 5 quickly and easily creates an ABABA pattern."
- "Child 5 creates an AABBAABB pattern quickly."
- "Child 5 quickly and easily creates an AABBAABB pattern."
- "The child (Child 5) creates an ABBABBA pattern independently."
- "The child (Child 5) creates an AABBAABB pattern on the cookie sheet."
- "The child (Child 5) creates an AABBAABB pattern on the cookie sheet."

Reading patterns in rhythm with one-to-one correspondence

Another theme that recurred during the pattern making lessons was the children's ability to read patterns with one-to-one correspondence. Some of the children easily understood the connection between the sound and the note value, but others needed extra coaching. The researcher noted when the children were and were not able to demonstrate one-to-one correspondence:

- "When asked to read it, Child 1 did so, but did not understand that it was different from the others and not a pattern. I asked that the child make the cookie sheet look like the rest of the class's patterns. I came back to this child and the child read the notes correctly and in tempo."

- "Child 1 could read it in tempo. The child was unable to play the pattern in tempo using the cymbals."

- "I helped Child 1 read the pattern twice because the child is having trouble. I ask the child to do it alone the third time. The child is tentative, but does it."

- "The child (Child 1) does not understand."

- "Child 1 reads it, but only after I recite the pattern."

- "I have to intervene with Child 1 and remind that a pattern has to repeat. I give examples and the child creates a pattern. The child ends up creating a unique pattern (ta ta ti, ta ta ti) and is able to read it in tempo. This is a tremendous leap in understanding for this child."

- "Child 2 easily creates an ABABA pattern and is able to read it in tempo."

- “Child 2 requests 2 extra notes and then has a couple of false starts. The child self-corrects, starts again, and taps the beat with one-to-one correspondence in tempo. Impressive.”
- “Child 2 is last to read the rhythm and does it correctly and n tempo.”
- “Child 2 easily creates an ABABA pattern on the cookie sheet, but reads it in an even, steady beat. I intervene and have the child reread in tempo with me.”
- “Child 2 reads the pattern, but not in tempo.”
- “Child 2 quickly and easily creates another AABBAAB pattern on the cookie sheet, but reads it in an even rhythm when asked to use ta and ti.”
- “Child 3 very quickly and easily creates an ABABA pattern on the cookie sheet and is able to read it in tempo.”
- “Child 3 is able to read the ABABA pattern I created on the cookie sheet in chorus and in tempo.”
- “Child 3 reads the pattern in tempo alone and does this perfectly.”
- “Child 3 again creates a pattern that has not been introduced (AAABBAAABB). The child reads the pattern in close to perfect tempo.”
- “Child 3 creates an AABAABAA pattern. Again, this was not a pattern introduced in class. The child reads it incorrectly with a steady beat, but is able to do it in tempo when I demonstrate.”

- "I started and Child 3 finished in perfect tempo and touched each note as it was read."
- "Child 4 slowly creates an ABABA pattern on the cookie sheet, but reads it in an even tempo."
- "Child 4 reads the pattern, but not quite in tempo."
- "Child 4 creates an AABBAABB pattern on the cookie sheet fairly quickly and with minimal checking on others' sheets. The child reads the pattern in tempo while pointing to each note as it is read."
- "Child 4 creates an ABABA pattern, but reads it in an even tempo. I correct the reading and the child does it correctly with me."
- "Child 4 struggles to read the pattern in tempo even with my intervention."
- "Then, the child (Child 4) creates an AABBAABB pattern and is able to read it in tempo."
- "Child 5 quickly and easily creates an ABABA pattern and is able to read it in tempo and with one-to-one correspondence."
- "Child 5 creates an AABBAABB pattern quickly and easily on the cookie sheet and reads it in tempo"
- "Child 5 quickly and easily creates an AABBAABB pattern. The child reads the pattern with an even beat and I correct this. The child rereads in tempo."

- "Child 5 creates an ABBABBA pattern independently and reads it easily in tempo."

- "Child 5 creates an AABBAABB pattern on the cookie sheet, but reads it in an even tempo. I correct the rhythm."

- "Child 5 creates an AABBAABB pattern on the cookie sheet and reads it in tempo."

Unique pattern making

The final theme evidenced by the observations during the lessons was unique pattern making. The children played with the manipulatives during the lessons and created unique patterns that had not previously been introduced. The researcher took notes about when patterns were created and what kinds of patterns were created:

- "Child 1 ends up creating a unique pattern (ta ta ti, ta ta ti) and is able to read it in tempo. This is a tremendous leap in understanding for this child."

- "Child 2 creates an ABCABC pattern when asked to make up a pattern using an instrument. The instrument was shaken in the air, on a knee, and then on the ground and repeated. This had not been done before by me or any of the other children."

- "Child 3 created this pattern: ABBAABBA and played it almost perfectly. This was a unique pattern that I did not introduce in class, or help this child create."

- “Child 3 then plays a pattern using a tambourine and a rhythm stick (AABBAABB) by hitting the tambourine twice and then shaking the tambourine twice. No other children did anything like this.”

- “Child 3 was told to create a pattern using rhythm sticks, the child creates (AABBBAABBB). Once again, the child created a new and more complex pattern than had been introduced in class.”

- “Child 3 created an ABBABBA pattern. Once again, this was a pattern was unique and one that only this child created.”

- “Child 5 plays an ABCABC pattern and incorporates a dotted eighth note. This is a rhythm that has not been introduced.”

- “Child 5, when paired with another child, plays an ABABAB pattern and an AABBCAABBC pattern. This is a far more complex pattern than was introduced in the lessons”.

Table 7

Pattern Path Assessment Pretest in Shape and Rhythm Compared to Musical Patterning Performance Tasks

Child	Pattern Path Assesssment Pretest (shape)	Pattern Path Assessment Pretest (rhythm)	Pattern Lesson (Color/shape)	Pattern Lesson Rhythmic reading/playing	Pattern Lesson Unique
1	X		X*	X*	X*
2			X	X	X
3	X	X	X	X	X
4		X	X	X	
5	X		X	X	X

*with difficulty

Table 6 displays each of the 5 children's performances on the Pattern Path Assessment Pretest specifically in regard to mathematical shape patterning and musical patterning (Clements & Sarama, 2009). The table also displays each of the 5 children's performances in musical patterning as recorded during the video-taping of the lessons. The table is designed to present the data in a side-by-side comparison. During the lessons, shape, color, and rhythmic patterning was introduced using manipulatives of different shape and color and the researcher noted the performance of each child as the pattern was created and recited in rhythm. During lessons from Day 4 through Day 8, children were asked to create unique patterns not introduced in class.

Child 1

Child 1 created a shape pattern on the pretest, but did not create a rhythmic pattern on the pretest. Child 1 created a color and shape pattern and read it in rhythm, but had great difficulty. Day 4 was the only day that Child 1 successfully and independently created a pattern. The researcher's notes said, "The child was able to create this pattern on the cookie sheet and could read it in rhythm." However, Child 1 usually required extra coaching. The researcher wrote on Day 5 of the lessons, "Child1 has consistently had trouble creating the cookie sheet pattern." And on Day 6 of the lessons, the researcher commented, "Only Child 1 did not make a pattern." Further, on the final day of lessons, the researcher wrote, "Child 1 did not make a pattern. This has been an ongoing issue, and I chose to intervene again." Similarly, in the video-tape notes of the last day's lesson, the researcher recorded, "…and (I) have to intervene with this child and remind that a pattern has to repeat. I give examples and the child creates a pattern. The child ends up creating a unique pattern (AABAAB) and is able to read it in rhythm." Though Child 1 often needed help and did not usually create patterns without individual instruction and the unique pattern was created after redirection and only on the last day of lessons, Child 1 did show progress from the beginning of the lessons to the end of the lessons. The researcher wrote, "This (the creation of a unique pattern) is a tremendous leap in understanding for this child."

Child 2

Child 2 did not create a shape pattern on the pretest and did not create a rhythmic pattern on the pretest. Child 2 created a color and shape pattern and read it in rhythm. Creating shape and color patterns was consistently easy for Child 2. The researcher wrote, “The child easily creates an ABABA pattern…” and continued to write similar comments about Child 2’s color and shape patterning ability throughout the 8 days of lessons. Child 2 could read the simpler patterns in rhythm on Days 3 through 5 as evidenced by the researcher’s notes: “The child easily creates an ABABA pattern and is able to read it in rhythm.”, “The child requests 2 extra notes and then has a couple of false starts. The child self-corrects, starts again, and taps the beat with one-to-one correspondence in rhythm.”, and “The child is last to read the rhythm and does it correctly and in rhythm.” However, on Days 6 through 8, the child begins reading the patterns in an even tempo. The researcher noted: “The child easily creates an ABABA pattern on the cookie sheet, but reads it in an even, steady beat. I intervene and have the child reread in rhythm with me.”, “The child reads the pattern, but not in rhythm.”, and “The child quickly and easily creates another AABBAABB pattern on the cookie sheet, but reads it in an even rhythm when asked to use ta and ti.” Child 2 created a unique pattern using movement and an instrument. The researcher noted this saying, “The child creates an ABCABC pattern when asked to make up a pattern using an instrument. The instrument was shaken in the air, on a knee, and then on the ground and repeated. This had not been done before by me or any of the other children."

Child 3

Child 3 created a shape pattern on the pretest and created a rhythmic pattern on the pretest. The shape and color pattern was simple for this child and the researcher comments on this by saying, "Child 3 finds this consistently easy." The researcher also notes several different instances in which the child creates patterns without assistance: "The child very quickly and easily creates an ABABA pattern on the cookie sheet…"; "The child easily and quickly creates an AABBAABB pattern on the cookie sheet."; "The child again creates a pattern that has not been introduced (AAABBAAABB)."; "The child creates an AABAABAA pattern."; and "The end creation is an ABBABBA pattern." Similarly, Child 3 easily read the patterns in rhythm from the first day of readings, Day 3, through the last day of readings, Day 8, without difficulty: "The child very quickly and easily creates an ABABA pattern on the cookie sheet and is able to read it in rhythm."; "The child is able to read the ABABA pattern I created on the cookie sheet in chorus and in rhythm."; "The child reads the pattern in rhythm alone and does this perfectly."; "The child again creates a pattern that has not been introduced (AAABBAAABB)."; "The child reads the pattern in close to perfect rhythm."; "The child creates an AABAABAA pattern. Again, this was not a pattern introduced in class. The child reads it incorrectly with a steady beat, but is able to do it in rhythm when I demonstrate."; and "I started and the child finished in perfect rhythm and touched each note as it was read." Child 3 also created unique patterns more often than any of the five children. The researcher notes each of the three instances a unique pattern was created by Child 3: "The child then plays a pattern using a tambourine and a rhythm stick (AABBAABB) by hitting the tambourine twice and then shaking the tambourine twice. No other children did anything like this."; "When told to create a pattern using rhythm sticks, the child creates (AABBBAABBB). Once again, the child created a new and more complex pattern than had been introduced in class."; and "The end creation is an ABBABBA pattern. Once again, this was a pattern was unique and one that only this child created."

Child 4

Child 4 did not create a shape pattern on the pretest, but created a rhythmic pattern on the pretest. Child 4 created a color and shape pattern on each day it was requested (Day 3 through Day 8). The researcher recorded Child 4's progress and noted: "The child slowly creates an ABABA pattern on the cookie sheet."; "Child 4 creates an ABABA pattern fairly easily and checks neighbor's sheets to make sure the pattern is correct."; "The child creates an AABBAABB pattern on the cookie sheet fairly quickly and with minimal checking on others' sheets."; "The child creates an ABABA pattern."; "The child quickly and easily creates an AABBAABB pattern without checking any other child's cookie sheet."; and "Then, the child creates an AABBAABB pattern." Child 4 also read patterns in rhythm only on Days 5 and 8. The researcher takes note of Child 4's reading and writes on Day 5 and Day 8: "The child creates an AABBAABB pattern on the cookie sheet fairly quickly and with minimal checking on others' sheets."; "The child reads the pattern in rhythm while pointing to each note as it is read."; and "Then, the child creates an AABBAABB pattern and is able to read it in rhythm."   Child 4 did not create a unique pattern.

Child 5

Child 5 created a shape pattern on the pretest, but could not create a rhythmic pattern on the pretest. Child 5 created a color and shape pattern each day it was requested (Day 3 through Day 8). The researcher noted each of the patterns when writing: "The child quickly and easily creates an ABABA pattern."; "The child creates an AABBAABB pattern quickly."; "The child quickly and easily creates an AABBAABB pattern."; "The child creates an ABBABBA pattern independently."; "The child creates an AABBAABB pattern on the cookie sheet."; and "The child creates an AABBAABB pattern on the cookie sheet." Similarly, Child 5 could read patterns in rhythm and completed this task on each of the days it was requested except Day 7. The researcher wrote: "The child quickly and easily creates an ABABA pattern and is able to read it in rhythm and with one-to-one correspondence."; "The child creates an AABBAABB pattern quickly and easily on the cookie sheet and reads it in rhythm."; "The child quickly and easily creates an AABBAABB pattern."; "The child reads the pattern with an even beat and I correct this."; "The child rereads in rhythm."; "The child creates an ABBABBA pattern independently and reads it easily in rhythm."; and "The child creates an AABBAABB pattern on the cookie sheet and reads it in rhythm." Child 5 created two unique patterns, neither of which had been introduced in class. Both patterns were more complex than patterns introduced in class. The researcher noted this by writing, "The child plays an

ABCABC pattern and incorporates a dotted eighth note. This is a rhythm that has not been introduced.” and “When paired with another child, the child plays an ABABAB pattern and an AABBCAABBC pattern. This is a far more complex pattern than was introduced in the lessons.”

CHAPTER V

DISCUSSION AND SUGGESTIONS FOR FUTURE RESEARCH

Summary

The purpose of this study was to observe how mathematics patterning skills and concepts developed when young children experienced integrated mathematics and music lessons. The lessons, based on NCTM, MENC, and NAEYC standards, supported the use of integrated, developmentally appropriate music and mathematics lessons as a means through which mathematics learning may be enhanced. Specifically, the lessons employed music as a means to teach the discrete mathematical concept of patterning.

While Child 1 and Child 3 showed no change from the pretest to the posttest (both easily completed the color and shape pattern tasks and Child 3 also correctly completed the rhythmic pattern tasks), Child 2, Child 4, and Child 5, did have a change from the pretest to the posttest. All three demonstrated change in the same categories. Each had a change in the “Pattern Fixer”, “Pattern Extender”, and “Pattern Unit Recognizer” sections. Child 2 also showed a change in the “Numeric Patterner” section.

During the music and math lessons, each of the 5 children created a color and shape pattern-ABABA and AABBAABB-and read the patterns in rhythm. Also, each of the children (with the exception of Child 4) created a unique pattern during the lessons. The 7 themes generated from the observation before the lessons, metacognitive fieldnotes, and video-tape recording of the lessons were:

1. The children have a natural interest in music.

2. The instruments were used as non-musical toys before music and math lessons.
3. The children's natural interest in music was piqued during music and math lessons.
4. Non-pattern sounds were created by the children.
5. The children made patterns with color and shape.
6. The children read patterns in rhythm with one-to-one correspondence.
7. The children made unique patterns.

These themes resulted as the researcher noticed similar trends among the students' actions and behaviors.

Discussion

The Pattern Path Assessment pretest and posttest are an important starting point for the discussion of this study as they offer valuable information about where a child's developmental level was and whether there was growth as it pertains to mathematics patterning.

Because three out of the five children who pretested showed improvement in some of the patterning concepts on the posttest and because the observational data sources indicated knowledge gained in the children's concepts of patterning, it seems that the patterning skills of the students may be following the developmental levels described by Clements and Sarama (2009). Clements and Sarama discussed the stages of patterning the children may move through with the use of the trajectories as the guide to the ultimate goal of understanding mathematical concept of patterning. In this case, musical patterning through rhythm was part of this trajectory and seemed to influence the children's understanding of pattern. Where the children had little knowledge of patterning, I used the children's preexisting knowledge of rhythmic repetition through the use of songs familiar to the children as a platform upon which the concepts of repeating rhythmic patterns was laid. This rhythmic pathway or trajectory helped those students make a connection to mathematical patterning concepts which were demonstrated on the posttest.

However, merely looking at the posttest does not give a full view of the children's patterning understanding and development. While the pretest and posttest are a valuable source of information, they alone were not sufficient in the assessment of the children's patterning concepts. In my candidacy study, the quantitative assessment was the sole source of data and my recommendation for a future study was that it contain more data sources in order to optimize understanding of the children's performances (Wade, 2009). Therefore, the remaining three observation-based/qualitative data sources were vital to a broader scope of understanding how children's patterning concepts develop during a series of integrated mathematics and music lessons. Had I only analyzed the Performance Task Pattern Path Assessment, I would have gained some insight into the children's development; however, many questions as to how the children's knowledge developed and what knowledge they may have gained would have remained unanswered. The three observational sources added several windows through which I captured multiple glimpses into the actions, reactions, and behaviors of the children. Those windows created a new dimension and greater depth of understanding of the elements listed on the Pattern Path Assessment checklist.

For instance, two of the children who scored similarly on the pretest, Child 1 and Child 2, revealed starkly contrasting concepts about patterning when the three observational assessments were analyzed.

Child 1 is a student of great interest because of the child's ability to recognize, duplicate, and create mathematical patterns using manipulatives on the pretest, but the inability to make the leap into musical patterning. The child could create a color/shape pattern on the cookie sheet sometimes when prompted, but could not keep a steady beat, create an aural rhythmic pattern or duplicate a clapped or tapped pattern. In the 7^{th} lesson, the child seemed to turn a corner when a unique pattern was created (with help) and read in rhythm. I question the depth of knowledge of pattern, however, of this child if there is an inability to create a musical pattern and understand what is happening even though this child easily created and recognized mathematical patterns with manipulatives. My questions as a researcher are, "Does Child 1 have the same knowledge as Child 2 because both of the children had the same score on the pretest?" and if no, "Is there greater depth of knowledge required when a child is able to create and copy musical pattern than the knowledge that is required to create a solely a mathematical pattern using manipulatives?" The beginnings to an answer may lie in the observations of the remaining students.

This brings the discussion to Child 2 because a researcher who only looked at the pretest and posttest in mathematical patterning might conclude that Child 1 and Child 2 should receive the same "grade" as far as proficiency is concerned according to the Pattern Path Assessment. I would argue, however, that Child 2 has a broader understanding of pattern than does Child 1 because Child 2 completed the musical patterning tasks on the assessment and in the series of lessons. I think I should have questioned Child 2 more deeply and probed more as far as the understanding of note values in time is concerned.

Child 3 also displayed an understanding of pattern in the math assessment and had a similar pretest and posttest to Children 1 and 2. However, I would venture to say that this child has an even greater depth of understanding than the other children do. Out of the group of five children, this child displayed the most ease during the pretest and all subsequent observations and during the posttest. The child had a level of knowledge beyond all of the others and seemed aware of this. There was an air of confidence in this child and a willingness to use creativity when given the opportunity to do so. This child's understanding of pattern goes beyond color and even the idea of ABABA in rhythm. The child understands that as long as what is played is repeated, it is a pattern.

In contrast to Child 3, Child 4 showed very little knowledge of patterning according to the pretest, but was able to create rhythmic patterns and tap along to the beat very easily from the first day of lessons. Again, traditionally and just analyzing the mathematical tasks, this child would be marked as having no patterning knowledge according to the pretest, but musically, this was a different case. Music seems to be a successful approach for this child in the teaching of pattern. The confidence level of this child seemed to increase over the course of the eight lessons. Whereas the child was reticent to create patterns at the beginning of the lessons and checked many of the other children's cookie sheets, by the last several lessons, the child was creating patterns on the cookie sheet unaided. Child 4 was also the child who made the greatest gains on both the posttest and in the fieldnotes and video-tape notes.

Additionally, Child 4, who was initially unable to complete most of the patterning tasks on the pretest, easily completed the posttest and revealed an ease of understanding of rhythmic patterning. Music seemed to open a door to understanding of patterning for this child. While the actual patterning on the cookie sheets did not begin until Lesson 3, this child enthusiastically participated in the tapping the beat exercises I introduced to the children from the first lesson on Day 1. Whereas Child 4 seemed confused by the pattern tasks on the pretest, the child readily created patterns using the musical manipulatives when given the opportunity. While I do not believe music was a magic potion for understanding pattern, I do believe that because there was a visual and an aural component to the lessons, the child had ample time to contemplate the link between what was played by the other students and what appeared on the other students' cookie sheets. This child spent a lot of time watching the other children and copying their patterns before the child was able to independently create a pattern. When the child finally created a pattern independently from the other children, the child was able to successfully repeat the task several times on the remaining lesson days. This integrated approach, which is supported by research on multiple intelligences conducted by Howard Gardner, was just the key this child needed to unlock a mental connection to patterning (1983).

Child 5 is of particular interest, as this is the child who showed the most natural interest in music during the observation before the series of lessons began. This child displayed a large amount of timidity when other children were readily participating; however, as the lessons progressed and the child achieved a comfort level, confidence and enthusiasm for performance of the patterns was evident. This child was easily able to create color patterns, but needed some help with playing the rhythms. The child seemed to also need help finding a steady beat, but when given a chance to play, created some complex patterns. The child also appeared happy and smiled profusely while playing the instruments. Musical play seemed to be a natural behavior and often caused a look of wonderment in this child's eyes.

While no other children expressed the level of intensity of Child 5, the children readily participated in the lessons and appeared to have a natural enjoyment of music in the classroom both before and after the lessons were taught. During the observations before the series of lessons began, the children naturally gravitated toward the instruments and many wanted to test the sounds of each of the instruments. While there was an ebb and flow of activity around the bucket of instruments, the lessons generated a much more consistent atmosphere of enthusiasm. I believe there are several reasons for this. I started each lesson with a welcome song that was familiar to the children and that the children also had a hand in choosing. Allowing choice gave me the opportunity to show the children that I value their ideas and helped with the children's comfort level as I was a newcomer to their classroom. Further, I encouraged group participation in singing and tapping the beat to the songs, and I praised the children for a job well-done. I often referred to the children as musicians and helped them take ownership of the patterns they created by calling their rhythmic patterns musical compositions. I explained on several occasions that the note manipulatives they were using were just like the notes musicians read when they play music. In other words, I built upon the children's previous knowledge-that there are songs they know and hear on the radio or elsewhere-and added the idea that the sounds they heard had a written form. As a teacher and a researcher, I observed that music was an organic part of their lives, and I used this as a catalyst for expanding their knowledge. Additionally, I found that I didn't have to fight to keep the children's attention during the lessons. The children participated with enthusiasm and seemed to have fun creating patterns.

During the observation that took place before the series of lessons began, the children had an interest in the instruments but often used them as toys and non-musical objects. While children may display natural interests in one area or another, it does not follow that an interest in a subject area blossoms into a deep understanding of a matter unless investigation and play is nurtured and facilitated. Further, the interest in the instruments was short-lived, and without knowledge of the properties of the instrument and what its use may be, the children would grow tired of the toy and quickly discard it.

Along the same lines, when the instruments were used as instruments and played before the series of lessons began, the sounds were not regular or repeating musical patterns. Rather, the sounds were random bursts of percussive noises without any apparent structure. Again, the children had no classroom instruction about rhythmic patterning and the exploratory play in which they were engaged seemed largely focused on what sounds each instrument made. This kind of play, however, offers an optimum entry point for facilitation by the teacher. The issue that arises is when a teacher is unacquainted with the signs of the learning moment. When discussing the learning trajectories in their book, Clements and Sarama point out that if a teacher is unaware of the mathematical levels of development, he or she may miss the opportunity to facilitate movement through the levels. Musical patterning is a part of the many activities suggested by the authors to guide the children through their mathematical development (Clements & Sarama, 2009). More specifically, simply placing musical instruments in a play center without any instruction will not help the children grasp the concepts of mathematical patterning. Observation, careful guidance, and instruction are needed.

I found that when the aforementioned instruction began, the children's natural interest in music was piqued. The natural interest that I had observed in the exploratory play during my initial observations came back when the children were exposed to new ideas. Whereas the children had begun to ignore the instruments after several days and the newness of the play toys began to wear off in the play centers, the excitement was renewed when I explained how the instruments were properly played. The children had many opportunities for more exploratory play throughout the eight days of lessons and I noticed that when the children had some knowledge about how instruments are used, they were able to play regular, repeating patterns. This is something that did not spontaneously occur during the pre-observation period. This natural interest seemed to create a greater drive among the children to play and gather more knowledge.

This drive and curiosity may also explain why the children displayed an ease of understanding ABABA and AABBAABB patterning as it related to the color and shapes of the musical note manipulatives. All of the children created these patterns without excessive coaching or aide. I was surprised at how easily the transfer of knowledge occurred. I thought the children would have more trouble with the note value representation; however, none of the children expressed any anxiety or frustration with the manipulatives. I introduced the quarter note by its name and gave it another name, "ta". I also introduced the eighth note by its name and gave it another name, "ti".

Instead of trying to explain that two eighth notes make one quarter note, I modeled the sounds of “ta” and “ti” for the children. Surprisingly, most of the class could emulate the rhythm and sound I introduced. They were able to vocally copy my patterns and seemed to have an innate acceptance of what I was telling them. I truly believed that the transfer of the knowledge they needed from mathematics to music and the understanding that the notes were just representations of sound was going to take several lessons, but the repetition of the sounds of the beats and the short reminders of the sounds during the daily introductions of the patterns were enough to spark the children’s memories.

More than that, the children were also able to read the patterns in rhythm with one-to-one correspondence without a great deal of teacher intervention. While I was still contemplating whether, and to what extent, any transfer of knowledge had taken place, I observed this second phenomenon. There was no pretest or pre-observation that focused on one-to-one correspondence, but the children pointed to each note as they read their cookie sheet patterns aloud without any extra instruction. I modeled this behavior the way I would when reading a sentence on a chalkboard to a group of small children; however, I did not specifically require the children to do this as they performed their creations.

Four out of the five children who were the focus of the study created unique rhythmic patterns that had not been introduced by the researcher. I only introduced ABAB and AABBAABB patterns during the eight lessons, but gave the children many opportunities to play with the manipulatives. Given that there were only two colors and shapes from which to choose, the children still managed to create unique patterns. I encouraged them to do this by asking that they make something new. Some of the children did this physically by playing an instrument using different positions for each sound, while others made new rhythmic patterns solely by playing a chosen instrument. Still others created unique patterns with the manipulatives and played them for the class. I never expected the children to display their understanding in so many different ways and was pleased by the progress of the five children as well as the class as a whole. There was a willingness and excitement about the children as they performed their rhythmic compositions. They loved having the spotlight during the performance and were eager to create something none of the other children had seen. The children who succeeded in this activity demonstrated an understanding of pattern beyond regurgitation of the lessons I introduced. In order to be successful in this endeavor, the children had to know that whatever pattern they created, rhythmically, using the manipulatives (color) or both, that the unit of the pattern had to repeat. The fact that four out of the five children had success was beyond my expectations, as I thought this may be beyond their capabilities. The one child who was not able to create a unique pattern was also the child who could not complete most of the tasks on the pretest. My feeling was that this child had a steeper learning curve than did the other four children and was doing exceptionally well to have grasped the duplication, replication, and extension of the patterns introduced during the lessons.

The two things that struck me the most as I contemplated the implications of the lessons on the children's mathematical development, were my underestimation of the children's grasp of abstract concepts and the pace with which the class moved once the concepts were introduced. I should not have been so surprised, as the children who participated in my pilot study displayed similar understanding to the students in the current study. The difference was that the quantitative methods I used to gather data could not quantify what I thought I was observing (Wade, 2009). This time, armed with the Pattern Path Assessment, an assessment tool more aligned with children's development and behaviors and three other observational tools with which to capture the children's moments of struggle and success, I had larger windows through which I viewed the children's actions. What I see is that children's knowledge is not fractured and compartmentalized. They don't know that representation of sound is difficult. They just hear music and rhythm and they want to be a part of it. We sing lullabies to newborns, clean-up songs to pre-kindergarteners, and birthday songs to all who celebrate. We have our own pattern of music making in a young child's life. Isn't it natural to use that technique to teach mathematics? The children seem to think so.

Suggestions for Future Research

I am motivated by this research and am interested in what else may be done to further the use of music and the arts in the classroom.

Specifically in this study, it would have been helpful if there had been a post-observation of play with the instruments. While the pre-observation (before the series of lessons began) was imperative, somehow, the idea of a post-observation did not occur to me. It would be interesting to see whether the play changes and becomes more focused after the lessons. I wonder whether the children would be more apt to use the instruments as instruments, or whether they would revert back to using them as play objects. I also wonder whether there would be spontaneous rhythm and music making now that the children have had an introduction to these concepts.

In addition, I would add the cookie sheets and manipulatives into the play area to see whether the children continue to create patterns in the absence of a formal lesson.

Further, the fact that there are only two colors and note values with which to play severely limits the creativity of the children and I would introduce and add new colors and note values to the manipulatives.

Conclusion

While the above suggestions address the limitations and ideas for expansion of the present study, possibilities abound in the expansion of the study of patterning in young children. Musically, patterning occurs at the rhythmic level just like the music and mathematics lessons in the present study teach, but patterning can also be found in the melodies of a composition, in the structure of a piece, and even within the style and genre to which the piece may belong. Patterning connections may further be made to the historical context in which the pieces of music live. Teachers can discuss why certain pieces of music were created and why a specific sound and style of music became popular. Further, teachers can ask the children to look for similar patterns within pieces of art, poetry, and fashion from the same genre. Teachers can use patterning when discussing scientific observation and the environment around us. If carefully planned, these kinds of connections to musical patterning can offer children a chance to make connections and transfer their knowledge from music to math to history and many other areas of study. Patterning in this context becomes a frame of mind instead of a discrete mathematical concept to be mastered at the pre-kindergarten level. It becomes a tool a pre-kindergartener employs from childhood through adulthood to understand the world around him. The options are endless if the knowledge of children's mathematical development is strong. The children are capable of understanding more than an ABAB pattern using color blocks and should given the opportunity to do so.

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