PRESCHOOL MATHEMATICS: AN EXAMINATION OF ONE PROGRAM'S ALIGNMENT WITH RECOMMENDATIONS FROM NAEYC AND NCTM

Elisabeth Johnston, B.S., M. A.

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APPROVED:

Jeanne Tunks, Major Professor
Carol Hagen, Minor Professor
Ron Wilhelm, Committee Member
Prerna Richards, Committee Member
Nancy Nelson, Chair of the Department of Teacher Education and Administration
Jerry R. Thomas, Dean of the College of Education
James D. Meernik, Acting Dean of the Robert B. Toulouse School of Graduate Studies

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The purpose of this study was to determine the extent to which a preschool program followed the recommendations outlined by the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics (NCTM) in their joint position statement "Early Childhood Mathematics: Promoting Good Beginnings." Six teachers were randomly selected from three of the preschool program's six locations that are situated in an urban city in North Texas. Two parts of this program's approach to mathematics were investigated: the teachers' instructional practices and the program's curricular materials. Data came from observations using the Classroom Observation of Early Mathematics—Environment and Teaching (COEMET) protocol and field notes. Each teacher participated in three interviews over the course of this research. Analyses of these sources provided insights into teachers' instructional practices for mathematics. Reviews of curricular documents and lesson plans for mathematics instruction provided information pertaining to the math curriculum used at this preschool program. All of these data sources were analyzed using the framework presented in NAEYC and NCTM's position statement.

Analysis of the data indicated that, although teachers did not have any knowledge of these guidelines, teachers followed some of these recommendations; such as presenting children with daily developmentally appropriate mathematics activities and connecting mathematics to classroom routines. Other practices did not

align with NAEYC and NCTM’s suggestions, such as offering children few opportunities to engage in problem-solving situations and providing an inconsistent integration of mathematics into meaningful activities related to other content areas. Several possible factors may have influenced teachers’ use of these recommendations. Teachers’ prior educational opportunities, the program’s curriculum materials, and the teachers’ prior experiences with mathematics all may have contributed to the teachers’ understandings of high quality mathematics instructional practices. Results from this research help to provide the foundation for future investigations of how teachers of young children follow NAEYC and NCTM’s recommendations.

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CHAPTER 1

INTRODUCTION

> Citizens who cannot reason mathematically are cut off from whole realms of human endeavor. Innumeracy deprives them not only of opportunity but also of competence in everyday tasks. All young Americans must learn to think mathematically, and they must think mathematically to learn.
>
> National Research Council, 2001

Many adults indicate their dislike for mathematics or their lack of ability to complete simple tasks such as calculating the tip for a server at a restaurant. Sometimes, these feelings develop after a frustrating experience when learning math in school (Carroll, 1994). Low-achieving students as early as third grade, show a dislike for mathematics (Kloosterman & Clapp Cougan, 1994). Providing high-quality mathematical learning experiences may help to build a foundation to prevent these outcomes.

Research supports the benefits of early learning opportunities (Barnett, Lamy, & Jung, 2005; Campbell, Ramey, Pungelllo, Sparling, & Miller-Johnson, 2002; Ou & Reynolds, 2006; Schweinhart, 2005). Variance is present in programs for young children, so it is important to insure that these early learning opportunities are high quality (Bracey & Stellar, 2003; Neuman, 2003; Varol & Farran, 2006). To help improve the instructional practices in the classrooms of young children, many national and state organizations have provided teachers with indicators or guidelines for high quality learning experiences (Bordova, Leong, & Shore, 2004). Forty-six states have comprehensive learning standards for preschool children (Barett et al., 2008). Furthermore, national organizations such as the National Association for the Education of Young Children (NAEYC) and National Council of Teachers of Mathematics (NCTM) have created specific recommendations related to high quality mathematics instruction in the early childhood classroom (NAEYC & NCTM, 2002; NCTM, 2000; NCTM, 2006). Once these recommendations or standards are disseminated to the public it is important for researchers to determine whether teachers understand these guidelines and how they are being used in the classroom.

Problem

In early childhood education, there are different types of programs such as privately funded preschools, state funded prekindergarten programs, and federally funded Head Start programs. With this variety, come issues with the quality of individual programs (McMullen & Alat, 2002). For instance, some early learning programs do not focus on high quality mathematics instruction (Rudd, Lambert, Satterwhite, & Zaier, 2008) despite research supporting early mathematics experiences influencing mathematical outcomes later in school (Lopez, Gallimore, Garnier, & Reese, 2007; Slaby, Loucks, & Stelwagon, 2005) and promoting school readiness skills in mathematics (Gormley, Gayer, Phillips, & Dawson, 2005; Magnuson, Ruhm, & Waldfogel, 2005). In addition, teachers' misconceptions of appropriate high-quality mathematical learning opportunities for young children may hinder their ability to incorporate new mathematical standards (Lee & Ginsburg, 2009).

Purpose

The purpose of this study was to determine the extent to which a preschool program followed the recommendations outlined in the National Association for the

Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics' (NCTM) position statement *Early Childhood Mathematics: Promoting Good Beginnings* (2002).

Research Questions

1. To what extent do the preschool teachers' instructional practices follow the recommendations outlined in NAEYC and NCTM's position statement *Early Childhood Mathematics: Promoting Good Beginnings* (2002)?

2. To what extent does the preschool program's curriculum align with the recommendations outlined in NAEYC and NCTM's position statement *Early Childhood Mathematics: Promoting Good Beginnings* (2002)?

Working Assumptions

1. Teachers will show a limited implementation of the recommendations outlined by NAEYC and NCTM (2002).

2. This preschool program's adapted curriculum will align with the recommendations outlined by NAEYC and NCTM (2002).

Methodology

The sample for this study consisted of 6 teachers from a preschool program in an urban area in Texas. To determine the extent the preschool teachers followed the suggestions provided by NAEYC and NCTM (2002), I observed each teacher 6 times using the Classroom Observation of Early Mathematics—Environment and Teaching (COEMET) (2007) protocol. To provide support for the data collected using the COEMET, I wrote field notes of items observed during my observations. To gain an understanding of the teachers' perspectives, I interviewed each teacher 3 times. To determine how the curriculum aligned with the recommendations outlined by NAEYC and NCTM (2002), I collected weekly lessons plans from teachers each time I went to observe them. In addition, I had access to all the preschool program's math curriculum materials for the purpose of document analysis.

National Council of Teachers of Mathematics (NCTM)

To provide the context for this study, it is important to provide a brief overview of some of the documents published prior to NAEYC and NCTM's (2002) position statement. These publications presented an articulated list of standards influencing educational practices. In addition, they laid the foundation to the ideas expressed in *Early Childhood Mathematics: Promoting Good Beginnings* (NAEYC & NCTM, 2002).

Standards Movement

In 1989 NCTM published *Curriculum and Evaluation Standards for School* (*CESS*), considered one of the first documents of the standards or reform movement (Herrera & Owens, 2001). This publication, along with *Professional Standards for Teaching Mathematics (PSTM*, 1991) and *Assessment Standards for School Mathematics (ASSM*, 1995) influenced mathematics education in the 1990s. *CESS* (1989) provided K-12 educators guidelines for what mathematical concepts teachers should focus on in the classroom. The organization of the document included three grade groupings (K-4, 5-8, 9-12) of standards. *PSTM* (1991) presented guidelines to help teachers create mathematical environments to support children's understandings of these standards. NCTM (1995) developed *ASSM* to help guide teachers' development of new assessment strategies to support the evaluation of these standards.

Principles and Standards for School Mathematics (PSSM)

To develop a better understanding of NAEYC and NCTM's (2002) position statement *Early Childhood Mathematics: Promoting Good Beginnings*, it is important to understand NCTM's (2000) latest standards document, *Principles and Standards for School Mathematics (PSSM)*. The following paragraphs include a description of the development of this document and a description of the key elements.

Development of PSSM

In response to concerns about the clarity and currency of previous standards documents, NCTM decided to create a new coherent document (Herrera & Owens, 2001). In 1995 NCTM created the Commission on the Future of the Standards to oversee this process. By spring 1997, the writing group was formed and was composed of a variety of members, including teachers and researchers in the field of mathematics education. The goal of this group was to develop a document with a revised set of standards that included selections from previous NCTM writings: *CESSM* (1989), *PSTM* (1991), and *ASSM* (1995). In addition, this new document would include four grade groupings (Prek-2, 3-5, 6-8, and 9-12) (NCTM, 2000).

The writing group met during the summers of 1997, 1998, and 1999. "The writers had access to collections of instructional materials, state and province curriculum documents, research publications, policy documents, and international frameworks and curriculum materials" (NCTM, 2000, p. x). In addition, throughout the creation of this document, the Commission on the Future of the Standards facilitated a review of the document. Members of the Conference Board of the Mathematical Sciences participated in this process by responding to a variety of questions about the document. Their answers helped to shape the format and content of the new standards (NCTM, 2000).

To help support the writing team, NCTM's Research Advisory Committee developed white papers (NCTM, 2000, p. x) or research summaries on eight major topics related to high quality mathematics education. Papers presented at the Conference on Foundations for School Mathematics provided additional information for the writing team. All of these documents are complied in the book *A Research Companion to NCTM Standards* (NCTM, 2000).

Close to 30,000 copies of the completed draft were distributed for review. NCTM made the draft available online to allow interested parties to critique the ideas outlined in the new document. Six hundred fifty individuals and 70 groups submitted comments. Using qualitative analysis methods, these submissions were coded and given to the writing group. During the summer of 1999, the writing group used these suggestions to make necessary modifications or adjustments to the document (NCTM, 2000).

PSSM *Description*

Principles. NCTM (2000) identifies six principles of high-quality mathematics instruction: equity, curriculum, teaching, learning, assessment, and technology. Although, these principles are described separately, NCTM (2000) emphasizes that all must be in place to lay the foundation for creating mathematical environments that are challenging and supportive for all children.

Equity focuses on the importance of all students having access to quality mathematics environments. Three components of this principle are outlined in *PSSM* (2000). First, all students should have teachers who create learning environments in which high expectations and quality learning opportunities are central to every mathematics lesson. Second, teachers should develop modifications to provide all children access to learning materials. Lastly, *PSSM* emphasizes the importance of all children having the necessary resources to create high-quality learning opportunities (NCTM, 2000).

The second NCTM principle relates to the importance of the mathematics curriculum. Curricula should be coherent so that mathematical ideas build on previous learning experiences. In addition, it is pertinent that the curriculum focuses on key mathematical ideas children need to learn to be successful and understand the world around them. Alignment among the grade levels provides teachers with an understanding of the foundational skills children need to learn to be ready to understand more complex mathematical thinking. Furthermore, it prevents unnecessary repetition of material.

The next principle, teaching, emphasizes the teacher’s role in high quality mathematical learning environments. Teachers need to understand children’s prior knowledge about a concept and connect these experiences to new ideas. Instructors should have a thorough understanding of the math concepts children need to learn at a particular grade level. Furthermore, teachers need to support children's learning while providing challenging activities (NCTM, 2000).

Learning, the fourth principle focuses on the importance of children developing more than a superficial understanding of mathematical concepts. Students need to have opportunities to create a deep understanding of new ideas that go beyond memorization of facts or strategies. Learning environments that connect children's natural inquisitiveness about mathematics to new ideas help to encourage positive experiences. In addition, students should have opportunities to communicate with others about various mathematical ideas and strategies (NCTM, 2000).

The next principle, assessment, focuses on the importance of monitoring a student's mathematical development. NCTM (2000) emphasizes that assessment should focus on more than end of unit tests. Assessment is an integral part of the mathematics classroom, which includes helping to inform which mathematical activities to include. Assessments provide teachers, as well as students, with a wealth of knowledge about a student's mathematical development. A variety of types of assessments should be used including observations, portfolios, and performance-based activities.

The last principle addressed in *PSSM* is technology. NCTM (2000) encourages teachers to use computers, calculators, and other forms of technology to support and enhance mathematical understanding. Teachers need to select appropriate learning opportunities to include technology that will allow children to access meaningful mathematical material.

Standards. The next section of the document describes the five content standards (number and operations algebra, geometry, measurement, and data analysis and probability) and the five process standards (problem solving, reasoning and proof, communication, connections, and representation). In addition, at the beginning of each grade grouping there is an introductory section that gives the reader a general overview of mathematics learning during that stage.

Suggested concepts for the PreK-2 group for the number and operations standard include: understanding a variety of problems involving addition and subtraction situations, developing foundational notions of the base ten system, and building a strong number sense. One of the key concepts addressed in the algebra strand for this age range is patterning. NCTM (2000) emphasizes the importance of children creating and extending a variety of patterns with sounds, shapes, and numbers. For the geometry standard, children should begin to develop an understanding of 2 and 3-dimensional shapes including opportunities to create and to sort by characteristics. When considering the measurement standard, young children should have chances to work with a variety of units, including nonstandard and standard, and measure different attributes of an object (e.g., length, weight, area). The last standard focuses on data analysis. NCTM (2000) recommends that children have opportunities to collect and analyze data using graphs to organize this information.

The final section of the document addressed the five process standards: problem solving; reasoning and proof; communication; connections; and representation. These elements are key to high-quality learning environments and children should have opportunities to engage in these types of activities across all five content standards.

Young children should have chances to solve meaningful problems that challenge them to develop understanding of their mathematical world. When solving these problems, students should share their strategies and provide reasons to support why they selected a given approach. High-quality mathematics environments provide children time to discuss these ideas with the teacher as well as with peers. In addition, mathematics should be connected to children's daily routines and other areas of study to help them deepen their understanding of various concepts. Mathematical activities should provide students with a variety of ways to show their mathematical understanding through pictures, words, and numbers.

"Early Childhood Mathematics: Promoting Good Beginnings"

To support the National Council of Teachers of Mathematics' (NCTM) inclusion of prekindergarten in its *Principles and Standards for School Mathematics* (*PSSM*, 2000), NCTM and the National Association for the Education of Young Children (NAEYC) published a joint position statement in 2002 titled *Early Childhood Mathematics: Promoting Good Beginnings*. In this document, NAEYC and NCTM (2002) outlined 10 recommendations to help teachers provide high-quality mathematics instruction for children ages 3 to 6 years old. The recommendations suggested by NAEYC and NCTM (2002) include:

1. Enhance children's natural interest in mathematics and their disposition to use it to make sense of their physical and social worlds.

2. Build on children's experience and knowledge, including their family, linguistic, cultural, and community backgrounds; their individual approaches to learning; and their informal knowledge.

3. Base mathematics curriculum and teaching practices on knowledge of young children’s cognitive, linguistic, physical and social-emotional development.

4. Use curriculum and teaching practices that strengthen children’s problem solving and reasoning processes as well as representing, communicating, and connecting mathematical ideas.

5. Ensure that the curriculum is coherent and compatible with known relationships and sequences of important mathematical ideas.

6. Provide for children’s deep and sustained interaction with key mathematical ideas.

7. Integrate mathematics with other activities and other activities with mathematics.

8. Provide ample time, materials, and teacher support for children to engage in play, a context in which they explore and manipulate mathematical ideas with keen interest.

9. Actively introduce mathematical concepts methods, and language through a range of appropriate experiences and teaching strategies.

10. Support children’s learning by thoughtfully and continually assessing all children’s mathematical knowledge, skills, and strategies. (p. 3)

In addition, this document provides four recommendations for early childhood education advocates in leadership positions such as policymakers and program leaders.

Recommendation 1 focuses on a child’s early mathematical experiences prior to formal instruction. According to NAEYC and NCTM (2002), teachers should tap into these prior experiences by creating activities that will “cultivate and extend children’s mathematical sense and interest” (p. 4). These positive experiences will help children gain confidence in their emerging mathematics ability as well as foster in them mathematical dispositions “such as curiosity, imagination, flexibility, inventiveness and persistence” (NAEYC & NCTM, 2002, p. 4).

Recommendation 2 indicates to teachers the importance of understanding various aspects of each child's background and how their experiences might influence their understanding of mathematical concepts. The NAEYC and NCTM (2002) document acknowledges, "Young children have varying cultural, linguistic, home, and community experiences" (p. 4). Teachers should be aware of children's different learning styles and provide students with a variety of modalities to learn mathematical concepts. Taking these differences into consideration, educators should connect children's prior knowledge to new mathematical experiences in the classroom, which include making connections to the formal vocabulary of mathematics.

Recommendation 3 addresses the need of developing mathematics activities that take into consideration not only the cognitive development of the child but also other areas such as linguistic, physical, and social-emotional development. Looking at the whole child will help the teacher create developmentally appropriate activities. In connection with these ideas, NAEYC and NCTM (2002) hold that due to, ". . . enormous variability in young children's development, neither policymakers nor teachers should set a fixed timeline for children to reach each specific learning objective" (p. 5). Rather, it is more important for children to build a strong conceptual understanding of ideas independently of a fixed timeline.

Recommendation 4 focuses on the importance of problem solving in the mathematics classroom. As part of this process, children should have opportunities to participate in mathematical conversations and to represent mathematics in a variety of ways. In addition, NAEYC and NCTM (2002) address providing children occasions to make connections among different mathematical concepts. "When children connect number to geometry…they strengthen concepts from both areas and build knowledge and beliefs about mathematics as a coherent system" (NAEYC & NCTM, 2002, p. 6). Children should also connect mathematical concepts to other content areas as well.

Recommendation 5 discusses the importance of developing a mathematics curriculum that is coherent. "To create coherence and power in the curriculum, however, teachers also must stay focused on the 'big ideas' of mathematics and on the connections and sequences among these ideas" (NAEYC & NCTM, 2002, p. 6). Educators should also be aware of how concepts are developed throughout the first several years of schooling.

Recommendation 6 suggests that teachers need to provide children with a mathematics curriculum that allows them to develop a depth of understanding of the concepts. In order to have these meaningful learning opportunities, teachers need to formally introduce a variety of mathematical ideas to students. In addition, children need opportunities to engage with these ideas at home with their families.

Recommendation 7 addresses the importance of integrating mathematics with other content areas as well as children's daily routines. NAEYC and NCTM (2002) suggest developing integrated projects that will allow children to make connections between mathematics and the different subject areas. "Extended investigations offer children excellent opportunities to apply mathematics as well as to develop independence, persistence, and flexibility to making sense of real-life problems" (NAEYC & NCTM, 2002, p. 7).

Recommendation 8 encourages teachers to provide children with opportunities to play. When playing, children discuss mathematical ideas about the world around them and develop various strategies for solving problems. Teachers can support these emerging ideas by asking children questions to “provoke clarifications, extensions, and development of new understandings” (NAEYC & NCTM, 2008, p. 8). NAEYC and NCTM (2002) recommend the use of block play as one way for children to develop a variety of mathematical ideas such as sorting, seriating, and patterning. In addition, teachers should use their observations of children’s play to help guide the mathematics activities in the classroom.

Recommendation 9 focuses on the importance of introducing mathematical concepts to young children. These activities can occur in large group or small group settings; however, it may be easier to focus children’s attention and to make observations with a smaller number of children. Teachers should plan meaningful activities that allow children to connect prior experiences to new ideas. Part of this planning includes deciding which materials are developmentally appropriate.

Recommendation 10 discusses the use of assessment in the mathematics classroom. Assessment provides teachers with vital information about children’s mathematical understandings. NAEYC and NCTM (2002) suggest using a variety of types of assessment including observations, portfolios, and performance assessment while cautioning the use of “single group-administered test[s]” (p. 10). Teachers should take into consideration differences among individual children and make modifications to assessments when necessary.

This study investigated the extent to which teaching practices align with these recommendations (NAEYC & NCTM, 2002) in a metropolitan preschool program. These findings provide information related to teachers’ use of these recommendations and possible areas for professional development. In addition, an analysis of the curriculum materials indicates any alignment with the recommendations (NAEYC & NCTM, 2002). This information provides details pertaining to possible gaps in mathematics curricula for young children.

Definitions

- Classroom Observation of Early Mathematics—Environment and Teaching (COEMET) – Observation protocol designed to identify the quality of mathematics teaching in early childhood programs (Kilday & Kinzie, 2009; Sarama & Clements, 2007).
- *Early Childhood Mathematics: Promoting Good Beginnings* – Position statement from NAEYC and NCTM that outlines 10 recommendations for high-quality mathematics learning environments for children ages 3-6 years old
- Expanded protocol – Term to describe when the observer completed all items on the specific math activity (SMA).
- Head Start – A federally funded early childhood program for children 3-5 years old. Most children who qualify for this program come from families living below the poverty line. In 2009, the poverty guideline for a family of four was $22,050 (U.S. Department of Health and Human Services, 2010).
- Mini specific math activity (mSMA) – A type of math activity identified on the COEMET in which the teacher does not address the mathematics in the learning experience (Sarama & Clements, 2007)

- National Association for the Education of Young Children (NAEYC) – A professional organization for early childhood professionals working with children from birth to age 8.
- National Council of Teachers of Mathematics (NCTM) – A professional organization for mathematics educators.
- *Principles and Standards of School Mathematics (PSSM)* – NCTM document that provides guidelines for high-quality mathematics instruction for PreK-12 grade.
- Program – Term used to describe all the preschool locations that are part of this population.
- Site – Term used to describe one of the schools that is part of this preschool program.
- Specific math activity (SMA) – A type of math activity identified on the COEMET in which the teacher addresses the mathematics in the learning experience (Sarama & Clements, 2007)

Limitations of the Study

This research study has several limitations. First, the present study only focused on one preschool program, so the results of this study only pertain to the population of this research. Next, the data collection for this study occurred during the last 2 months of the school year. Conducting this research during another part of the school year may have elicited different results.

Lastly, how often I observed the teachers and when I observed them might have influenced these results. Incorporating more than 6 observations could have provided a more accurate picture of the teaching practices. In addition, I observed the teachers in the morning from approximately 8:30 to 11:30 because of the amount of time required by the COEMET protocol for each observation. Including more variation in the observation times may provide additional information about the instructional practices of this program.

Summary

This chapter outlined the context and rationale for this study. Understanding the benefits of high-quality, early learning programs provides the support to investigate the excellence of mathematics instruction preschool environments. Recommendations such as those ideas presented in NAEYC and NCTM's (2002) position statement *Early Childhood Mathematics: Promoting Good Beginnings*, provide guidance to teachers when they are preparing learning activities for young children. This study investigated the extent to which one preschool program followed the suggestions proposed by NAEYC and NCTM (2002). The subsequent chapters provide more details about this study. Chapter 2 includes a review of related research supporting NAEYC and NCTM's (2002) recommendations and early childhood mathematics curricula. Chapter 3 provides details about the methodology for this research. Chapter 4 presents the results for this study. Finally, chapter 5 includes the findings and recommendations for future research.

CHAPTER 2

REVIEW OF LITERATURE

This chapter focuses on the literature related to understanding early childhood mathematics and previous research connected to the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics' (NCTM) position statement (2002). The first section consists of a summary of past occurrences that influenced mathematics instruction in early childhood classrooms. The next section includes theoretical perspectives that help to inform instructional practices for young children in mathematics. Also included are empirical studies related to teachers' use of these recommendations and a section about the research supporting the suggestions provided by NAEYC and NCTM (2002). Finally, existing research-based mathematics curricula for early childhood are reviewed in terms of the extent of alignment with these recommendations.

Historical Perspective

To provide a context to the current state of mathematics education for young children in the United States, it is important to investigate the historical events that shaped today's practices. The following section briefly summarizes the history of mathematics education from colonial times until the present, focusing on events influencing early childhood practices.

When common schools first appeared in New England in the 1700s, the main purpose of schooling was to educate individuals to read the Bible (Saracho & Spodek, 2008) and "to instill habits of obedience, reverence, and industry" (Lascarides & Hinitz, 2000). Prior to the 1800s, few individuals studied mathematics in depth. Most children only attended school for a couple of years but math concepts were not introduced until the age of 12 or 13. During this time, the focus of mathematics instruction was on the study of arithmetic (Latterell, 2005). Teachers provided students with sets of rules to memorize and did not give children opportunities to develop new strategies (Colburn, 1970). According to Colburn (1970), these rules were based "on a set of abstract numbers, so large that he could not reason on them if he had been disposed to do so" (p. 26). Educators began to focus on the pedagogy of mathematics at the beginning of the next century.

Several events influenced this change in philosophy. In 1818, Samuel Goodrich published the book, *The Children's Arithmetic*. This text supported the use of concrete materials to help children develop a conceptual understanding of arithmetic (Saracho & Spodek, 2008). "This method would help children to physically understand the addition or multiplication procedure…long before they learned abstract numbers" (Saracho & Spodek, 2009, p. 299). This type of discovery learning was in stark contrast to the earlier approaches of teaching mathematics. Furthermore, Goodrich believed that children between the ages of 3 and 5 were capable of understanding these concepts (Saracho & Spodek, 2008; 2009).

Another publication that influenced this shift in pedagogy was Colburn's (1825) text, *First Lessons in Arithmetic on the Plan of Pestalozzi, with Some Improvements*. Based on the work of Pestalozzi, Colburn's text coined the term mental arithmetic and described two components to this process: intellectual learning and inductive reasoning. Similar to Goodrich's work, intellectual learning focused on children using concrete materials to understand mathematical concepts first and then on making the transition to symbolic representations of these ideas. Inductive reasoning encouraged children to develop strategies to solve problems prior to the formal introduction of common algorithms (Saracho & Spodek, 2008). Colburn (1970) believed that young children "should be allowed to pursue their own method first, and then they should be made to observe and explain it, and if it was not the best, some improvements should be suggested" (p. 15). Colburn reasoned that children would acquire these more common strategies when they could connect these ideas to existing schema (Saracho & Spodek, 2008).

In the late 1820s, infant schools gained popularity in the United States with schools in several major cities such as New York and Boston (Saracho & Spodek, 2008). The establishment of these schools was the third influence in this paradigm shift. Established in 1818 in London by Robert Owen, infant schools provided an alternative to the crowded Dame schools (Lascarides & Hinitz, 2000). Infant schools introduced young children to a wider variety of curriculum topics than other programs for this age group, which including topics such as natural history and ancient history (Saracho & Spodek, 2008). In addition, "The infant school's approach to arithmetic focused on understanding the different arithmetical operations and, like Pestalozzi, Owen advocated using manipulative materials" (Saracho & Spodek, 2008, p. 5). Similar to Goodwin and Colburn, Owen supported the idea that young children were capable of grappling with a variety of mathematical ideas if provided with concrete materials to help foster these understandings.

In the mid 1800s, Friedrich Froebel's kindergarten, another European program for young children, was established in the United States. Froebel believed that play helps children to make sense of the world around them. Teachers' observations of children's play provided an understanding of how to modify learning environments to meet the needs of the child (Froebel, 1861/1895). To facilitate children's play, Froebel developed gifts that included 3-dimensional and 2-dimensional objects. These materials ranged from a set of 6 colored balls to a set of sticks. Another component of Froebel's kindergarten was what he termed occupations (Lascarides & Hinitz, 2000). These activities focused on training "children in such activities as drawing, modeling in clay, and using paper and pliable materials in a multiplicity of ways" (Lascarides & Hinitz, 2000, p. 104). The kindergarten movement spread to a variety of cities in the United States. Furthermore, Milton Bradley produced Froebel's gifts, which provided a wide variety of children access to these materials. Froebel's gifts encouraged children to think about various geometric ideas, counting principles, and other mathematical concepts (Saracho & Spodek, 2008).

At the beginning of the 1900s a split formed in the kindergarten movement in the United States between traditional Froebelians and progressive educators. Progressive educators believed that children should have more authentic learning experiences and learning activities should be developed from the interests of the child. In 1904, at a meeting of the International Kindergarten Union (IKU), the Committee of Nineteen convened for the first time to discuss the future of kindergarten education. This committee comprised of various leaders in the kindergarten educational community (Law, 1913). Over the next 7 years, the committee met 11 times. Unable to come to an agreement, three different types of kindergarten programs were described in the final report. Susan Blow (1913) authored the report representing Froebel's ideas, Patty Smith Hill (1913) wrote the report representing the progressive viewpoint, and Elizabeth Harrison (1913) documented the compromise (Lascarides & Hinitz, 2000; Law, 1913).

Hill's (1913) report described the progressive kindergarten classroom and its emphasis on using projects to facilitate learning instead of the direct instruction of mathematics. Hill (1913) writes,

> We value the mathematical basis of Froebel's materials as a substratum of experience having a sediment of great value of later consciousness; but we would make little effort to bring this to the consciousness of the child except in so far as he spontaneously reaches out for it, or as it furthers his construction, or fills some function in his work and play. (p. 285)

Kindergarten classrooms began the transition from using Froebel's gifts to using building blocks designed by Hill and by Carolyn Pratt. Pratt's blocks are similar to the ones found in many early childhood block centers today (Saracho & Spodek, 2008).

During the late 1800s and early 1900s, two movements began to take shape in the United States, progressivism and child study. As mentioned in the previous section, progressivists reformed kindergarten practices and slowly changed educational practices in many of America's classrooms. Although the early 1900s saw the beginning of the progressive movement, it did not fully take hold until the 1920s. Classroom practices included more hands-on experiences for children. For example, "The teacher, instead of exploring a rule, might set up a mathematical experiment, the goal of which is for the students to discover the rule" (Latterell, 2005, p. 19). During this period, teachers created environments where children used discovery learning to understand mathematical concepts.

The child study movement was another influential factor during this period. One psychologist who devoted time to these ideas is Stanley Hall. His work related to "the child's development at different stages" (Lascarides & Hinitz, 2000, p. 207). Hall's research as well as the work of others during this time period laid the foundation for the field of child development and promoted the idea of developmentally appropriate practices in the field of early childhood education (Lascarides & Hinitz, 2000; Saracho & Spodek, 2008). Hall believed that young children were not developmentally ready to understand many mathematical ideas and that mathematics instruction should be delayed until later in childhood (Saracho & Spodek, 2008). In the midst of these changes in mathematics education, the National Council of Teachers of Mathematics (NCTM) formed in 1920 (Evans Walmsley, 2007).

Another early childhood program with European roots was the Montessori method. Although Americans first heard of Maria Montessori's ideas in the early 1900s, it was not until the mid 1900s that this early childhood program spread in the United States. Montessori developed a multifaceted curriculum for young children, which built on ideas of Jean-Marc Gaspard Itard, Edouard Seguin, and Friedrich Wilhelm Froebel (Gutek, 2004; Holmes, 1912; Montessori, 1912/1964). Holmes (1912) describes Montessori's ideas in the following passage:

> It adapts to the education of normal children methods and apparatus originally used for deficients; it is based on a radical conception of liberty for the pupil; it entails a highly formal training of separate sensory, motor, and mental capacities; and it leads to rapid, easy, and substantial mastery of the elements of reading, writing, and arithmetic. (p. xvii)

Many of Montessori's ideas have influenced the early childhood educational scene.

Like Froebel, Montessori developed concrete materials for children. These manipulatives allowed children to construct knowledge about a variety of topics. Part of Montessori's (1912/1964) curriculum focused on the development of the senses, which allowed children to learn about their world. Using didactic materials, the children learned how to effectively use their sense of touch (tactile, thermic, baric, and stereognostic), taste, smell, sight (visual perception of dimensions and form, chromatic) and hearing. For example, when learning about differences in the thickness of objects, children used didactic materials consisting of prisms that they could order from thick to thin. Montessori (1912/1964) explains, "The child mixes them, scattering them over the little carpet, and then puts them in order, placing one against the other according to the graduations of thickness, observing that the length shall correspond exactly" (p. 192). Montessori (1912/1964) believed these earlier sensory experiences provided children with the necessary foundation for more complex tasks.

Montessori developed several activities to support children's mathematical development. For instance, Montessori (1912/1964) created ordered mathematical activities. Montessori (1912/1964) suggested beginning with counting activities. After students practice these skills, she introduced how to use the didactic materials. Montessori (1912/1964) wrote:

> Having taught numeration in this empiric mode, I pass to more methodical exercises, having as didactic material one of the sets of blocks…we have him count the red and blue signs, beginning with the smallest piece; that is, one; one, two; one, two, three, etc., always going back to one in the counting of each rod, and starting from the side A. (p. 327)

Many of Montessori's (1912/1964) methods of instructing young children reflected the notions of creating activities for students that are developmentally appropriate. Montessori's (1912/1964) materials promoted children's independence and encouraged "self-directed learning" (Schunk, 2004, p. 457). In the following excerpt, Montessori (1912/1964) described how these materials encourage auto-education. She wrote:

> The didactic material *controls every error*. The child proceeds to correct himself, doing this in various ways. Most often he feels the cylinders or shakes them, in order to recognise which are the largest. Sometimes, he sees at a glance where his error lies, pulls the cylinders from the places where they should not be, and puts those left out where they belong, then replaces all the others. (p. 170)

Montessori (1912/1964) believed children should work in a prepared environment that encouraged them to interact with the various didactic materials that they were developmentally ready to understand.

As World War II ended, the American public realized the need for a more rigorous mathematics curriculum to help promote the technological changes occurring in the world. During the late 1940s, NCTM created the Commission on Postwar Plans to help document the problems with current practices in mathematics education. The three reports published had little influence on mathematics curriculum and it was not until the launch of the Russia satellite *Sputnik* in 1957, that the landscape of mathematics education changed (Herrera & Owens, 2001).

The mathematics curriculum, New Math was common from the 1950s through 1970. These ideas created a shift to a more traditional curriculum; however New Math involved more technical language and set theory, which were new to the American mathematics scene, especially with young children. Unlike previous ideas related to mathematics curriculum, mathematicians without input from educators developed New Math. This disconnect caused many problems in the schools because teachers did not fully understand this complex program (Evans Walmsley, 2008; Latterell, 2005). Miller (1990) provided the following example to help understand the type of problems children had to solve.

> One feature of new-math logic involved sets, groupings of things. For example in Set A, list all the four-legged objects in the living room.
>
> A= chair, sofa, dog, table
>
> In Set B, list all the animate objects in the living room:
>
> B= dog, Aunt Jane
>
> The intersection of Sets A and B is written as:
>
> A[intersection]b= dog
>
> Sets are never added, subtracted, or multiplied; they are intersected, united, or complemented. The union of Sets A and B is written as:
>
> A[union]B=chair, sofa, dog, table, Aunt Jane (p. 81)

During the early part of the 1970s, mathematics curriculum did not follow one single focus throughout the country. Later in the decade, educators continued a traditional curriculum but focused on drill and practice and rote learning. It was not until the 1980s that the pendulum began to shift to a more progressive stance where the curriculum focused on problem solving and there was little study of basic facts (Evans Walmsley, 2008; Latterell, 2005).

Several key documents shaped mathematics during this decade and the next twenty years. First, in 1980, NCTM released *Agenda for Action*. In this document, the organization encouraged educators to use problem solving to help children develop mathematical ideas. Then in 1983, *A Nation at Risk* described America's poor educational success and concerns with competing in the global scene. Finally, in 1989, NCTM published *Curriculum and Evaluation Standards for School* (*CESS*). This document included specific objectives that children should master during different periods of their schooling (Evans Walmsley, 2008; Latterell, 2005).

NCTM's 1989 publication marked the beginning of a new time in mathematics education. Latterell (2005) wrote,

> Some call this period the time of NCTM. Others say 1989 to 2000 was the time of NCTM, and that we should call from 2000 through the present the time of the math wars. Some argue that from 1989 to 2000 was the time of the math wars and we are now in the time of NCTM. (p. 27)

Despite which name one ascribes to, most educators agree that NCTM's 1989 document influenced dramatic changes in early childhood education (Davison & Mitchell, 2008). For example, during the 1990s many states created mathematics objectives for public schools that were in line with NCTM's standards (Evans Walmsley, 2008).

Theoretical Connections

Many of the ideas that Piaget proposed as part of his theory of cognition have influenced the field of early childhood education, particularly in the area of mathematics (Herrera & Owens, 2001). Elements from Piaget's views on knowledge, cognitive development, and mathematical development have been incorporated into early childhood programs. Piaget believed:

1. Young children construct knowledge through experience (Bringuier, 1977/1980).
2. Individuals progress through four different stages of cognitive development (Bringuier, 1977/1980).
3. Children's developmental stage influences their view of the world (Piaget, 1941/1952).
4. Children develop various mathematical processes over time (Piaget, 1941/1952).

The following section includes a detailed discussion of these ideas and how these components of Piaget's theory relate to early learning programs.

Piaget's view of knowledge differed from other theories of his time that emphasized knowledge as a set of facts for students to learn and obtain. He used the term constructivism to describe the process of gaining new information. Piaget states, "[k]nowledge is neither a copy of the object nor taking consciousness of a priori forms predetermined in the subject; it's a perpetual construction made by exchanges between the organism and the environment…" (Bringuier, 1977/1980, p. 110). Piaget proposed that part of this process included an individual's development of schemes to organize information (Thomas, 2005). This organizational system becomes more complex and intricate as children acquire new knowledge. According to Piaget, learners try to assimilate new knowledge into existing schemes. Sometimes this new information conflicts with prior knowledge. When this happens the child needs to create a new scheme or revise an existing scheme to make sense of this information (Singer & Revenson, 1996). Piaget believed that "intervening factors-those due to external experience, social life, or language and those due to the internal structure of the thinking of the subject" (Bringuier, 1977/1980, p. 18) influence this process. These ideas support the philosophy of many early childhood programs that try to provide young children with high-quality learning experiences to help build a strong foundation for learning in elementary and secondary school.

Piaget described three types of knowledge: physical, social-conventional, and logico-mathematical. Physical knowledge pertains to information related to an object's characteristics such as weight and size. Social-conventional knowledge relates to information about the world created by people such as language. Logico-mathematical knowledge pertains to mental relationships individuals create about the world. Piaget believed that the first two types of knowledge the child develops with interaction from the outside world while the child develops logico-mathematical knowledge within his/her mind, which makes this type more difficult to observe (Kamii, Rummelsburg, & Kari, 2005).

Piaget believed that children progress through four stages of cognitive development from birth to adolescence: sensorimotor, preoperational, concrete operational, and formal operational (Singer & Revenson, 1996). According to Piaget, every child goes through these stages in the same order; however, each child will progress through these stages at a different pace. Piaget mentioned that there might also be cultural differences in the rate of development but not in the sequence (Bringuier, 1977/1980).

Children from about ages 2 to 7 are preoperational thinkers. According to Piaget, operation means to solve a problem through logical thinking. Therefore, children at this stage are pre-logical (Snowman & Beihler, 2006). Another way that Piaget described children during this stage is egocentric because children assume that everyone sees the world as they do (Bybee, 1982). Piaget understood that children's views of the world are different from an adults'. High-quality early childhood educators take these ideas into consideration when planning mathematical opportunities for young children.

According to Piaget, children in preoperational stage have a difficult time with conservation. This term describes the ability of children to understand that some attributes stay the same despite a change in the appearance of the object (Snowman &

Biehler, 2007). For example, Piaget conducted interviews where the children had two glasses with the same amount of water in each glass and the container was the same size and shape. The interviewer would ask the children if there was the same amount of water in each glass. Children would be able to verify this correctly; however, when the interviewer poured one of the glasses of liquid into two smaller cups, children who did not understand conservation, were unable to determine the equivalence of the two situations (Piaget, 1941/1952). Conservation is a task that will take several years to develop because there are several components for the child to understand. Piaget stated, “[f]irst, matter; then a year or two later, with the same arguments weight; and finally, volume. Volume measured by the level of water displaced if you drop a pellet or clay sausage into a glass of water” (Bringuier, 1977/1980, p. 32). Egocentrism and a child’s inability to master reversibility of actions interfere with a preconventional child’s ability to master conservation tasks. Another impediment includes the idea of perceptual centration. Piaget used this term to describe a child’s ability to focus only on one attribute of an object at a time. Not all early childhood educators agree with some of the limitations Piaget expressed in the abilities of young children (Herrera & Owen, 2001).

Piaget (1941/1952) addressed how children develop a variety of mathematical processes such as one to one correspondence, cardinal numbers, seriation, ordinal numbers, and reversibility as it relates to the four operations of addition, subtraction, multiplication and division. When describing this process, Piaget (1941/1952) described the steps children go through before mastering these ideas fully. For example, when discussing one-to-one correspondence, Piaget (1941/1952) identified three stages of development. In Stage 1, the child does not correspond the objects exactly and there is no equivalence. When reaching Stage 2, the child may engage in one-to-one correspondence but there is still no lasting equivalence between the objects in the two groups when one of the sets is moved into a different arrangement. Finally, in Stage 3, the child shows both one-to-one correspondence and lasting equivalence. These stages show the progression of the various skills during the course of a child's development of a particular mathematical concept. Various mathematical researchers identify similar learning trajectories (Clements, Swaminathan, Hannibal, & Sarama, 1999; Clements, Wilson, & Sarama, 2004; NAEYC & NCTM, 2002).

Researchers such as Constance Kamii (2005) continued studying many of Piaget's ideas. Kamii's research focused on the three different types of knowledge identified by Piaget: physical, social, and logico-mathematical (Kamii & Kato, 2005; Kamii & Kysh, 2006; Kamii et al., 2005; Miyakawa, Kamii, & Nagahiro, 2005). For example, Kamii, Rummelsburg, and Kari (2005) studied the effect of using physical-knowledge games for understanding of arithmetic. Children in the experimental group played games such as pick-up sticks, bowling, and balancing cubes. These games encouraged children to use their physical and social knowledge while helping them to expand their logico-mathematical knowledge in five areas. The games assisted the children in developing the following skills: classification, seriation, number, spatial relationships, and temporal relationships. At the conclusion of the study, each child participated in a posttest in the form of an individual interview. According to Kamii et al. (2005), the constructivist group did better overall on the first part of this assessment and on 8 out of 17 problems; there was a statistically significant difference between the two groups. With the word problems, the constructivist group did better than the traditional group on all the problems; however, only in two of the problems did they find any statistically significant difference.

According to Kamii (2000), Piaget believed the aim of education was to help children develop a sense of autonomy. Kamii (2000) wrote, “Autonomy means not the right but the ability to be self-governing” (p. 57). Constructivist classrooms helped children develop these skills by allowing them to build knowledge through experiences instead of learning a set of facts the teacher gives them. These environments encouraged children to develop ideas and discuss them with other learners to encourage conceptual understanding.

Research Related to NCTM Standards

A review of the literature did not result in any research studies investigating teachers’ use of NAEYC and NCTM’s (2002) recommendations. As mentioned in chapter 1, these recommendations are based on the *Principles and Standards for School Mathematics* (*PSSM;* NCTM, 2000). When including *PSSM* in these queries, I found some studies that measured the extent early childhood professionals used *PSSM* (Berry & Kim, 2008; Berry, Bol, & McKinney, 2009; McKinney, Chappell, Berry, & Hickman, 2009).

This limited research suggests there is variation in the how teachers follow the guidelines provided by NCTM (2000) (Berry & Kim, 2008; Berry et al., 2009; McKinney et al., 2009). According to Berry et al. (2009), observations of teachers indicated their proficiency in implementing the curriculum principle. More variability was evident across the other principles. One reason suggested for these findings related to the school district's choice to align the curriculum to NCTM (2002) practices.

Other research supported inconsistencies in implementation. For example, despite reform efforts, K-5 teachers tended to focus on more traditional methods of instruction such as lecture, drill and practice, and teacher directed instruction. Portfolios and other forms of authentic assessment were used infrequently (McKinney et al., 2009). In addition, Berry and Kim (2008) reported that first grade teachers' interactions with children did not support ideas in PSSM. Although, different patterns of discourse existed among these educators, most of the questions posed to the students required them to recall a set of facts. Most often teachers in this study did not require students to explain their thinking or prove ideas.

Research Supporting Recommendations

To provide a research base for this study, the first section addresses research supporting some of the major components proposed in the ten recommendations outlined in *Early Childhood Mathematics: Promoting Good Beginnings* (NAEYC & NCTM, 2002). The second part includes a description of early childhood mathematics curricula and their alignment with NAEYC and NCTM's recommendations (2002).

Recommendation 1

Recommendation 1 encourages teachers to promote children's natural interest in mathematics. By connecting mathematics to children's daily lives, teachers help develop positive dispositions in young children (NAEYC & NCTM, 2002). Observations of 3-year-olds suggest that some children do not overtly engage in mathematical activity during everyday experiences (Tudge & Doucet, 2004). These findings indicate the importance of adults in helping children develop these mathematical connections.

Some preschool teachers' beliefs about mathematics instruction align with ideas presented in this first recommendation. According to Lee and Ginsburg (2007), preschool teachers believe that many classroom routines, such as the number of napkins needed for snack, provide important mathematical learning opportunities. Furthermore, mathematics activities that relate to classroom routines and children's interests foster children's emergent mathematical skills (Arnold, Fisher, Doctoroff, & Dobbs, 2002).

Research supported the use of different instructional approaches to help develop children's interest and positive dispositions in mathematics. Using literature in the mathematics classroom promoted children's mathematical interest (Jennings, Jennings, Richey, & Dixon-Krauss, 1992) and positive dispositions (Hong, 1996). Creating a supportive problem-solving environment encouraged children's development of mathematical dispositions (McClain & Cobb, 2001). Positive dispositions or approaches to learning such as motivation, persistence, and attention supported mathematical growth from kindergarten to third grade (DiPerna, Lei, & Reid, 2007).

Recommendation 2

In Recommendation 2, NAEYC and NCTM (2002) indicate the importance of taking into consideration children's diverse experiences when planning mathematical activities. A student's language, culture, and prior knowledge may influence a teacher's instructional practices (NAEYC & NCTM, 2002).

Research suggested concerns about the student achievement of diverse learners (Chang, 2008; Fantuzzo et al., 2005; Jensen, 2007). For example, Chang (2008) reported low mathematics achievement among Hispanic students, especially with English language learners (ELLs), in kindergarten. Further analysis indicated, that ELLs were negatively influenced by teacher-directed whole group instruction. Supportive classroom environments that included positive relationships, bilingual materials, and opportunities for interaction with native English speakers could help ELLs make the transition into a monolingual classroom (Gillanders, 2007). Furthermore, mathematics achievement improved when Spanish was incorporated into classroom instruction of kindergarten children who came from Spanish speaking homes (Jensen, 2007).

Another instructional consideration addressed in this recommendation is children's prior knowledge and how it influences their approaches to learning. Teachers' interpretations of this knowledge affect perceptions of children's behavior and mathematical learning (Anderson & Gold, 2006). For example, Anderson and Gold described a 3-year-old boy who liked to play Chutes and Ladders. When Danny played this game, he had developed a strategy of double counting to avoid chutes and to land on ladders. From the teacher's viewpoint Danny was cheating, from the viewpoint of his grandmother he was a smart boy who figured out how to win this game. Anderson and Gold wrote, "The teacher does not see his double-counting as mathematics, and it is therefore unavailable to her and to Danny for further in-school mathematical learning"

(p. 283). The teacher's lack of understanding Danny's prior experiences interfered with her instructional practice.

Recommendations 3 and 5

Recommendation 3 suggests the importance of including developmentally appropriate practices and Recommendation 5 emphasizes the need to focus on the "big ideas" in mathematics. Both of these recommendations relate to the use of developmental continua to aid in understating which concepts to focus on in the early childhood classroom (NAEYC & NCTM, 2002).

According to Lee and Ginsburg (2007), preschool teachers believed that it is important for children to learn specific mathematical concepts. For example, one teacher said, "It's just important to be able to focus on one skill, and for them to learn it, and to, you know, to master it, and then to go on to another skill" (p. 127). This quotation questioned how teachers might approach mathematics instruction and did not build the conceptual understanding suggested by NAEYC and NCTM (2002).

Part of a high quality early childhood mathematics environment is providing children with developmentally appropriate learning opportunities. Learning trajectories help teachers identify the different steps in children's development of mathematics concepts (Clements et al., 1999; Clements et al., 2004; Sarama, Clements, Starkey, Klein, & Wakeley, 2008). These developmental paths cover a range of topics such as composition of geometric shapes (Clements et al., 2004) and counting (Sarama et al., 2008). For example, Sarama et al. (2008) explain:

> The learning trajectory for counting specifies a developmental progression of levels of competences, including Precounter, Reciter (competent verbal counting,

> to 5 and later to 10), Corresponder (maintains a one-to-one correspondence between enunciation of counting words and objects), Counter—Small Numbers (counts sets of objects to 5, with cardinal understanding), Producer—Small Numbers (counts out a set of objects to 5), Counter and Producer—10+ (counts and counts out sets to 10 and beyond, keeps track of items counted even in unorganized arrays), and so forth. (p. 96)

These guidelines support teachers' understandings of young children's emergent mathematical understandings.

State standards provide teachers with suggested skills to teach for different content areas. Bracken and Crawford (2009) recently reviewed standards across all fifty states for prekindergarten, kindergarten, and first grade and identified some of the major components across these documents. Several math concepts were identified: numbers/counting, sizes/comparisons, shapes, direction/position, quantity, and time/sequence. Standards varied across states, which " reveals a virtual patchwork quilt of concept, knowledge, skills, and abilities" (Bracken & Crawford, 2009, p. 9).

Another tool available to teachers is the *Curriculum Focal Points* (NCTM, 2006). Three major concepts are identified for each grade level preK through Grade 8. For example, prekindergarten children should develop conceptual understanding of the following ideas:

(a) Numbers including ideas such as counting and cardinality

(b) Shapes and spatial relationships

(c) Measurement of objects and comparison of these objects based on these measurements

By providing these guidelines NCTM (2006) gave teachers the opportunity to focus on the major mathematical ideas that will help build the foundation for later mathematics instead of a list of skills.

Recommendation 4

Recommendation 4 indicates the importance of creating meaningful problem solving situations for young children. These activities should allow children to develop various strategies for solving problems and also provide opportunities for children to engage in significant mathematical discourse (NAEYC & NCTM, 2002).

Research supported young children as successful problem solvers (Carpenter, Ansell, Franke, Fennema, & Weisbeck, 1993) and recognized their ability to develop a variety of solution strategies (De Corte & Verschaffel, 1987). Providing children with frequent opportunities to engage in meaningful problem solving increased their ability to complete these activities successfully (Fennema et al., 1996; Peterson, Carpenter, & Fennema, 1989). In addition, children had opportunities to practice computational skills without the need for drill and practice activities (Fennema et al., 1996). This type of learning environment increased teachers' understanding of children's problem solving strategies (Warfield, 2001). Teachers who focus on teaching problem solving strategies, instead of allowing children to develop these strategies, negatively influenced children's mathematical abilities (Peterson, Carpenter, & Fennema, 1989). Salient characteristics of a classroom environment that supported children's emerging problem solving abilities included: having opportunities to participate in conversations related to problem solving strategies (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Fennema et al., 1996), engaging in successful problem solving opportunities (Fennema et al., 1996), having teachers who accept varied solution methods (Carpenter et al., 1989; Fennema et al., 1996), and participating in discussions about alternative solutions (Carpenter et al., 1989).

Despite the importance placed on mathematical communication (NAEYC & NCTM, 2002), some preschool children do not have opportunities to engage in these types of conversations on a consistent basis (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006). Most often children's discussions related to number concepts (Rudd, Lambert, Satterwhite, & Zaier, 2008) or cardinality (Klibanoff et al., 2006). Cooke and Buchholz (2005) suggested several ways that teachers can promote mathematical discourse in the early childhood classroom.

1. Use teachable moments to review mathematical concepts introduced earlier in the year
2. During center time, engage children in emergent mathematical situations
3. Connect new mathematical knowledge to prior experiences
4. Connect mathematics to daily routines
5. Include different types of questions to engage children in mathematical conversations
6. Introduce mathematical vocabulary

Recommendation 6

Recommendation 6 indicates the value of young children having opportunities to explore mathematical concepts for extended periods. One suggestion by NAEYC and NCTM (2002) is to provide families with opportunities to expand mathematics learning at home. Research indicated that parents would engage children in mathematical activity at home when they are provided materials to help them support these experiences (Anderson, 1997; Skwarchuk, 2009).

Providing families with materials to engage in mathematical conversations gave children varied opportunities to connect to mathematics (Anderson, 1997; Skwarchuk, 2009). Often the focus of these discussions involved situations connected to numbers and operations (Skwarchuk, 2009). In addition, observational data suggested that there were missed opportunities for mathematical discourse (Anderson, 1997; Skwarchuk, 2009). Skwarchuk (2009) indicated a possible reason might relate to parents' lack of knowledge regarding how to engage children in these types of conversations. Furthermore, Skwarchuk (2009) reported that complex number experiences at home, beyond counting, influenced mathematics achievement in preschool.

Early childhood programs facilitated mathematics learning at home by including a variety of opportunities for families. These activities included:

1. Worksheets that include information for families about the mathematical concepts addressed at school (Chard et al., 2008)
2. Hands-on activities that were similar to in-class projects (Sophian, 2004; Starkey, Klein, & Wakeley, 2004)
3. Parent math nights to inform parents of how to complete at-home activities (Starkey et al, 2004)
4. Materials to finish at home activities. (Sophian, 2004; Starkey et al, 2004)

Including these activities in early learning programs helped to provide support to families.

Recommendation 7

Recommendation 7 describes the significance of creating opportunities for children to make connections among mathematics and other areas of the curriculum. The integration of subjects allows children to make important relations with mathematics in a variety of contexts (NAEYC & NCTM, 2002).

NAEYC and NCTM (2002) suggests including high-quality children's literature in mathematics activities. Several research studies indicated the possible benefits of using storybooks as a way to expose children to mathematics in different situations (Anderson, Anderson, & Shapiro, 2004; Bennett, 2000; Heuvel-Panhuizen & Boogaard, 2008; Hong, 1996; Jennings, Jennings, Richey, & Dixon-Krauss, 1992; Keat & Wilburne, 2009).

Reading literature with mathematical connections increased children's exposure to meaningful problem solving opportunities (Anderson et al., 2004; Hong, 1996; Keat & Wiburne, 2009). Keat and Wilburn (2009) identified three types of problem solving activities that children engaged in when participating in activities related to mathematics literature.

1. Character-posed problems are questions related to the characters and the situations in the book
2. Teacher-posed problems extend the ideas in the book to new problems and contexts created by the teacher
3. Student-posed problems are situations in which the students use ideas from the book to make connections to the world around them

These types of problem solving opportunities encouraged children's dialogue of important mathematical ideas. Other studies indicated increases in children's use of mathematical vocabulary (Jennings et al., 1992) and discussions (Anderson et al., 2004; Heuvel-Panhuizen & Boogaard, 2008) when exposed to mathematics literature.

Reading mathematics literature to young children encouraged them to connect mathematics to other areas of the curriculum such as dramatic play, writing (Keat & Wiburne, 2009), and center activities (Hong, 1996). Children's exposure to these storybooks influenced interest in mathematics (Hong, 1996; Jennings et al., 1992) and reading (Jennings et al., 1992). Furthermore, research indicated that kindergarteners in classrooms where high-quality mathematics literature is incorporated into everyday activities increased their mathematical achievement (Jennings et al., 1992).

Recommendation 8

Recommendation 8 emphasizes the importance of providing young children opportunities to play. These play experiences allow children to explore a variety of mathematical concepts in meaningful, everyday settings (NAEYC & NCTM, 2002). Several studies suggested play's importance in children's mathematical development (Cook, 2000; Golomb & Cornelius, 1977; Hanline, Milton, & Phelps, 2008; Park, Chae, & Boyd, 2008; Pepler & Ross, 1981; Wyver & Spence, 1999; Yawkey, 1981).

Studies highlight the importance of the teacher's role in play environments (Golomb & Cornelius, 1977; Johnson, Ershler, & Lawton, 1982; Yawkey, 1981). Children's understandings of conservation tasks were strengthened when teachers engaged children in symbolic play (Golomb & Cornelius, 1977; Johnson et al., 1982). In addition, children who engaged in adult guided sociodramatic play showed increased achievement in mathematics (Yawkey, 1981). As recommended by NAEYC and NCTM (2002), this research supported the importance of a teacher's role in facilitating mathematics learning during play.

Another body of research concerns the role of play materials in children's mathematical development (Cook, 2000; Pepler & Ross, 1981; Wyver & Spence, 1999). Play materials influenced children's approaches to problem solving (Pepler & Ross, 1981; Wyver & Spence, 1999). Including mathematical items in dramatic play areas such as number magnets increased children's mathematical discourse during free play (Cook; 2000). NAEYC and NCTM (2002) outline the importance of creating an environment that encourages mathematical thinking during play activities.

Recommendation 9

Recommendation 9 stresses the significance of early childhood teachers formally introducing children to mathematical concepts. Children need a variety of different activities that help promote their mathematical understanding of various concepts (NAEYC & NCTM, 2002). Despite these recommendations, in a recent study, Rudd et al. (2008) reported no planned mathematical activities across 6 classrooms during 40 hours of observation.

One suggested strategy is the use of games to help support children's mathematical development (NAEYC & NCTM, 2002). Playing number games improved children's number sense abilities (Peters, 1998; Whyte & Bull, 2008). Furthermore, Peters (1998) indicated that children's number understanding is enhanced when adults support these emerging ideas during game play. Linear board games, rather than circular, helped develop children's knowledge of numbers as well as their arithmetic skills (Siegler & Ramani, 2009).

Research indicated that playing games helps children develop logico-mathematical knowledge (Kamii & Kato, 2005; Kamii, Rummelsburg, & Kari, 2005). For example, Kamii et al. (2005) described the effects of a constructivist mathematics program for first graders. Children in these classes spent the first half of the year playing physical knowledge games such as Pick-Up Sticks to develop their logico-mathematical knowledge. The second part of the year children transitioned to playing addition games and solving word problems. When compared to a control group who received a traditional curriculum of a textbook and worksheets, the children in the constructivist group performed better on arithmetic tasks.

In connection with the ideas described above, it is important to discuss another point. Kamii and Kato (2005) believed that mathematics activities should not be "isolated, superficial, and artificial" (p. 382). Furthermore, these researchers express concerns with some of the examples outlined in NAEYC and NCTM's (2002) recommendations as to whether these ideas encourage rigorous developmentally appropriate activities.

Playing games not only supported mathematical development but also provided children with opportunities to participate in mathematical conversations (Tatis, Kafoussi, & Skoumpoudri, 2008). These authors described the conversations that 5-year-olds engaged in after playing games with spinners with unequal portions. With the support of a teacher led discussion, children indicated issues concerning the "fairness" of the games. These mathematical conversations helped lay the foundation for more complex probability situations.

Another component of this recommendation relates to technology in the mathematics classroom. Early childhood professionals need to understand how to select developmentally appropriate materials that support mathematical development (NAEYC & NCTM, 2002). Research supported the use of multimedia activities to facilitate children's understanding of various mathematical concepts such as fractions (Goodwin, 2008) and number concepts (Weiss, Kramarski, & Talis, 2006).

Technology use varied among different preschool programs (Craig, 2000). Craig (2000) identified four different models of how preschool programs incorporated technology into the mathematics curriculum. Differences among the models included: number of students per computer (6-12 students), how often computers were used for mathematics (daily, weekly, 1 week per month), how many students used the computer at once (individual or group), and the types of mathematical activities children engaged in on the computer.

Varol and Colburn (2007) provided guidelines for selecting software based on relevant research and guidelines from NAEYC and NCTM for computer use and mathematics instruction. The following list included aspects of computer software to consider for early childhood children.

1. What is the purpose of the software?
2. Does the content support high-quality mathematics instructions? (Varol and Colburn (2007) connect this section to many of the recommendations outlined by NAEYC and NCTM (2002).)
3. Is the software "age appropriate, culturally appropriate, and reflects gender equity" (p. 163)?
4. Is the software visually appealing? Does it include graphics to help children focus on the mathematical content?
5. Does it contain violence? Is it safe?
6. Do the practice activities connect to prior learning experiences? Does the software provide guidance for incorrect answers?
7. Does the software include developmentally appropriate assessment of mathematical knowledge?
8. Does the software provide feedback to the student about his or her progress?

Recommendation 10

Recommendation 10 emphasizes the significance of including developmentally appropriate assessment measures in the early childhood classroom. Observations, interviews, portfolios and performance assessments are some of the suggested methods of assessment (NAEYC & NCTM, 2002). A review of the literature revealed studies reporting the development of evaluation instruments for young children (Atkins, Kelly, & Morrison, 2001; Clements, Sarama, & Liu, 2008; Meisels, Xue, Shambolt, 2008). Some studies reported teachers' use of assessment in the early childhood classroom (Benson & Smith, 1998; Hanline, Milton, & Phelps, 2001; MacDonald, 2007; Perry, Dockett, & Harley, 2007).

Assessment in the early childhood classroom relied on documentation and observations of students' learning (Benson & Smith, 1998; Hanline et al., 2001; MacDonald, 2007; Perry et al., 2007). Learning stories documented students' learning through pictures and teachers' commentary about these learning experiences (Perry et al., 2007). Pedagogical documents incorporated these components as well as children's quotations and artifacts (MacDonald, 2007). Portfolios included a collection of student work selected by the child (Benson & Smith, 1998). Teachers reported several benefits of using these forms of assessment:

1. They facilitated communication with families about children's development (Benson & Smith, 1998)
2. They provided valuable information about individual student's progress (Benson & Smith, 1998; MacDonald, 2007; Perry et al., 2007)
3. They informed instruction practices and influenced curricular decisions (Benson & Smith, 1998; MacDonald, 2007; Perry et al., 2007)
4. They focused attention on the learning process (MacDonald, 2007)

Parents indicated having a better understanding of the concepts students were learning and better opportunities to facilitate discussions with children about their learning (MacDonald, 2007).

Teachers using portfolio assessment reported the need for student coaching on how to select an item to include in the portfolio. To help with this process, teachers incorporated several strategies such as teacher modeling, portfolio conferences, and portfolio sharing (Benson & Smith, 1998).

Summary

Despite the lack of studies directly related to the recommendations, a review of the related literature indicated support for NAEYC and NCTM's (2002) recommendations. Several major components of these recommendations were outlined in this review.

1. Development of children's interest and dispositions towards mathematics (Recommendation 1)
2. Benefits of focusing on the individual characteristics of learners (Recommendation 2)
3. Importance of focusing on developmentally appropriate practice and on major mathematical concepts (Recommendations 3 & 5)
4. Advantages of high quality problem solving opportunities, which promote mathematical discourse (Recommendation 4)
5. Suggestions of how to include families in mathematical learning activities at home (Recommendation 6)
6. Benefits of integrating mathematics into the curriculum such as literature (Recommendation 7)
7. Advantages of including opportunities for children to engage in play (Recommendation 8)

8. Ways to introduce mathematical concepts such as games and computers (Recommendation 9)

9. Types of assessment tools teachers use in early childhood classrooms (Recommendation 10)

Early Childhood Mathematics Curricula

The following section describes several research-based early childhood mathematics curricula and the research that supports using these systems to provide high-quality mathematics instruction. In addition, a description of how these curricula align with NAEYC and NCTM's (2002) recommendations is included.

Building Blocks is a curriculum for PreK-2. The National Science Foundation provided funding for the development of these materials (Clements & Sarama, 2008). Clements (2002) described the Building Blocks curriculum as "finding the mathematics in, and developing mathematics from, children's activity" (p. 168). Using computers, manipulatives, and print materials (Clements, 2002) children explored a variety of geometric and number concepts (Sarama & Clements, 2004). In addition, these mathematical activities were based on children's prior knowledge and natural interest in mathematics (Clements, 2002; Sarama, & Clements, 2004).

Curricular activities related to various learning trajectories developed by the authors of this program. Learning trajectories for different concepts gave teachers a picture of a child's developmental progress in understanding a concept (Sarama & Clements, 2004). For example, one learning trajectory outlines the steps children go through when learning addition. The authors described the first level "non-verbal addition" by providing the following example. "After watching two objects, then one more placed under a cloth, children choose or make collections of three to show how many are hidden in all" (p. 182). Then in the next stage children begin to develop an understanding of addition word problems with sums up to 5. Children continue to progress on this continuum at their own pace and development.

Research indicated that early childhood professionals could successfully implement the various parts of the Building Blocks curriculum when provided with appropriate training and support. Observational data suggested that classrooms using the Building Blocks curriculum provided high-quality mathematical opportunities for children. In addition, Building Blocks activities showed increased mathematics achievement in diverse populations (Clements & Sarama, 2008).

Several aspects of the Building Blocks curriculum aligned with the recommendations provided by NAEYC and NCTM (2002). This curriculum explicitly stated the importance of connecting activities to children's interests and everyday tasks (Recommendation 1). Learning activities connected to children's experiences and required children to represent mathematical ideas in a variety of ways (Recommendation 2). Learning trajectories provided developmentally appropriate activities for children (Recommendation 3) and identified the major concepts young children should understand (Recommendation 5) such as geometry and number (Recommendation 6). Children engaged in learning opportunities that allowed them to connect mathematical ideas (Recommendation 4). Curricular activities were planned, coherent and incorporated other content areas such as art and music (Recommendation 7). Block play (Recommendation 8) and meaningful computer activities (Recommendation 9) were part of the curriculum (Clements, 2002; Clements & Sarama, 2008; Sarama & Clements, 2004).

Most of the recommendations outlined by NAEYC and NCTM (2002) aligned with the Building Blocks curriculum. One area not identified in the articles reviewed (Clements, 2002; Clements & Sarama, 2008; Sarama & Clements, 2004) was the type of assessments teachers used to monitor the students' mathematical understanding (Recommendation 10). In addition, play is not described as a component of this program; however, children do have opportunities to use building blocks (Recommendation 8).

Another early childhood mathematics curriculum is Pre-K Mathematics. This research-based program included "27 small group activities with concrete materials" (Strakey, Klein, & Wakeley, 2004, p. 104) that aligned with NCTM (2000) standards. Units included topics on number sense, operations, spatial awareness, geometry, patterns and measurement. The following is an example of one of the small group activities for the measurement unit: "Teams of two children remove two sticks form a search box and line up the ends of the sticks to see if one stick is longer" (p. 105). This program also included computer and center activities that aligned with the weekly activities. In addition, home activities supplemented mathematical learning and provided parents with opportunities to extend learning opportunities.

Research supported the use of this mathematics curriculum. Regardless of SES, children participating in the Pre-K Mathematics program did statistically significantly better than children in the comparison group in terms of mathematics achievement.

Children participating in this mathematics program improved in several areas of mathematics including: number, arithmetic, and patterns (Starkey et al., 2004).

Some of the components of the Pre-K Mathematics program aligned with the recommendations of NAEYC and NCTM (2002). Modified activities for high and low achieving students and scaffolding strategies helped to individualize this instruction and meet children's developmental needs (Recommendations 2 and 3). Alignment with NCTM (2000) standards provided teachers with an outline of the major mathematical ideas preschool children should understand (Recommendation 5). The family component included at home support for the mathematical learning occurring in the classroom (Recommendation 6). The Pre-K Mathematics program was a planned and coherent curriculum (Recommendation 7). Small group instruction and computer activities gave children opportunities to engage in meaningful mathematical learning (Recommendation 9). Assessment recoding sheets were provided to help teachers keep track of their observations of children's mathematical development during small group activities (Recommendation 10) (Starkey et al., 2004).

Several recommendations were not apparent in the Pre-K Mathematics curriculum. Activities included do not appear to connect to children's natural interests (Recommendation 1). Problem solving opportunities available in this program are not outlined (Recommendation 4). Furthermore, there is no discussion of children's play as it relates to mathematical development (Recommendation 8).

Sophian (2004) described a preschool mathematics curriculum designed for a Head Start program. This research-based program provided preschoolers with weekly activities focused on number, measurement, or geometry concepts. Sophian included the following description of this curriculum:

> … designed to familiarize children with units of quantification for different quantitative dimensions (e. g., length, area, volume, mass, number) and to explore how those units apply to activities involving (a) counting and reasoning about numerical increases and decreases; (b) measurement, or quantitative comparison; and (c) the identification of relations among geometric shapes. (p. 66)

Teachers participating in this program received weekly lesson plans that outlined the activities and provided suggestions on how to include related concepts into daily activities. Weekly activities included games, problem solving, and other situations that allowed children to develop a conceptual understanding of the mathematics. For example, during the third week of the program, children use "a balance made out of a coat hanger…[and] compare weights of objects that vary in size, including ones that are unusually light or heavy for their size" (Sophian, 2004, p. 76). Each week, a similar activity was sent home with the children to help their parents engage them in mathematical thinking outside of school.

Research findings indicated positive outcomes for children participating in this mathematics program. Sophain (2004) reported that children having the opportunity to take part in this mathematics curriculum scored statistically significantly higher than comparison groups on an assessment aligned with the mathematical content in this program and on a standardized instrument of basic mathematical competence.

Various aspects of this program aligned with NAEYC and NCTM's (2002) recommendations. Concepts introduced in weekly activities were incorporated into other daily activities (Recommendation 1) and provided students opportunities to represent and quantify mathematical ideas (Recommendation 2). Weekly activities encouraged children to develop problem-solving strategies (Recommendation 4). The curriculum focused on major mathematical ideas (Recommendation 5) and provided children with developmentally appropriate activities (Recommendation 3). Weekly family activities provided opportunities for children to extend learning outside of the classroom (Recommendation 6). Incorporated games and review opportunities allowed children time to build a strong foundation of these new concepts (Recommendation 9) (Sophian, 2004).

Some recommendations (NAEYC & NCTM, 2002) do not align with this Head Start curriculum. Weekly activities do not connect with other content areas (Recommendation 7). Play was not a component of this program (Recommendation 8). A description of how teachers assessed children's conceptual understanding of these mathematical ideas was not included (Recommendation 10).

Another curriculum, Early Learning in Mathematics (ELM), designed for kindergarteners, focused on developing children's number sense. "Three components comprise the conceptual framework for the ELM program: (a) the use of mathematical models; (b) mathematics related vocabulary and discourse; (c) procedural fluency and automaticity" (Chard et al., 2008, p. 13). This curriculum contained 100 lessons developed around the strands of numbers and operations, geometry, measurement, and vocabulary. Each lesson incorporated four to five skills across all of these strands. Every lesson started with the review of a familiar concept. Next a new concept was introduced and students completed a math practice sheet. Each of these worksheets included a family activity to extend the mathematical development to the home environment. Children had opportunities to engage in problem solving activities about once a week.

> For example, an early problem-solving activity focuses on geometric shapes and vocabulary words related to various attributes of color and size. Children each select a shape and then discuss with partners how their shape is the “same” as and/or “different” from their partner’s. (Chard et al., 2008, p. 14)

In addition, calendar activities during circle time provided children opportunities to develop understandings about a variety of concepts such as place value and patterns (Chard et al., 2008).

Chard et al. (2008) reported several positive outcomes. Most teachers successfully implemented at least 86 of the 100 lessons. Furthermore, teachers indicated satisfaction with the curriculum and easy implementation of these lessons. Promising achievement results indicated that “ELM accounted for 35% of variance” (p. 17) in mathematics scores.

The ELM curriculum included several of the recommendations outlined by NAEYC and NCTM (2002). Opportunities to connect prior knowledge to new concepts and vocabulary strengthened children’s conceptual understanding (Recommendation 2). Problem solving provided children time to communicate about mathematical ideas (Recommendation 4). Focusing on major ideas such as number and operations, geometry, and measurement (Recommendations 3 and 5). Inclusion of a family component allowed children opportunities to extend mathematical understanding (Recommendation 6). Revisiting concepts and providing games helped children to solidify an understanding of new ideas (Recommendation 9) (Chard et al., 2008).

Some recommendations were not included in the description of ELM. Mathematics lessons are not connected to children’s natural interest in mathematics

(Recommendation 1). Play was not incorporated into ELM activities (Recommendation 8). Assessment procedures for teachers were not outlined (Recommendation 10).

The four curricula reviewed in the previous section aligned with many of the recommendations proposed by NAEYC and NCTM (2002) indicating high-quality mathematics instruction. See Table 2.1 for a summary of alignment of all programs.

Table 2.1

Curriculum Alignment with NAEYC and NCTM Recommendations

Recommendation	Building Blocks	Pre-K Mathematics	Head Start	ELM
1	X		X	
2	X	X	X	X
3	X	X	X	X
4	X		X	X
5	X	X	X	X
6	X	X	X	X
7	X	X		
8	X			
9	X	X	X	X
10		X		

Many of the recommendations were supported by the mathematics curricula. Individualized instruction (Recommendation 2), developmentally appropriate practice (Recommendation 3), focus on big ideas (Recommendation 5), deep and extended activities (Recommendation 6), and active introduction of mathematical concepts

(Recommendation 9) were apparent in all of the curricula. Some of the recommendations were not supported by the early childhood mathematics curricula. Only one out of the four programs provided any indication of assessment (Recommendation 10) or play (Recommendation 8). Only two out four programs provided support for integration (Recommendation 7) and connection to natural interest of the child (Recommendation1). These findings only address descriptions of these curricula in empirical research studies; however, these components may be part of these early mathematics programs.

Summary

Chapter 2 reviewed the literature relevant to this study. First, a historical overview of mathematics provided the context for current practices in early childhood education. Next, theoretical connections laid the foundation for many important principles in educating young children's development of mathematical ideas. Then, a review of research supporting these recommendations indicated studies related to the ideas presented in NAEYC and NCTM's (2002) position statement. Finally, the last part of this chapter assessed how four mathematics curricula for young children aligned with NAEYC and NCTM's (2002) guidelines. Chapter 3 includes a description of the methodology used in this study.

CHAPTER 3

METHODOLOGY

The purpose of this study was to determine the extent to which a preschool program followed the recommendations outlined in the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics' (NCTM) position statement *Early Childhood Mathematics: Promoting Good Beginnings* (2002). This chapter includes the methodology of this study. Listed below are the research questions that guided this study.

1. To what extent do the preschool teachers' instructional practices follow the recommendations outlined in NAEYC and NCTM's position statement *Early Childhood Mathematics: Promoting Good Beginnings* (2002)?

2. To what extent does the preschool program's curriculum align with the recommendations outlined in NAEYC and NCTM's position statement *Early Childhood Mathematics: Promoting Good Beginnings* (2002)?

Setting

This study took place in a large city in northern Texas. One preschool program in this metropolitan area participated in this study. This NAEYC accredited preschool program consisted of 24 classrooms at 6 different locations in this city with each preschool site located in a different neighborhood. Thirteen of the classrooms were part of the Head Start program. The remainder of the classrooms were tuition based with a sliding scale according to the income of the family. Most of students in this preschool program were from low-income families and were English language learners (ELLs). Children in the program ranged in ages of 2 ½ to 5 years. Each classroom contained 18 students and 2 teachers.

According to this program's website, the curriculum focused on educating the whole child. With a student population of 89% Hispanic, one of the primary goals of this program was to provide a language-rich environment to help all children gain a strong foundation in the English language. Both the Head Start classrooms and the tuition-based classrooms followed the same curriculum. In addition, this preschool program provided breakfast, lunch, and snack for each child and employed a nutritionist on staff.

Population

The population for this study consisted of the 48 teachers who worked for this preschool program. Ninety-eight percent of the teachers were Hispanic. One of these teachers was African American. All the teachers were bilingual and female. Lead teachers in the program must have at least a child development associate (CDA) credential or a degree in early childhood education. Teachers without a CDA credential were enrolled in courses to obtain this degree.

Sample

The sample for this study included 3 of the 6 sites from this preschool program. Two teachers from each of the 3 sites were randomly selected to participate in this study ($N = 6$). There were two teachers in each classroom, a lead teacher and assistant teacher. Only lead teachers were included in this sample. All 6 participants in this study were female and Hispanic. Table 3.1 provides additional demographic data about the participants.

Table 3.1

Teachers' Educational Background, Teaching Experience, and Membership in Professional Organizations

	Teacher					
Characteristic	A	B	C	D	E	F
Education						
Highest degree	BA	CDA+	CDA+	CDA	CDA+	AA+
Highest EC degree	AA	CDA	CDA	CDA	CDA	AA
Experience						
Years at program	6	5	13	5	8	8
Total years teaching	6	5	13	8	8	15
Professional Membership						
NAEYC	No	No	No	No	No	Yes
NCTM	No	No	No	No	No	No
Journal usage	Yes	Yes	No	No	No	Yes

Note. CDA = Child Development Associate credential; AA= Associate degree; BA= Bachelor's degree; NAEYC = National Association for the Education of Young Children; NCTM = National Council of Teachers of Mathematics. " +" indicates that teacher is taking courses to obtain a higher degree.

All the participants in this study received some formal education after high school. Four of the teachers obtained a child development associate (CDA) credential. In order to be eligible for this credential, applicants must have a high school diploma or GED, 120 hours of child care education, and 480 hours of experience working with young children. Another part of the application process is for the candidate to distribute parent questionnaires and to set up a time for a CDA advisor to observe her teaching abilities. After the application is submitted, a council representative visits the applicant to verify all application materials, to administer a multiple-choice exam, and to conduct an oral interview (Council for Professional Recognition, n. d.). At the time of the study, Teachers B, C, and E were working on completing their associate degrees (AA) in early childhood education. Teacher C indicated that she needed one more math course to finish this degree. Teachers A and F earned AAs in early childhood education. In addition, Teacher A had a bachelor's degree (BA) in journalism. Teacher F was working on her BA in applied technology and performance improvement.

The average length of time teachers worked at this preschool program was 7.50 years while the average years of total teaching experience was 9.17 years. Four of the participants only had worked at this preschool program. Teacher D taught 3 years at another Head Start program in the state. Teacher F had 7 years of experience outside of the state working with preschool children.

Only Teacher F indicated being a member of NAEYC. None of the participants were members of NCTM. When asked about their use of publications from NAEYC and NCTM such as *Young Children*, *Teaching Young Children*, and *Teaching Children Mathematics*, only Teachers A, B, and F were familiar with these journals. Teacher B mentioned that she had access to these materials through her college courses; however, she had not read any articles pertaining to math instruction. Teachers A and F stated that they implemented ideas from these journals in their classrooms when appropriate. In addition, none of the teachers seemed to be familiar with NAEYC and NCTM's position statement *Early Childhood Mathematics Promoting Good Beginnings* (2002).

Classrooms

Every teacher I observed followed a similar schedule of activities each day. Each teacher provided the same types of learning experiences but the order of these activities varied slightly. Table 3.2 provides a typical day for a classroom in this program.

Table 3.2

Sample Schedule

Time	Activity
7:30-8:30	Meet & Greet
8:30-8:50	Morning Circle
8:50-9:00	Thematic Read-Aloud Vocabulary Added to Word Wall
9:00-10:00	Learning Centers/Choice Time (I CARE)
10:00-10:30	Small Groups
10:30-11:00	Outside Play
11:00-11:30	Music, Nursery Rhymes, Finger plays, Stories
11:30-12:00	Lunch, Brush Teeth, Story Time
12:30-2:30	Rest Time
2:30-2:45	Snack Time
2:45-3:15	Afternoon Circle
3:15-4:00	Learning Centers/Choice Time (I CARE)
4:00-4:30	Outside Play
4:30-5:00	Departure

Environment

Each classroom had a variety of learning areas for the children. These centers containing various hands-on materials for the children to explore included: dramatic play, block area, writing center, sensory table, language, math, science, library area, and art. Figure 3.1 shows a typical floor plan of the classrooms I observed.

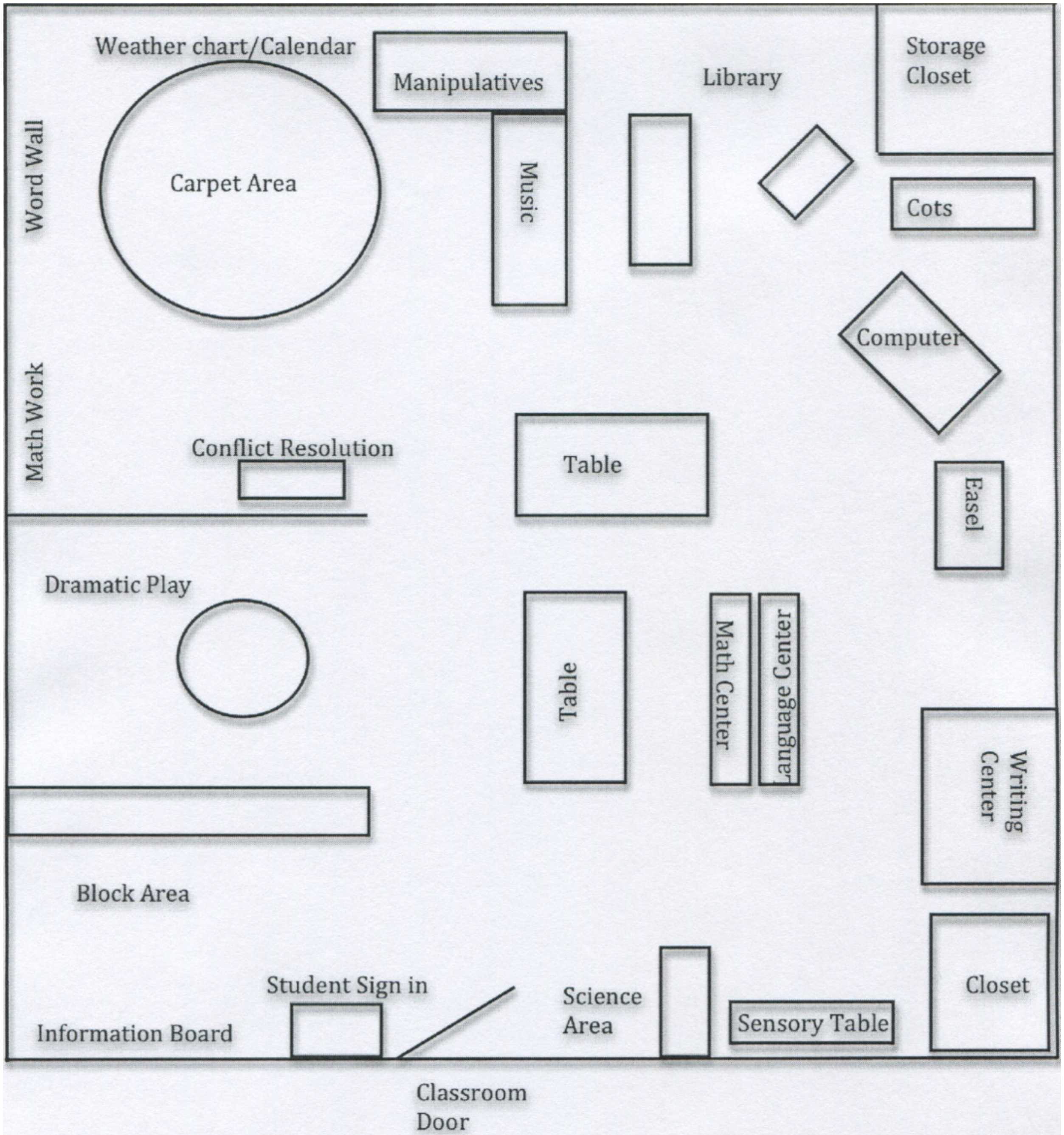

Figure 3.1. Sample classroom floor plan**.**

Thematic Units

Another component of the classroom environment was linked to the curriculum. Some of the classroom activities related to themes that changed throughout the year. These themes connected to ideas presented in the curriculum texts, *Scholastic Early Childhood Program* (2003) and *Building Language for Literacy* (2000), or topics listed in the *Educator's Handbook*. Table 3.3 provides the theme selections for each month of the school year.

Table 3.3

Topics for Themes

Month	Themes
August	Home*, Friends and School+
September	Napping House, Store*, Community+
October	Fall, Fairy Tales, Fire Safety
November	Space, Airport*, Make It, Build It+, Holiday- American Indians
December	Winter Celebrations Around the World, Let's Explore+
January	Eric Carle, Holidays- Martin Luther King, Chinese New Year, Farm*/Zoo*, Animals and Where They Live+
February	Dinosaurs, Museum*, Reptiles+, Black History, Holiday- Valentine's Day
March	Spring, Garden*, Everything Changes+, Insects, Holiday- St. Patrick's Day
April	Teacher Selected Project, Week of Young Child, Holiday- Easter
May	Aquarium, Under the Sea, Holidays- Cinco de Mayo, Mother's Day
June	Fun Days, Summer Safety, Holiday- Father's Day

Note. BLL = Building Language for Literacy. SECP = Scholastic Early Childhood Program. *Theme for BLL classes. +Theme for SECP classes.

Question 1: Preschool Teachers' Instructional Practices

To what extent do the preschool teachers' instructional practices follow the recommendations outlined in NAEYC and NCTM's position statement Early Childhood Mathematics: Promoting Good Beginnings *(2002)?*

Three types of data were collected to determine the extent preschool teachers followed the recommendations in NAEYC and NCTM's (2002) position statement. First, using the Classroom Observation of Early Mathematics—Environment and Teaching (COEMET) (Sarama & Clements, 2007), I observed each teacher 6 times over the course of a 2-month period. Second, field notes written throughout the observations provided observational data about the teachers that were not included on the COEMET. Third, I interviewed each participant 3 times during the study.

Observation Instrument

Kilday and Kinzie (2009) reviewed several observation protocols that measure the quality of mathematics instruction in the early childhood classroom. In this review, the authors evaluated 9 instruments, based on theoretical basis, goals/constructs measured, intended grade levels, time/personnel required, and psychometric properties. The authors reported only "three instruments have consistently exhibited the most desirable characteristics for a measure of high quality mathematics classroom instruction" (p. 371). These measures included the Classroom Observation of Early Mathematics—Environment and Teaching (COEMET), the Reformed Teaching Observation Protocol (RTOP), and the Inside the Classroom Observation Protocol. The authors suggest that the RTOP is suitable for Grades 6 and higher and the Inside the Classroom Observation Protocol works best with K-5 classrooms. COEMET is the only recommended instrument designed for the early childhood classroom, specifically the preschool environment. Table 3.4 indicates how the COEMET met some of the evaluation criteria established by Kilday and Kinzie.

Table 3.4

Evaluation Criteria for COEMET

Criteria	Description
Theoretical Basis	NCTM Standards
Goals/Constructs	Quality of mathematics environment- Quality of activities, student/teacher interactions, accuracy of mathematics content, appropriate lesson plans, management of classroom activities
Grade Levels	Early Childhood- PreK
Time/Personnel	At least half a day for each observation, no training necessary-read manual

Note. Table adapted from Kilday and Kinzie (2009).

The psychometric data reported for this instrument included inter-rater reliability (r^2 = 88), internal consistency (Cronboch's α > .94), and Rasch model reliability (.96). In addition, three recent studies used the COEMET observation protocol to determine the quality of the mathematics instruction in early childhood classrooms (Clements & Sarama, 2008; Sarama, Clements, Starkey, Klein, & Wakeley, 2008; Varol, 2009).

Description of COEMET

COEMET measures the quality of mathematics instruction in the early childhood classroom (Kilday & Kinzie, 2009). When using this instrument, each observation should last at least 3 hours (Clements & Sarama, 2008). There are three parts to the COEMET: observation information sheet, classroom culture (CC), specific math activity (SMA). The observation information sheet provides space for the observer to include data about the classroom and teacher such as number of children, number of computers, and amount of time teacher left classroom. In addition, there is a section to write a brief description of the schedule and activities (Sarama & Clements, 2007).

The CC section reflects some general characteristics of the mathematics classroom and is filled out one time for each observation. For example, Item 4 states "Children took turns using computers with math software." For this item, the observer circles the percentage of time (0, 1-25%, 26-50%, 51-75%, and 76-100%) the children spent on the computer completing math activities during the observation. The CC component consists of 9 items, 6 Likert-type ratings (*strongly disagree*, *disagree*, *neutral/not applicable*, *agree*, *strongly agree*) and 3 frequency items (0, 1-25%, 26-50%, 51-75%, and 76-100%) (Sarama & Clements, 2007).

The SMA section includes two different types of math activities. A full SMA consists of any mathematics activity where the teacher is involved in the learning process. A separate SMA form was completed for each mathematics activity meeting this requirement. For instance, Item 13 states "The pace of the activity was appropriate for the developmental levels/needs of the children and the purposes of the activity." For this item, the observer rates the pace of the SMA using the following scale: *strongly disagree*, *disagree*, *neutral/not applicable*, *agree*, *and strongly agree*. The SMA component contains 22 items, 3 checklists (math topics, instructional organization, and teaching strategy), 18 Likert-type (*strongly disagree*, *disagree*, *neutral/not applicable*, *agree*, *strongly agree*) and 1 frequency (0, 1-25%, 26-50%, 51-75%, and 76-100%). However if “the activity called for no extensive discussion of concepts or strategies” then the observer only completes the first 8 items (Sarama & Clements, 2007). In addition, there is a place for the observer to include a short description of the math activity.

A mini SMA (mSMA) is a classroom activity that is student directed or an activity where the teacher does not focus on the mathematics components inherent to the exercise. For example, finger plays, rote calendar activities, or children’s use of mathematical materials without instructions from the teacher qualify for this type of SMA. The mSMA includes two of the checklists from the SMA (math topic and instructional organization). As with a full SMA, a mSMA should be completed for each activity that meets these requirements.

COEMET’s Alignment with NAEYC and NCTM’s Position Statement

Despite the related research that supports the use of the COEMET to observe mathematics instruction in the early childhood classroom, it is important to determine whether this instrument aligns with the recommendations provide by NAEYC and NCTM’s position statement, *Early Childhood Mathematics: Promoting Good Beginnings* (2002). To help with this process, I read the document several times to develop a through understanding of the material. Next, I selected key quotations from the position statement that helped to describe the meaning of each of the recommendations. For example, Recommendation 7 states “Integrate mathematics with other activities and other activities with mathematics” (p. 7) The quote, “Also important is weaving into children's experience w/literature, language, science, social studies, art, movement, music, and all parts of the classroom environment" (p. 7) helps explain this statement in further detail. See Appendix A for a complete list of these key quotations. Table 3.5 shows how the items of the COEMET support the recommendations of NAEYC and NCTM (2002).

Table 3.5

COEMET's alignment with "Early Childhood Mathematics: Promoting Good Beginnings"

Recommendation	COEMET Items
1	3, 8, 9, 18
2	24, 25, 28
3	5, 11, 13, 16, 28
4	6, 7, 12, 17, 19-23, 25-26 Math topic checklist on SMA
5	
6	Average number of children on SMA Average number of minutes on SMA Math topic checklist on SMA
7	3, 9
8	5, 9 Instructional organizational checklist on SMA
9	4, 14-16 Instructional organizational checklist on SMA Teaching strategy checklist on SMA
10	27

Note. COEMET = Classroom Observation of Early Mathematics—Environment and Teaching. SMA = specific math activity.

Observations

During this study, I observed each teacher 6 times. Each observation lasted approximately 3 hours. These observations focused on the teachers' mathematics instructional practices including how the teachers incorporated math experiences into their daily activities and how they engaged children in these mathematical opportunities. Observations for Teachers A, B, C, and D occurred 3 times on a language focus day and 3 times on a math focus day. Due to scheduling conflicts, observations for Teachers E and F took place 4 times on a language focus day and twice on a math focus day. Observing teachers' language arts lessons helped to provide a more complete picture of how the teachers integrated mathematics into other areas of the curriculum and into the daily classroom routines. Table 3.6 includes the total number of observation minutes for each teacher over the course of this research.

Table 3.6

Observation Minutes

Teachers	Total	Teacher Out of Room	Interruptions to Schedule
A	1080	65	103
B	1069	0	142
C	1081	0	56
D	1080	59	163
E	1074	75	91
F	1080	0	129
Program	1077	66.33	114

Note. Each teacher observed 6 times.

Some teachers left their classrooms during the observations. As indicated on the COEMET, each time a teacher left the classroom for more than ten minutes, I noted this departure. Reasons for leaving varied from taking a break (another adult would cover the class), taking some students to an activity outside of the classroom, assessing a child, checking on a problem with another staff member, or switching classes with another teacher. Other interruptions that influenced these observations related to changes in the schedule. Such events included graduation practice, evacuation drills and special guests. Table 3.6 indicates the number of interrupted minutes over the course of the study. The average number of interruptions for all teachers was 114 minutes over the 6 observations or 10.58%.

Besides the COEMET observation protocol, I wrote field notes to reflect on these observations and to include any information observed in the classroom that did not have a place on the COEMET.

Interviews

To give support and extend the information obtained from the COEMET, I interviewed each teacher 3 times. The interview questions either aligned with one of the recommendations described in NAEYC and NCTM's (2002) position statement or provided information about the teachers' educational background, teaching experience, or participation in professional organizations. Some of the questions, related to the position statement, represented ideas that might be difficult to see during classroom observations of the teacher. For example, Recommendation 6 describes the importance of providing families with ways to extend mathematical learning opportunities at home.

To understand how teachers met this expectation, I included the following questions in the interview script:

1. What types of math activities do you send home to support what you are doing in the classroom? How often do you send home these activities?
2. What types of family events do you provide at the school related to mathematics? How often do you have these opportunities?

Other questions included in these interviews provided more insight into classroom practices observed. For instance, in Recommendation 10, NAEYC and NCTM suggests appropriate assessment practices for the early childhood mathematics classroom. Although observations of teachers gave some insight into how they evaluated children's mathematical understanding, including interview questions related to these ideas helped to provide a more complete picture of this instructional practice. The following questions related to Recommendation 10:

1. What types of assessments do you use to determine your students' understanding of mathematical concepts?
2. How do you use these assessments to help plan for mathematics instruction?

After developing all of the interview questions, I divided the questions into three interviews. The first two interviews focused on the teachers' mathematics instructional practices while the majority of the third interview included questions related to the teacher's educational background, prior teaching experiences, and information relating to professional teaching organizations. For each interview, I grouped similar questions together. In addition, I tried to organize questions so that easier questions were at the beginning and end of each interview and more complicated questions appeared in the middle of the interview. See Appendix B for the list of the questions and how they align with *Early Childhood Mathematics: Promoting Good Beginnings* (NAEYC & NCTM, 2002).

During the interviews, teachers seemed to provide an honest reflection of their mathematics instruction. When scheduling interviews, teachers were flexible and accommodating. Only one obstacle emerged when conducting these interviews. After observing Teacher D twice in her classroom, I planned to interview Teacher D for the first time. At this time, Teacher D indicated to me that she did not feel comfortable with her English skills. She asked if the assistant teacher in her classroom could be part of the interviewing process by translating items into Spanish. When the interviews began, the assistant teacher chose to answer the questions instead of translating them. Teacher D provided answers to the questions in English; however, the assistant teacher also answered many of the questions. Although Teacher D was not confident in her knowledge of English, she did use English when speaking to the children in the classroom.

Each interview lasted approximately thirty minutes. I audio tapped these interviews and transcribed them. To allow for member checking, I gave each transcript to the teachers to make sure that I accurately represented their thoughts (Glesne, 2006). I gave the teachers these transcriptions the next time I observed them, usually 1 or 2 weeks after the interview. Only Teacher F chose to make changes to her interview answers.

Question 2: Preschool Program's Curriculum

To what extent does the preschool program's curriculum align with the recommendations outlined in NAEYC and NCTM's position statement Early Childhood Mathematics: Promoting Good Beginnings *(2002)?*

Lesson Plans

To fully understand the mathematics instruction at this preschool program, I collected a lesson plan from each participant for each observation. Although I only observed a teacher once during a school week, the lesson plans included all the activities the teachers planned for Monday through Friday. Using the codes in the Data Analysis section below, I looked for connections between the lessons plans and the recommendations provided by NCTM and NAEYC (2002).

Curriculum

To gain an in depth understanding of the mathematics instruction, I reviewed all curriculum materials related to mathematics. The following resources were part of this preschool program's curriculum:

- Educator's Handbook

  A binder created by the preschool program with information about the curriculum. Materials in this binder were from a variety of sources. Sections in the binder included: thematic units, transitions, checklists, large group/center time, a section for each month of the year, language, rhymes/finger plays, outside play.
- Math/Science Binder

  This binder focused on math and science learning experiences. Activities in this resource were from a variety of sources.
- *Mathematical Discoveries for Young Children: Using Manipulatives* (Abrohms, 1992)

This resource presented 8 math units on topics such as patterning and measuring. This book was part of a math kit that contained a variety of math manipulatives. Hands-on materials in the kit included: attribute blocks, pattern blocks, links, snap cubes, sorting beads, counting cubes, vehicle counters, number cards, large foam dice, a balance, a large number line, coins, geometric solids, a clock, and different sized bear counters. The activities incorporated hands-on learning with math concepts.

- *Building Language for Literacy* (Snow & Neuman, 2000)

  A literacy curriculum that used familiar places such as home and a store as a context for the activities. It incorporated activities from other content areas into the language curriculum.

- *Scholastic Early Childhood Program* (Block, Canizares, Church, & Lobo, 2003)

  This integrated curriculum had literacy focus. It included a variety of themes such as Friends and School.

- *Learning Accomplishment Profile* (3rd ed.) (Sanford, Zelman, Hardin, & Peisner-Feinburg, 2003)

  A criterion-referenced individually administered assessment for children 36-72 months. This assessment focused on six areas of development: gross motor, fine motor, pre-writing, cognitive, language, self-help, and personal/social.

- *Developmental Indicators for the Assessment of Learning* (3rd ed.)

  (Mardell-Czundnowski & Goldenberg, 1998)

  Individually administered screening assessment used when children enter and exit the program. Five areas addressed by DIAL-3: motor, language, concepts, self-help, and social development.

- *Millie's Math House*

  This computer software included seven different math activities. These interactive learning experiences focused on sizes, shapes, patterns, numbers, addition, and subtraction.

Using the codes described in the next section, I looked for how the curriculum materials related to the recommendations provided by NAEYC and NCTM (2002).

Data Analysis

The COEMET presented different types of data to analyze: Likert-type items, percentage items, and checklists. For each of the Likert-type items, I assigned a numerical value to each of the ratings: *strongly disagree* = 1*, disagree = 2, neutral/not applicable* = 3*, agree* = 4*, strongly agree* = 5. Using these values, I calculated the means for each teacher and the mean for the program. For each percentage item, I assigned a numerical value to each range: 0% = 0, 1-25% = 1, 26-50% = 2, 51-75% = 3, and 76-100% = 4. Then I calculated the means for these items. For the checklists, I made frequency counts for the various items.

As I reviewed the data from the COEMET, it became apparent that many of the SMAs did not use the full protocol. As mentioned earlier, for each SMA the observer does not complete all the items if “the activity called for no extensive discussion of concepts or strategies” (Sarama & Clements, 2007, COEMET SMA, p. 1). The total number of SMAs observed during this study for all the teachers was 152. Only 14 of these math activities warranted the use of the extended protocol or 9.21%. The items in this portion of protocol will not be analyzed or discussed in Chapter 4 because of the low number of SMAs reporting statistics for these items.

As mentioned earlier, I observed Teachers A, B, C, and D on 3 language focus days and 3 math focus days. I observed Teachers E and F 4 times on a language focus day and twice on a math focus day. To determine whether there was any difference between the number of mathematics activities on language days and math days, I ran a *t-test*.

The observation field log, interview transcripts, lesson plans and math curriculum materials were coded using an a priori list of codes developed before the start of data collection. As suggested by Miles and Huberman (1994), this predefined list of codes was developed to align with the recommendations provided by NAEYC and NCTM (2002). Using the key quotations (see Appendix A), I identified key components for each recommendation and converted these ideas into a list of codes. As I collected and coded the data, this list of codes changed and evolved to match the ideas in the data. For example, as I analyzed data pertaining to Recommendation 6, I decided that I needed to include more minor codes to help understand the different types of mathematical opportunities. Table 3.7 displays the codes for Recommendation 6 prior to the start of data collection and the current list of codes.

Table 3.7

Codes for Recommendation 6

A Priori List	Current List
DE: Family	DE: Family
DE: Number and Operations	DE: Number and Operations DE-NO: Adding DE-NO: Counting DE-NO: Estimation DE-NO: Fractions DE-NO: Subtraction
DE: Geometry	DE: Geometry DE-GE: Shapes DE-GE: Spatial Relationships
DE: Measurement	DE: Measurement DE-ME: Length DE-ME: Time DE-ME: Weight
DE: Patterns	DE: Algebra DE-AL: Patterns DE-AL: Sorting
	DE: Data Analysis
DE: Depth of Mathematical Activities	DE: Depth of Mathematical Activities

The revised code list for Recommendation 6 included all five math standards and more minor codes to explain different types of mathematical activities present in the data. The current list of codes contains 10 major codes and 64 minor codes. See Appendix C for the complete list of codes.

To note the emic perspective of the teachers, in-vivo codes were developed. These codes used the participants' terminology for ideas in the data instead of predetermined ideas (Corbin & Strauss, 2008). In-vivo codes for this study included:

anecdotal notes, colors, “I care” centers, LAP-3, and math kit. These codes represented ideas specific to the teachers in this sample.

Throughout the coding process, I wrote memos to help clarify the analysis and to make a record of any themes, connections, confusions, or summaries about the data (Corbin & Strauss, 2008). For instance, one memo included my thoughts relating to the teachers’ understandings of the concept of color. As I analyzed the data, it appeared to me that some of the teachers thought learning the names of the colors was a mathematical skill. I wrote a memo to help reflect on these ideas and to help me remember to look back at the data for other instances that supported or refuted my assumptions.

To help analyze the interview transcripts and curriculum materials, I used the qualitative software NVivo 8. This software makes the analysis of qualitative software easier for a researcher. Besides helping with the coding process, this software provides reports of the analysis. For instance, coding summaries listed information about the items coded to a particular parent node. I hand coded lesson plans and field notes.

To help organize the data, I created a visual wall display for each of the ten recommendations. As new themes or connections emerged for a recommendation, I added these new findings to this display. This visual representation of the material helped to identify strengths and weakness of the program as well as helped with the organization of the material. In addition, seeing the data visually helped me to identify any possible gaps in my analysis. After identifying one of these gaps, I then reviewed the data to establish the reason for this occurrence. Did it represent weak alignment to a recommendation or did I miss evidence during my prior analysis? See Appendix D for photographs of this visual representation.

Summary

To answer Question 1, I observed teachers, wrote observational field notes, and interviewed teachers to determine the extent their instructional practices align with NAEYC and NCTM’s (2002) recommendations. To answer Question 2, I reviewed lesson plans and curricular materials to look for connections to these recommendations. I analyzed patterns among the data to help develop a complete picture of the extent to which this preschool program’s mathematics practices adhere to NAEYC and NCTM’s (2002) ideas about high quality mathematics for young children. Chapter 4 describes the results of this study.

CHAPTER 4

RESULTS

The purpose of this study was to determine the extent to which a preschool program follows the recommendations outlined in the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics' (NCTM) position statement *Early Childhood Mathematics Promoting Good Beginnings* (2002). The data collected included the Classroom Observation of Early Mathematics—Environment and Teaching (COEMET) observation protocol, field notes from observations, transcriptions from teacher interviews, teacher lesson plans, and math curriculum materials.

Organization of Data Analysis

The first section of this chapter addresses the descriptive statistics relating to this study. The subsequent sections are organized by recommendation and include the data that directly align with this part of NAEYC and NCTM's (2002) position statement. For each recommendation, the first part summarizes the extent to which the preschool teachers in this program followed NAEYC and NCTM's (2002) suggestions. The next section addresses how the adopted curriculum aligns with the recommendation. The last part summarizes how this preschool program follows the ideas suggested in the recommendation. The final section of the chapter provides an overall summary of this program's use of the recommendations outlined by NAEYC and NCTM (2002).

Descriptive Statistics

The observation protocol used for this study was the COEMET (Sarama & Clements, 2007). This protocol required me as the observer to classify math activities lasting longer than 30 seconds as a specific math activity (SMA) or a mini specific math activity (mSMA). A SMA included any math activity in which the teacher directed the children's attention to the mathematical ideas in the lesson. A mSMA was a math activity in which the teacher did not focus on the math inherent in the materials or was not involved in the activity. Table 4.1 presents the average number of math activities per observation.

Table 4.1

Number of Math Activities

Teachers	SMA	mSMA	Total
A	5.30	3.50	8.80
B	3.67	2.17	5.83
C	6.33	4.00	10.33
D	2.00	2.83	4.83
E	4.50	2.67	7.17
F	4.83	1.67	6.50
Program	4.44	2.81	7.24

Note. SMA = specific math activity, mSMA = mini specific math activity.

SMAs ranged from 2.00 activities per observation to 6.33 activities (M = 4.44). mSMAs ranged from 1.67 per observation to 4.00 (M = 2.81). Teacher C's classroom had the most math activities per observation with 10.33 and Teacher D's classroom had the fewest with 4.83 math activities (M = 7.24).

As mentioned earlier, observations for Teachers A, B, C, and D occurred 3 times on a language focus day and 3 times on a math focus day while observations for Teachers E and F occurred 4 times on a language focus day and twice on a math focus day. Table 4.2 shows the number of math activities on math focus days and language focus days.

Table 4.2

Number of Math Activities for Math Focus Days and Language Focus Days

	Math			Language		
Teacher	SMA	mSMA	Total	SMA	mSMA	Total
A	5.67	2.33	8.00	5.00	4.67	9.67
B	3.00	1.67	4.67	4.33	2.67	7.00
C	7.00	3.00	10.00	5.67	5.00	10.67
D	1.67	2.67	4.33	2.33	3.00	5.33
E[a]	5.00	2.50	7.50	4.25	2.75	7.00
F[a]	6.50	1.00	7.50	4.00	2.00	6.00
Program	4.69	2.25	6.94	5.31	4.06	9.37

Note. SMA = specific math activity; mSMA = mini specific math activity. [a]Two math observations and four language observations.

On math days, the number of SMA ranged from 1.67 activities to 7.00 (M = 4.69) while on language days the number of SMA activities ranged from 2.33 to 5.00 (M = 5.31). For mSMAs, the range on math days was 1.00 to 3.00 (M = 2.25) activities per observation while on language days mSMA ranged from 2.00 to 5.00 (M = 4.06) activities. Teacher C had the highest number of math activities on both math focus days (m = 10.00) and language focus days (m = 10.67) while Teacher D had the lowest number of math activities on both math focus days (*m* = 4.33) and language focus days (*m* = 5.33). Table 4.3 provides the t-test results indicating any statistically significant difference in the number of math activities.

Table 4.3

t-*Tests for Number of Math Activities on Math Focus Days and Language Focus Days*

		95% CI			
Type of Math Activity	*M (SD)*	*LL*	*UL*	*t*(5)	Significance
SMA	0.54(1.38)	-0.90	1.99	0.97	.378
mSMA	-1.15(0.86)	-2.05	-0.25	-0.25	.021*
Total	-0.53(1.56)	-2.17	1.11	1.11	.446

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit; SMA = specific math activity; mSMA = mini specific math activity. $p < .05$.

The *t*-tests did not show statistical significance for the number of SMAs on math focus days compared to language focus days; however, there was a statistically significant ($p > .05$) difference between the number of mSMAs on math focus days compared to language focus days.

Three items on the COEMET relate to teacher involvement during the observations. Table 4.4 presents the averages for these items. Items 1 and 2 related to the percentage of time teachers and staff responded appropriately to children. These interactions could occur throughout the course of the day, they did not have to be related to mathematical learning experiences. Teachers responded appropriately 76-100% of the time. Item 15 indicated the percentage of time teachers were involved in SMAs. Teacher involvement in these activities averaged from 51-100% of the time. A review of these components of the COEMET, indicate that teachers were responsive to children's needs and were involved the majority of the time in the mathematical activities they planned.

Table 4.4

Teacher Involvement During Classroom Observations

	COEMET Item		
Teacher	1[a]	2[b]	15[c]
A	4.00	4.00	3.26
B	4.00	4.00	3.75
C	4.00	4.00	3.71
D	4.00	4.00	3.67
E	4.00	4.00	3.74
F	4.00	4.00	3.67
Program	4.00	4.00	3.60

Note. Scale for COEMET Items: 0 (0%), 1 (1-25%), 2 (26-50%), 3 (51-75%), 4 (76-100%). COEMET = Classroom Observation of Early Mathematics—Environment and Teaching. SMA = specific math activity. [a]Teacher responded to children. [b]Other staff responded to children. [c]Percentage of time teacher involved in SMA.

Analysis of Data

The same format is used to describe how this program aligned with each of the ten recommendations outlined in NAEYC and NCTM's position statement *Early Childhood Mathematics Promoting Good Beginnings* (2002). First, I discuss all the data sources related to how the teachers implemented the recommendation. The data sources analyzed to answer this aspect of the study included the COEMET observation protocol, observation field notes, and transcriptions of teacher interviews. Next, I describe all the data sources related to how the curriculum aligned to the recommendation. The data sources analyzed to answer this aspect of the study included teacher lesson plans and math curriculum materials. The final section for each recommendation includes a program summary indicating how this preschool program aligned with NAEYC and NCTM's (2002) recommendations. Figure 4.1 outlines the organization that will be used to describe each of the ten recommendations

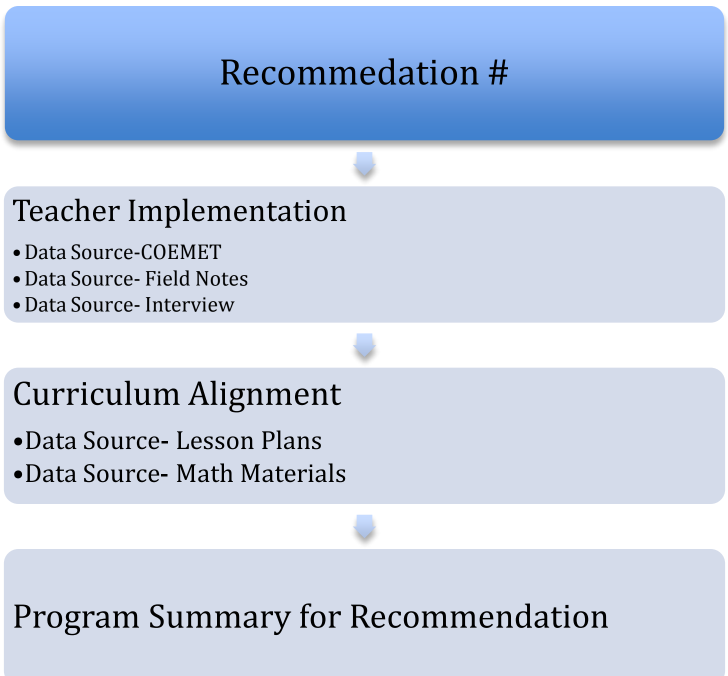

Figure 4.1. Organization of data analysis.

Recommendation 1

Recommendation 1 indicates the importance of a teacher fostering a child's natural interest in mathematics. Teachers should create a learning environment in which a child can develop a sense of confidence and enjoyment in connecting these mathematical experiences to new ideas and concepts. In addition, these learning opportunities should allow children to connect mathematics to the world around them.

Teacher Implementation

Data source-COEMET. Four items from the COEMET support ideas from this recommendation. As mentioned in Chapter 3, items in the extended protocol are not included in this discussion because not enough SMAs required completion of this section of the protocol (9.21%). Since Item 18 is from the extended protocol it is not addressed in this section. Table 4.5 includes the average ratings of the other three items from the COEMET.

Table 4.5

COEMET Averages for Items Aligned to Recommendation 1

	COEMET Item		
Teacher	3[a]	8[b]	9[c]
A	3.50	3.17	3.17
B	4.00	3.80	3.60
C	4.00	3.67	3.20
D	2.67	2.83	2.33
E	2.83	3.83	3.00
F	3.60	3.80	3.60
Program	3.41	3.50	3.12

Note. Scale for COEMET items: 1 (strongly disagree), 2 (disagree), 3 (neutral or not applicable), 4 (agree), 5 (strongly agree). COEMET = Classroom Observation of Early Mathematics—Environment and Teaching. [a]Teachable moments related to math. [b]Teacher showed math as enjoyable. [c]Teacher connected math to real world.

Item 3 related to the degree that a teacher took advantage of teachable moments in the classroom to help children develop various mathematical concepts. Teacher ratings ranged from 2.67 to 4.00 (M = 3.41). Teachers B and C (m = 4.00) provided more opportunities for children to engage in deeper mathematical thinking by encouraging math ideas that emerged during everyday activities. For instance, during one observation, Teacher B told the children that they had five more minutes to read books from the classroom library. One of the children commented that he wished he could have 10 more hours. The teacher responded to the child that 10 hours is a long time. They talked about different amounts of time and then the teacher mentioned to the child that minutes are shorter than hours. Finally, she suggested that 30 minutes might be a good amount of time to read.

Teacher D (m = 2.67) and Teacher E (m = 2.83) did not encourage these opportunities on a consistent basis. For instance, one day during small group time, Teacher E indicated to the group that they would need to share glue bottles. Teacher E told the children that they had 4 glue bottles and 8 people so there would be one glue bottle for every 5 children. When a child asked how the teacher did that, the teacher responded, “It is even” and continued with the rest of the activity. Teacher E started this teachable moment talking about the mathematics of the situation but instead of extending the child’s understanding when he asked about the solution, the teacher continued with the planned lesson. In Teacher D’s classroom, a child made a drawing and brought it to the teacher. The child told her that she made a circle. The teacher responded to the child by saying “Okay,” and moving on to the next student. In this situation, Teacher D missed an opportunity to engage this child in a mathematical discussion.

Item 8 on the COEMET indicated whether a teacher demonstrated enjoyment for mathematics through her actions during the observations. For example, during one observation in Teacher F’s class, while some of the children finished a small group activity, the rest of the class played a game in which they had to find different shapes in the classroom. Ratings on this item ranged from 2.83 to 3.83 (*M* = 3.50). For this item, two of the teachers ranked in the middle, indicating inconsistent or a neutral view of mathematics.

Item 9 was the final component on the COEMET relating to Recommendation 1. For this item, teachers were rated for their enthusiasm for mathematics and how they connected mathematics to the real world. For instance, during one observation in Teacher B’s class, the children found a dead insect. Prior to throwing the insect away, the children looked at the bug and discussed the names of the different parts. In addition, children counted the number of legs and antennae. Ratings ranged from 2.33 to 3.60 (*M* = 3.12). Half of the teachers ranked in the middle, showing an inconsistent or neutral view of mathematics with some mathematical connections to the real world. Again, Teacher D (*m* = 2.33) ranked lower than the rest of the teachers.

Data source- field notes. No additional comments in the field notes align with this recommendation.

Data source- interviews. Two major ideas relating to Recommendation 1 emerged from the teachers’ comments during the interviews. First, teachers discussed several activities that connected mathematics to the real world. Table 4.6 displays the different ideas teachers discussed related to this first theme.

Table 4.6

Teachers' Comments About Connecting Mathematics to the Real World

Real Word Connection	Number of Teachers
Attendance	2
Class Decisions	1
Outside of Classroom	2
Personal Connection	1

Teachers D and E talked about connecting mathematics to routines such as taking attendance. (Although Teacher D mentioned developing mathematical ideas during attendance procedures, none of the observational data support this practice. See Table 4. 25) Teacher A discussed developing graphs to help make classroom decisions. She stated that her class made a graph to help the children decide the name for the class's pet frog. The following quotation is Teacher A's description of this activity.

> A great opportunity to introduce them [*sic*] a graph was last week for example. We have a pet, a frog pet and then we, the whole class, decide a name. We choose a name. One of them wants Blue, Froggy, and Max. Then we start to graph. Which is your favorite name? If you want Blue raise your hand and then we start to count and then another one…who has the most was Max. Then we decided to put Max. That is one of the things we used graphs. Anything that we want to do and we need to decide I take that opportunity to do graphs.

Teachers C and F described how to connect mathematics to environments outside of the classroom including finding shapes in buildings and taking trips to the grocery store.

The other theme related to developing children's interest in mathematics. Table 4.7 includes the various ideas teachers described.

Table 4.7

Teachers' Comments About Developing Children's Interest in Mathematics

Teacher Perspective	Number of Teachers
Use of Attractive or Theme-based Materials	4
Difficulty of Grabbing Children's Interest	1
Difficulty of Knowing if Children are Interested	1

Four teachers expressed the importance of activities that will catch the children's attention, including items related to the weekly theme or attractive hands-on materials. Teacher B indicated that it is sometimes difficult to get some of the children interested in the math activities, so she needed to think of other ways to engage them in mathematics. In the following quote, Teacher B explains how she engaged one child in mathematically thinking.

> But he didn't really want to go to math, he was in the house area. So, what I did was brought the clock there, since the clock you could have in the house area…I started pointing to the numbers and he started telling me the numbers and stuff.

Teacher E had a different opinion from the rest of the participants pertaining to student interest in mathematics. She indicated that "it is kind of difficult to see if they are interested or not."

Curriculum Alignment

Data source- lesson plans. Lessons plans showed that teachers planned activities supporting ideas outlined in Recommendation 1. Table 4.8 lists these activities and the number of teachers who included these items in their lesson plans.

Table 4.8

Lesson Plan Activities Aligned With Recommendation 1

Type of Activity	Number of Teachers
Dramatic Play	5
Personal Connection	4

Five the teachers included opportunities in the dramatic play area to explore the mathematics in their lesson plans. Creating environments such as a recycling center, seafood restaurant, vegetable stand, and an insect store allowed children to develop ideas about various mathematical concepts. Sometimes the lesson plans also indicated activities that helped children to connect personally to mathematics. For instance, three of the teachers planned for their classes to create graphs depicting the children's favorite ocean animals.

Data source- math materials. One idea from this recommendation appeared frequently in the various curriculum materials. Several activities related mathematics to the children's world. Table 4.9 lists the various curriculum materials and the types of real world connections provided in these items. The majority of these learning experiences fell into two categories: environment related and child centered. Environment related activities were learning opportunities that helped children use mathematics to understand the environment around them. Activities such as looking for patterns in the classroom, measuring classroom plants, sorting sounds as loud or soft after going on a sound walk, and going on a shape hunt provide children with mathematical experiences that help them to make sense of the world around them.

Table 4.9

Real World Connections in Curriculum Materials

	Real World Connection	
Curriculum Source	Environment Related	Child Centered
Educator's Handbook	√	√
Math/Science Binder	√	√
Mathematical Discoveries for Young Children	√	√
Building Language for Literacy	√	
Scholastic Early Childhood Program	√	√

Child centered activities related to learning opportunities that connected mathematics to the child on a personal level. These experiences included: comparing height of a child to the teacher, counting letters in a child's first name, graphing the types of homes children live in and sorting children's teddy bears from home. Creating child centered mathematical learning situations allows children to see how mathematics relates to them in a more personal way.

Program Summary for Recommendation 1

Curriculum materials included activities that provided children with opportunities to connect mathematics to them. Math materials provided environment related and child centered learning experiences to help children make sense of the world around them. Lesson plans incorporated dramatic play scenarios that could facilitate mathematical discussions among children.

Although teachers did not always support these opportunities, some used teachable moments to help children relate to mathematics in everyday situations. They also indicated the importance of presenting interesting activities to children. Furthermore, teachers discussed using mathematics to connect to real word experiences.

Recommendation 2

Recommendation 2 focuses on children as individual learners with different family experiences, learning styles, and prior knowledge. Teachers should understand these differences in children and prepare activities with these ideas in mind. In addition, teachers should help children connect these learning experiences to the appropriate mathematics vocabulary.

Teacher Implementation

Data source-COEMET. Three items from the COEMET aligned with the ideas addressed in this recommendation. These items are in the extended protocol and therefore will not be discussed because of the low percentage of SMAs using this section.

Data source- field notes. Going beyond the items from the COEMET, teachers followed suggestions outlined in Recommendation 2 in two ways. First, teachers adapted math activities according to the needs of the children. Table 4.10 lists the different types of modifications observed.

Table 4.10

Modifications Observed

Modification	Number of Teachers
Adding Hands-on Materials	1
Asking Questions to Guide Child's Understanding	4
Pointing to objects	4
Adding visual pictures	3
Providing different activities for different abilities	3

Teachers' modifications included providing hands-on materials, guiding a child through a problem by asking questions, pointing to objects while a child counted, and providing visual pictures, such as dots, to help children recognize numbers. Sometimes teachers changed the activity to make the concept simpler. For example, Teacher B allowed children to point to a number instead of naming it. Teacher C encouraged children to use fewer items when creating patterns.

Another aspect of this recommendation observed was the teachers' use of math vocabulary in various situations. Teachers used a variety of math words from different NCTM standards. Table 4.11 indicates the number of unique math words each teacher used during the study and the number of NCTM standards addressed. The number of unique math words used by the teachers ranged from 11 to 61. Children in Teacher C's class heard the greatest variety of math words during these observations while Teacher D's class heard the least variety of math words. Only Teacher A's class heard words relating to all five NCTM Standards.

Table 4.11

Math Vocabulary Observed

Teacher	Number of Math Words	Number of Standards
A	23	5
B	37	4
C	61	4
D	11	4
E	29	4
F	33	4

Note. Shows the number of unique words, does not take into account frequency of use.

Words representing the number and operations standard included *how many, altogether, more*, and *fewer*. From the geometry standard, teachers used words such as shape names and position words. Sort and pattern represented words from the algebra standard. Teachers used words such as *smallest, hour, cups, longer*, and *lighter* from the measurement standard.

Data source- interviews. Four major themes emerged from the interview transcripts relating to Recommendation 2. First, some teachers discussed the various learning styles exhibited by their students. Table 4.12 indicates the different learning styles addressed by teachers during interviews. Only four teachers described at least one of the learning styles mentioned above and how they take these differences into consideration when planning math lessons. Teacher F emphasized the importance of having a variety of activities to meet all learners' needs. Teacher A indicated that she does not plan for different approaches to learning but modifies activities when necessary for different learners.

Table 4.12

Learning Styles Discussed During Interviews

Learning Style	Number of Teachers
Visual	4
Tactile	3
Auditory	1

The next theme related to differences in children's backgrounds. Table 4.13 lists the aspects of children's background.

Table 4.13

Teachers' Comments Relating to Children's Differences

Background Characteristic	Number of Teachers
Culture	2
Linguistic	3
Religion	1

Three teachers mentioned using Spanish to help children understand various mathematical ideas, especially at the beginning of the school year. Teacher B discussed incorporating major holidays from different cultures such as Cinco de Mayo to help children understand the cultural heritage of the children in the classroom. Teacher F talked about how home visits helped her to understand the cultural differences of her children. Teacher C said that her students come from similar backgrounds while

Teacher E stated that she did not take children’s backgrounds into account when planning math activities.

Despite these varying views, all the teachers discussed the importance of providing for differences among learners. Table 4.14 displays the different ways teachers described creating these opportunities.

Table 4.14

Teachers’ Comments Relating to Designing Activities for Different Learners

Comment	Number of Teachers
Assessment Results	4
Children’s Prior Knowledge	3
Children’s Interest	2
“I Care” Centers	4

Four teachers mentioned using assessment data to develop goals for students based on each child’s performance. These goals helped them to create learning activities based on the needs of each child. In addition, three teachers stated the importance of seeing what the child knows and then modifying activities when necessary to help support this individual’s understanding of the concept.

The final theme related to the introduction of math terms to children. Teachers A and E indicated that they typically introduce new terms during circle time after observing children grappling with the concept during play. Teacher B stated that she does not introduce much math vocabulary to her students because often they are not ready to understand these terms. This viewpoint seems to contradict the observational data since during the 6 observations she used 37 unique math terms with her students.

Teacher F's view on this topic probably aligns the most with NAEYC and NCTM's (2002) recommendations. She said,

> At this age it is important to be very concrete. For example if we notice that they check heights. Then we give them word that we can say, 'Who is taller, shorter?' Everybody can line up to check his or her height. Or 'Who is first of last?' It is important to give them the appropriated words and make sure they understand the concept.

Curriculum Alignment

Data source- lesson plans. One section of the lesson plan indicated individualized instruction. "I care" activities appeared daily in the lesson plan. These activities included a variety of concepts. Some of these ideas related to mathematics. Each day one skill was listed in this section along with the initials of between one and six children that the teacher would work with to develop this skill. Math related items included counting, number recognition, shape recognition, making shapes, and creating patterns. As indicated in Table 4.14, four of the teachers discussed the use of "I care" centers as a way to provide individual learners support.

Data source- math materials. Some of the activities presented in *Building Language for Literacy* (2000) and *Scholastic Early Childhood Program* (2003) identified modifications to consider for ELLs. These ideas introduced teachers to ways to make the activities more accessible to these students. For example, to help ELLs understand the words *same* and *different,* teachers should provide visual examples of groups of items that display the meaning of these words.

All of the various curriculum sources included mathematical terms to introduce to children during different activities. These terms spanned all of the NCTM standards. *Short, next, add, first, side,* and *sort* are some examples of this math vocabulary.

Program Summary for Recommendation 2

Three aspects of this recommendation appeared in multiple data sources. First, teacher interviews and math materials indicated how this program supported ELL by providing instructional support to these students. Second, observations of teachers, lesson plans, and teacher interviews provided documentation of how teachers incorporated individualized instructional opportunities for children. Third, observation field notes and math materials demonstrated the introduction of mathematical vocabulary in various activities. Little evidence supported how teachers plan for different approaches to learning.

Recommendation 3

Recommendation 3 relates to a teacher’s knowledge of children’s development and how these ideas inform instructional practices. This knowledge includes how a teacher incorporates learning materials such as math manipulatives. Teachers should review developmental continua for various skills to become knowledgeable about how children develop understandings of these math concepts. Their review should be grounded in the understanding that children will progress along these learning trajectories at different rates.

Teacher Implementation

Data source-COEMET. Five items from the COEMET align with ideas from this recommendation. Only three items will be discussed since items 16 and 28 are from the extended protocol. Table 4.15 includes the average ratings for these three items.

Table 4.15

COEMET Average for Items Aligned to Recommendation 3

	COEMET Item		
Teacher	5[a]	11[b]	13[c]
A	4.00	3.77	3.97
B	4.00	3.87	3.88
C	4.00	3.97	4.00
D	4.00	3.75	3.42
E	4.00	4.00	3.91
F	4.00	4.00	4.00
Program	4.00	3.90	3.91

Note. Scale for COEMET items: 1 (*strongly disagree*), 2 (*disagree*), 3 (*neutral or not applicable*), 4 (*agree*), 5 (*strongly agree*). COEMET = Classroom Observation of Early Mathematics—Environment and Teaching. [a]Math materials in the classroom. [b]Content of lesson developmentally appropriate. [c]Pace of lesson developmentally appropriate.

Item 5 related to the math materials available to students in the classroom. All classrooms seemed to have similar materials, center designs, and procedures for children’s access to these math items. Therefore it is not surprising that all teachers’ ratings were the same in this area. This rating indicates that these classrooms had a variety of math materials, children had access to these materials on a daily basis, and these items were developmentally appropriate.

Item 11 specified whether a SMA was developmentally appropriate for the children. Ratings ranged from 3.75 to 4.00 (M = 3.90). These averages indicate that the majority of the tasks were developmentally appropriate for this age group; however, there were some activities that fell below this standard. One example of a developmentally appropriate activity from Teacher F's classroom occurred during recess. Teacher F encouraged the children to use sidewalk chalk to make different shapes and to make a house with different shapes.

Item 13 represented whether the pace of a SMA was developmentally appropriate for the children. Ratings ranged from 3.42 to 4.00 (M = 3.91). These averages indicate that the pacing of SMAs was developmentally appropriate most of the time, but there were some cases that did not meet this expectation. Teachers C and F rated at the higher end of this range demonstrating on average these teachers provided the appropriate pacing of activities. One example from Teacher C's class happened during center time. A child was using the sensory table, which had grains of rice and measuring cups. Seeing the child's interest in this activity, Teacher C brought a bowl to the center. She asked the child to estimate how many cups of rice would fill the bowl. The child was unsure of how many but the teacher encouraged her to figure out the answer by counting the number of cups. The teacher helped the child count the number of cups, as the child filled them up with rice and put them into the bowl. This process continued until they filled the bowl with rice. The teacher then asked the child how many cups it took to fill the bowl and the child responded with the answer of 20.

The following example reflected inappropriate pacing that sometimes occurred during these observations. During circle time, each child was asked to come to the easel to draw a triangle. Teacher D watched the children and asked the rest of the class about the child's shape but as the activity went on children became restless. Despite the children's lack of attention, the teacher continued with the lesson until all the children had the opportunity to draw a triangle.

Data source- field notes. None of the field notes related to this recommendation specifically. Some of the ideas presented about Recommendation 2, in the section about the types of modifications teachers made for individual children, related to the teacher's understanding of the child's cognitive development. For instance, when a teacher provided counting materials for children, she understood that children of this age need concrete examples, especially when learning new ideas.

Data source- interviews. Table 4.16 indicates the different aspects of development the teachers mentioned when developing mathematical lessons.

Table 4.16

Developmental Considerations Mentioned by Teachers During Interviews

Aspect of Development	Number of Teachers
Cognitive	5
Motor	2
Social	1
Emotional	1

Four teachers discussed how they had to vary math activities because of the range of ages of the children in their classrooms. Teacher E described trying to balance the needs of the older and younger students. The following quotation indicates Teacher E's concerns about meeting all of her children's cognitive needs

> The ones that like get it more are usually the ones that are going to kinder because we have to prepare them for kinder. We are focusing more on them but then at the same time it is not fair that we only focus on them and then the others. So it is like, it is kind of hard. …it is difficult to focus more because the little ones have to comprehend it also and understand it. When we do our lesson plans, we also have to think of the little ones.

In addition to this discussion of the varying ages in the classroom, teachers described other aspects of the children's cognitive development. Teacher A indicated that the children's understanding of concepts had progressed over the school year and that at the end of the year they had a better understanding of many mathematical ideas. Teacher F mentioned the importance of hands-on activities for children of this age in helping them understand math concepts.

Most of the teachers either did not discuss the motor, social, and emotional development of children or did not take these ideas into consideration when planning math activities. Teacher F was the exception. She described the variance of children's fine motor skills by commenting:

> There is a big range. So, for the ones whose fine motor skills are not as developed yet, instead of telling them to write the numbers, we tell them to get Play-Doh and make numbers or shapes. So we try to develop those fine motor skills first. We don't force them to write or to draw a shape; we train them according to their development levels.

In addition, Teacher F discussed the importance of praise and acknowledgement to support a child's emotional development and of allowing children to play games in math to strengthen social skills while learning important math concepts.

Curriculum Alignment

Data source- lesson plans. The brief descriptions of the activities in the lesson plans do not provide enough information to indicate whether these items take into consideration all aspects of the child's development.

Data source- math materials. Activities presented in all the curriculum materials incorporated developmentally appropriate strategies such as using hands-on learning experiences. Providing children with math materials gives them opportunities to work with concrete examples. These were numerous examples in this data source that incorporated mathematical skills such as sorting, counting, and measuring with the use of real objects. In addition, some activities suggested adjustments for a lesson depending on the age of the child. These suggestions take into consideration the age range of the students in this preschool program.

Lessons in Mathematical Discoveries for Young Children and the Math/Science Binder provided information about how children learn certain concepts. These ideas help to inform teachers of the sequence of some mathematical skills. For instance, both resources discussed the importance of children understanding how to compare objects for similarities and differences prior to learning about how to order objects.

Program Summary for Recommendation 3

Four aspects of recommendation 3 became apparent from the data. First, observations and math materials indicated the use of developmentally appropriate practices. Teachers provided children with hands-on learning experiences for the majority of the mathematics activities. Second, interviews and math materials pointed to an emphasis on how the age of the child influences mathematical development. Third, most of the teachers did not take into consideration the child's motor, emotional, or social development when planning math lessons. Lastly, some math materials provided teachers with ideas about the appropriate sequence for math concepts.

Recommendation 4

Recommendation 4 focuses on the various mathematical processes that children should use to help them develop understanding of various concepts. These processes include problem solving, reasoning, representing, and communicating. In addition, teachers should provide activities that allow children to make connections among different areas of math (algebra, geometry, data analysis, measurement, and number/operations).

Teacher Alignment

Data source-COEMET. The COEMET protocol included two parts for SMAs. For each SMA, the observer should fill out Items 10-15; however, Items 16-28 should only be completed if there is an “extensive discussion of concepts or strategies” (COEMET, 2007, SMA). Although eleven items from the COEMET related to this recommendation, only three items will be discussed since Items 17, 19-23 and 25-26 are from the extended protocol. This lack of data indicated that many of the SMAs did not address the ideas presented in this recommendation. Table 4.17 presents the average ratings for these items.

Item 6 indicated whether the classroom environment had evidence of children’s mathematical work. Ratings ranged from 3.33 to 5.00 (M = 4.11). As these ratings suggest, all teachers displayed some student work related to mathematics in their classrooms; however, the quality and quantity of this work varied.

Table 4.17

COEMET Averages for Items Aligned to Recommendation 4

	COEMET Items		
Teachers	6[a]	7[b]	12[c]
A	3.83	3.67	2.22
B	5.00	3.80	2.94
C	4.33	4.00	2.53
D	3.33	3.00	1.92
E	4.17	3.67	2.35
F	4.00	4.20	2.28
Program	4.11	3.71	2.40

Note. Scale for COEMET items: 1 (*strongly disagree*), 2 (*disagree*), 3 (*neutral or not applicable*), 4 (*agree*), 5 (*strongly agree*). COEMET = Classroom Observation of Early Mathematics—Environment and Teaching. [a]Math work displayed in classroom. [b]Teacher's understanding of mathematics. [c]Teacher began lesson with engaging mathematical idea or question.

Teacher B's classroom rated higher than the other classrooms because of the variety of student work displayed. Furthermore, these items changed frequently, showing students' new and evolving mathematical thinking. For example, during one observation Teacher B's classroom displayed the following children's work: patterning with colors, ordering flowers from smallest to largest, patterning with different sized flowers, using pinto beans to make numbers, sequencing the order of plant growth, patterning with sponges, and sorting long/short words. In contrast, Teacher D rated lowest (m = 3.33) of the teachers. Although math work was always present in this classroom, the quantity and quality of the work was lower. In addition, many items were left posted for extended periods of time without the addition of new items.

Item 7 related to the teacher's understanding of mathematical ideas such as making connections among different math concepts. Ratings ranged from 3 to 4.20 (*M* = 3.71). These averages indicate that teachers appeared to have an understanding of mathematics with some exceptions. (See Table 4.18 for more information about these opportunities.)

Item 12 rated whether a teacher started a SMA with an engaging mathematical question or idea. Ratings ranged from 1.92 to 2.94 (*M* = 2.40). These averages indicate that the majority of SMAs did not begin by focusing children's mathematical thinking or that the teachers did not provide these opportunities on a consistent basis. Examples that provide evidence of the teachers' ability to engage students in mathematical thinking included asking the children questions such as:

"How many words are in this sentence?"

"Whose castle is taller?"

"How many bugs do you think are in this box?"

"How many cups does it take to fill this container?"

Often, teachers did not offer such opportunities. For instance, sometimes teachers included center activities but did not introduce these new learning opportunities to the class, or teachers asked the children to copy shapes in their journals without any discussion about these mathematical figures.

The COEMET required the observer to track the math concepts addressed during each SMA. Part of Recommendation 4 suggests the importance of connecting different math areas to help strengthen children's understanding of these concepts. So, to address these ideas, I looked for activities where the teacher connected two or more of the NCTM standards. Table 4.18 presents the number of SMAs addressing more than one standard.

Table 4.18

SMA Addressing Multiple NCTM Standards

Teachers	SMA	SMA with Multiple Standards	%
A	32	9	28.13%
B	22	4	18.18%
C	38	10	26.32%
D	12	0	0.00%
E	27	4	14.81%
F	29	2	6.90%
Program	160	29	19.08%

Note. SMA = specific math activity.

The percentage of SMAs with multiple standards ranged from 0 to 28.13 (M = 19.08). More than 25% of Teacher A and Teacher C's SMAs included multiple standards. For example, Teacher A had the children use shapes to make patterns (algebra and geometry) and Teacher C had children sort sea animals and then count to see how many items were in each group (algebra and number/operations). One note about the concept sorting, the NCTM Standards (2000) include this concept in the algebra and data analysis standards. For this study, all sorting activities were categorized as part of the algebra standard, unless the activity used sorting as a way to organize the information prior to constructing a graph.

Data source- field notes. Children did not have many opportunities to develop the process skills described in this recommendation as indicated with the lack of data from the second part of the COEMET. Sometimes teachers did provide short opportunities, usually in a conversation with an individual child, to develop problem-solving skills. For example, Teacher E asked a child to show 20 using his fingers. The child told the teacher that he does not have enough fingers. The teacher asked him, “How many fingers do you have?” The child counted his fingers and told the teacher 10. Then the teacher asked, “What can we do?” The child was unsure. The teacher then showed how the child could count beyond 10 by using his fingers.

Data source- interviews. Two major themes emerged from the interview transcripts related to the ideas presented in Recommendation 4. First, the teachers reflected about their approaches to teaching problem solving to their students. Table 4.19 lists the different viewpoints teachers indicated when discussing problem solving activities. Teachers A and B indicated that problem solving is something that they do not incorporate often during math although both teachers provided examples of problem solving when discussing other components of their math program. For example, when talking about centers, Teacher A stated that she might ask children various math questions in the block area such as “Can you build a tower with only 15 blocks?” Three teachers talked about providing children with problem solving opportunities by asking them to estimate different situations. In addition, Teacher F described how the children solve other simple problems. She provided the following examples:

> For example, one day a jar full of flowers and we asked them to estimate how many flowers in the jar and we did the same using frogs and then we count them together. We found out who had the closest number. We also told them, “We have five insects, if the frog eats three, how many are left?”

Table 4.19

Teachers’ Comments About Problem Solving Activities

Problem Solving Viewpoint	Number of Teachers
Need to incorporate more opportunities	2
Include problems related to estimation	3
Children are too young	1
Do not focus on problem solving	3
Use simple problems	1

Teacher D was the only teacher who believed that the children were not able to understand problem-solving situations.

The second theme related to mathematical connections among concepts. All the teachers agreed that several math skills could be addressed in one activity. All of them mentioned how patterning can be connected with other skills such as shapes, counting, sizes or positions. Teachers F and C discussed how sorting and counting could be combined by having children count the number of items in each group.

Curriculum Alignment

Data source- lesson plans. None of the activities listed in the lesson plans indicated the use of the process skills described in this recommendation. Several activities did incorporate ideas from more than one area of mathematics. The most common type required the students to sort a group of objects by size. This activity combines algebra and measurement.

Data source- math materials. Several of the activities included possible questions to ask children while completing the lesson. These questions varied from basic ones with only one correct answer to more complex ones that would require students to use higher order thinking skills. *Mathematical Discoveries for Young Children* (1992) provided the most support to teachers in this area. Simple questions included:

- Are there more children, or are there more chairs? (p. 35)
- Are both trains the same height? (p. 57)
- What is first in your line? (p. 80)

Questions requiring use of reasoning or other process skills included:

- Why does this belong? Do you have a rule for putting these things together? (p. 6)
- How do you know? (p. 33)
- Did anyone arrange their counters in another way? (p. 52)
- Tell me something you discovered about these shapes. (p. 67)

This recommendation emphasizes the importance of incorporating problem solving opportunities. Some of the activities presented in the curriculum provided rich learning experiences that allowed children to explore mathematics through developing a solution to a problem. One good example was from the *Building Language for Literacy* (2000) resource. In this activity children explored building tall buildings. During these explorations, the children tried to answer the following questions:

- Do some blocks work better at the top or the boom of your building?

- How tall does the building get before it has trouble staying up?
- What can you do to keep it from falling over? (BLL, p. 65)

Although some learning experiences incorporated problem solving and reasoning opportunities, many activities did not require children to use these processes. Often tasks included in the curriculum presented students with a skill based learning experience. For instance, after reading *The Three Little Pigs*, a suggested activity was to have children sort items into two groups, soft and hard.

As mentioned earlier, another component to this recommendation includes providing children opportunities to connect math concepts from two different areas. When these connections appeared in the curriculum, most often sorting or patterning skills were connected to another math area such as geometry or measurement. For example, one activity required children to create patterns using different shapes. This learning experience combines algebra and geometry.

Program Summary for Recommendation 4

Although curriculum materials include some activities that support the development of problem solving and reasoning skills, observational data and lesson plans indicated that children did not have many opportunities to practice these process skills. Many of the learning experiences included in the various data sources focused on skill based learning rather than introducing children to developing ways of thinking mathematically. For the most part teachers believed children should have these opportunities, although they did not always provide them in their classrooms. When looking for connections among different areas in mathematics, many of the opportunities included combining algebraic skills such as patterning and sorting with other mathematical areas.

Recommendation 5

Recommendation 5 suggests that teachers should focus on the big ideas in mathematics rather than a list of skills children should understand. In addition, teachers should be aware of developmental continua that identify typical development of these major concepts.

Teacher Alignment

Data source-COEMET. None of the items from the COEMET aligned with Recommendation 5.

Data source- field notes. None of the comments in the field notes align with this recommendation.

Data source- interviews. During the interviews, teachers discussed some of the major mathematical concepts children should understand prior to starting kindergarten. Table 4.20 lists the various skills mentioned. All the teachers emphasized the importance of children understanding numbers. Several teachers mentioned counting as one of the most important skills preschoolers need to understand. Other number concepts teachers addressed included one to one correspondence and recognizing numbers. In addition, three teachers believed knowing about shapes was an important skill for young children to understand. Measuring, patterns, and colors were other skills mentioned by a couple of the teachers.

Table 4.20

Teachers' Views of Major Math Skills

Math Concept	Number of Teachers
Numbers	6
Problem Solving	1
Measurement	2
Shapes	3
Colors	2
Patterns	2

Despite the fact that Teacher A mentioned her lack of problem solving activities in her classroom (See Recommendation 4), she believed that it was one of the most important skills for her children to understand. Teacher B was unsure of what was important as she noted in the following quotation.

> I don't know. To be honest, I don't know. I haven't really thought about that. I just really think that as long as they know some numbers, some shapes, and some colors, they are kind of ready that they…like they know the whole concept but they kind of know what is going to be taught and when they get there, "Oh I remember that. I leaned that" and stuff and they might learn when they get to kinder, they might get a little bit higher than they were here.

As indicated in the previous paragraph, two of teachers thought that learning the colors was an important mathematical skill for the children to learn. Even teachers, who did not mention this skill, discussed the use of color in the mathematics classroom. Teachers described asking children about the colors of objects as part of their math instruction. For example, Teacher A mentioned that when children play with LEGOS, she would ask them about the colors of the blocks they are using. Knowing colors is an important skill although it is not a mathematical skill. Yet understanding this concept can help children with mathematical ideas such as sorting and patterning. Teachers also discussed the use of color in these situations.

Curriculum Implementation

Data source- lesson plans. There was no indication in the lesson plans of math activities focusing on the big ideas. Each math activity pertained to a specific math skill that did not necessarily relate to the other math activities planned for the week.

Data source- math materials. As mentioned earlier (Recommendation 3), the curriculum materials, Mathematical Discoveries for Young Children and the Math/Science Binder, indicated math skills or experiences children should understand before learning a new concept. For example, both resources described how children typically learn how to rote count before they learn how to count a set of objects. Although some lessons provided this type of information, the curriculum did not include more specific learning trajectories for different mathematical skills.

One item in the curriculum that provided teachers information about skills obtained by chronological age was the Learning Accomplishment Profile-3 (2003) (LAP-3) assessment. The LAP-3 (2003) is a criterion reference assessment used by this program to evaluation children at the beginning, middle, and end of the year. Although the LAP-3 (2003) assessment provided teachers with lists of skills that children of different age groups should be able to complete, these items were not grouped by mathematical concept. The cognitive development section on the LAP-3 (2003) included the highest number of mathematical items but there were other non-math skills in this part of the assessment as well.

Program Summary for Recommendation 5

All teachers believed that number concepts such as counting and one-to-one correspondence were an important for children to understand prior to starting kindergarten. Math materials included some guidance to teachers about the sequence of math concepts but did not provide more specific milestones children pass through while learning a concept. In addition, although math materials were organized by major concepts, lesson plans and classroom observations indicated a more skill based approach to mathematics.

Recommendation 6

Recommendation 6 indicates the importance of young children having meaningful and sustained mathematical experiences. These in depth opportunities should center on activities from number and operations, geometry, and measurement. Although algebraic concepts should not be the main focus of the math curriculum, children should have opportunities to work on various patterning situations. In addition, teachers of young children should develop ways to help families extend mathematical experiences at home.

Teacher Alignment

Data source-COEMET. Three parts of the COEMET related to the ideas suggested in this recommendation. One aspect of each math activity tracked on the COEMET was the number of children who decided to participate in the lesson. Table 4.21 presents the average number of children per math activity.

Table 4.21

Children's Math Participation

	Teachers					
Aspect of Participation	A	B	C	D	E	F
Children per activity						
SMA	12.28	7.77	13.00	11.42	9.22	9.36
mSMA	12.77	10.23	12.00	13.29	13.44	7.60
Total	12.72	8.69	12.61	12.51	10.79	8.89
Children per observation	16.17	16.17	15.67	15.17	16.33	14.50
% of class participation						
SMA	75.94	48.05	82.96	75.28	56.46	61.31
mSMA	78.97	63.27	76.57	87.61	82.30	52.41
Total	78.66	53.74	80.47	82.47	66.07	61.31

Note. SMA = specific math activity; mSMA = mini specific math activity.

For SMAs, the number of children ranged from 7.77 per activity to 12.28 (M = 10.51) while for mSMAs ranged from 10.23 to 13.44 (M = 11.56). To determine the percentage of class participation in math, I compared the average number of children per activity to the average number of children per observation for each teacher. For SMAs, math participation ranged from 48.05% to 75.94% (M = 66.67%). For mSMAs, math participation ranged from 52.41% to 87.61% (M = 73.52`%). Teacher D had the highest class participation overall with 82.47% for all math activities while Teacher B had the lowest at 53.74% (M = 70.45%).

Another aspect of each math activity tracked on the COEMET was the average number of minutes a child engaged in an activity. Although time spent on mathematics does not indicate depth, the more time spent, the more opportunities children have to work on these ideas. Table 4.22 presents the amount of time spent on math activities.

Table 4.22

Time Spent on Mathematics

	Teachers					
Aspect of Time	A	B	C	D	E	F
Minutes per activity						
SMA	4.13	5.22	6.47	7.43	7.36	4.54
mSMA	1.23	2.71	1.62	2.65	1.53	2.80
Total	3.21	4.23	4.61	4.29	5.28	4.09
% of time spent on math						
Total observation	13.00	7.75	19.82	9.37	14.05	8.81
Adjusted minutes[a]	14.38	8.94	20.91	11.03	15.35	10.01

Note. SMA = specific math activity; mSMA = mini specific math activity. [a]Interruptions to schedule were subtracted from total number of observed minutes when determining adjusted percentages.

For SMAs, minutes per activity ranged from 4.13 minutes to 7.43 minutes (*M* = 5.86). For mSMAs, minutes per activity ranged from 1.23 minutes to 2.71 minutes (*M* = 2.09). Overall, Teacher E had the highest minutes per activity with 5.28 minutes and Teacher A had the lowest minutes per activity with 3.21 minutes (*M* = 4.29).

To gain a better understanding of the amount of time children spent on mathematics, I calculated the percentage of time spent on math by looking at the total math minutes and comparing it to the total number of observation hours. For each math activity, I determined how many children participated in the activity and compared it to the number of children in the class for that observation. If all the children participated, then the total number of minutes spent on the activity was included. When only some of the children participated in the activity then I prorated the number of minutes to reflect this difference. For example, if the average time spent on activity was 5.25 minutes but only 8 out of 14 children selected the activity, then only 57.14% of the time would be included in the total number of math minutes for that day or 3 minutes. To determine the adjusted minutes, I used the same process. However, this time I subtracted the number of minutes that reflected interruptions to the schedule from the total number of observation minutes, since the teacher had no control over these times (see Chapter 3, Table 3.6, for more information). As shown in Table 4.20, the adjusted percentage of time spent on mathematics ranged from 8.94% to 20.91% (*M* = 13.58%).

As mentioned earlier (see Recommendation 4), the COEMET protocol has the observer track math concepts in each SMA and mSMA. Since SMAs are teacher directed, only these items are addressed in this section. To align these math skills with NAEYC and NCTM's position statement, I grouped the various concepts according to the five standards addressed in Recommendation 6 (number/operations, geometry, algebra, measurement, and data analysis/probability). Table 4.23 presents the math topics addressed during SMAs.

Table 4.23

Math Topics Addressed During SMAs

	NCTM Standards				
Teacher	Number & Operations[a]	Algebra[b]	Geometry[c]	Measurement	Data Analysis[d]
A	65.63%	28.13%	21.88%	15.63%	3.13%
B	72.73%	18.18%	22.73%	22.73%	4.55%
C	71.05%	18.42%	34.21%	5.26%	0.00%
D	50.00%	8.33%	50.00%	0.00%	0.00%
E	66.67%	18.52%	14.81%	11.11%	0.00%
F	41.38%	34.48%	31.03%	6.90%	0.00%
Program	62.50%	22.50%	27.50%	10.63%	1.25%

Note. Percentages for one participant do not equal 100% since SMAs may address more than one standard. SMA = specific math activity, mSMA = mini specific math activity, NCTM = National Council of Teachers of Mathematics. [a]Includes counting, comparing/ordering, recognizing number/subitizing, composing numbers, adding/subtracting, multiplying/dividing, number recognition/writing. [b]Includes patterning and classifying. [c]Includes shapes, composing shapes, comparing shapes, motions/spatial sense. [d]Includes graphing (not listed on COEMET).

The percentage of SMAs including skills from Number and Operations was 41.38% to 72.73% (M = 62.50%). All teachers focused on math concepts from this area more than any other standard. The majority of activities focused on counting. Four of the teachers did not address the data analysis standard in the SMAs. Teachers' coverage of the other standards varied. One important note about the SMAs related to algebra. As mentioned earlier, patterning activities should be included in programs for young children. Of the SMAs relating to algebra, 52.78% focused on patterning.

Data source- field notes. There was no additional information to support this recommendation.

Data source- interviews. One main idea emerged from these interviews that aligned with the suggestions in Recommendation 6. All the teachers described how they involved families in the children's mathematical development. First, teachers mentioned providing mathematics homework 1 to 3 times a week. These assignments included activities related to the number or shape of the week. Teacher F mentioned that Pizza Hut™ created homework for the children. She explained that teachers provided the concepts and Pizza Hut™ created the materials. For example, children might be asked to make a house using various shapes. In addition, four teachers mentioned discussing with parents areas of improvement for children. Teacher C provided an example where she suggested to a parent that she take her child to the grocery store and use items in the produce section to help practice the child's counting skills.

Another way the teachers involved families was to hold a math/science night once a year at the school. During this event, parents had the opportunity to visit all the classrooms to learn about various math and science activities the children worked on throughout the year. Activities presented at this year's event included showing parents how to use a balance to weigh blocks, cutting pizza slices to represent the age of the child, counting Skittles® and creating a number book.

Curriculum Implementation

Data source- lesson plans. Providing time for children to have sustained mathematical experiences is an area supported by this recommendation. Lesson plans indicated that mathematics activities occurred on a regular basis. Small group time and center time provided children opportunities to work on mathematical activities on a regular basis. Twice a week for 15-30 minutes small group activities focused on a math skill. Center time occurred twice a day, for an hour in the morning and for 30 minutes to an hour in the afternoon. At least one of the center activities incorporated a math concept.

Lesson plans included skills from various standards. Weekly plans often included a number of concepts unrelated to each other. Switching from one skill to the next does not allow children the opportunity to develop these ideas deeply. One other area of note, the lesson plans did not include any indication of how parents might extend these ideas at home.

Data source- math materials. Various curriculum documents included evidence of sustained mathematical opportunities. The Math/Science Binder provided a scope and sequence indicating when various math concepts would be addressed during the year. For instance, in September the focus was patterns while in April the focus was geometry. In addition, for each of the topics listed in the scope and sequence, there were several lessons for teachers. Scholastic Early Childhood Program, included math activities integrated throughout each unit. Topics addressed throughout the year included concepts from the following areas: number and operations, patterning, geometry, measurement, and sorting/graphing. The first unit, Friends and School, included activities related to counting, sorting, and position words. In, Mathematics Discoveries for Young Children, the author organized the material into eight different units covering all five NCTM standards. Each unit included several activities to provide children with sustained learning opportunities for each concept.

Another area addressed in this recommendation pertains to extending mathematical learning experiences to the home environment. Only Mathematics Discoveries for Young Children included at home connections. For each unit, the author included a letter to send home to the families that described the mathematics being addressed, as well as activities that could be completed at home. For the unit on comparing and ordering, the author included two at home activities. One of the activities has families collect boxes or cans and then order them from smallest to tallest. After completing the activity, children draw a picture to demonstrate what they did.

Program Summary for Recommendation 6

Most of the data sources indicated that children have opportunities to engage in mathematical learning. Curriculum materials suggested extended learning experiences for a variety of topics while lesson plans and observational data indicated mathematical experiences that focused on skills rather than concept development. Data sources also suggested that teachers presented students concepts from many of the NCTM standards. Activities primarily focused on patterning, sorting, counting, measuring, and geometry.

Teacher interviews indicated how this program extends learning opportunities to the home environment. Homework, parent meetings, and math/science nights provided families with opportunities to connect mathematics to life outside of the classroom.

Recommendation 7

Recommendation 7 emphasizes the importance of integrating mathematics into all aspects of the day including routines and other content areas. Children should have opportunities to work on extended projects that integrate the various subject areas.

Teacher Implementation

Data source-COEMET. Two items from the COEMET align with this recommendation. Table 4.24 shows the average ratings for these items. As mentioned earlier (See Recommendation 1), item 3 related to the teacher’s use of teachable moments in the classroom to learn about the mathematics in the world around them and item 9 indicated if a teacher connected mathematics to real world situations. Both of these items provide insight into how teachers integrate mathematics throughout the day. Teacher ratings, for item 3, ranged from 2.67 to 4.00 (M = 3.41) and for item 9 ranged from 2.33 to 3.60 (M = 3.12).

Table 4.24

COEMET Averages for Items Aligned to Recommendation 7

	COEMET Item	
Teacher	3[a]	9[b]
A	3.50	3.17
B	4.00	3.60
C	4.00	3.20
D	2.67	2.33
E	2.83	3.00
F	3.60	3.60
Program	3.41	3.12

Note. Scale for COEMET items: 1 (strongly disagree), 2 (disagree), 3 (neutral or not applicable), 4 (agree), 5 (strongly agree) COEMET = Classroom Observation of Early Mathematics—Environment and Teaching. [a]Teachable moments related to math. [b]Teacher connected math to real world.

Data source- field notes. Teachers incorporated mathematics into many of the daily routines in their classroom each day. Routines observed incorporating mathematical opportunities included taking attendance, lining up to/from recess, setting the table for lunch, and doing activities related to the calendar. Table 4.25 shows the frequency of these activities for each teacher.

All of the teachers incorporated mathematics into their calendar activities. These opportunities included singing songs about the days of the week and months of the year; discussing today, tomorrow, and yesterday; and determining and writing today's date. Teachers also integrated mathematics when lining up to/from recess by counting the children in line.

Table 4.25

Frequency of Mathematics During Daily Routines

Teacher	Attendance	Calendar	Recess[a]	Lunch[b]
A	0	4	2	3
B	1	5	5	6
C	2	6	6	3
D	0	6	5	1
E	4	6	5	4
F	6	6	6	5
Program	2.67	5.50	4.83	3.67

Note. The highest frequency possible is six since each teacher was observed 6 times. [a]Includes children lining up going to recess and coming back from recess but does not include activities during recess. [b]Includes setting table for lunch and distributing food for lunch but does not include activities during lunch.

Some teachers counted the students while other teachers had a child count the number of children in line. At lunchtime, some classes provided children with the opportunity to set the table for lunch. In these rooms, two or three children would place a foam tray, napkin, plastic ware, and cup for each spot at the table. In addition, when the food arrived at the classroom, children served themselves and had to count the appropriate portions. For instance, each child would count out three steak fingers. Teachers E and F incorporated mathematics into taking attendance on a consistent basis. For example, in Teacher F’s classroom the children would count the number of girls and boys and then determine how many they had altogether. While the children counted, Teacher F would write the numbers for each group along with pictures to represent each child.

During these observations, teachers integrated mathematics with different areas of the curriculum. Table 4.26 indicates the different content areas teachers connected to mathematics.

Table 4.26

Integration of Mathematics with Other Content Areas During Observations

Content Area	Number of Teachers
Movement	3
Language	5
Music	6
Science	3
Art	2

All of the teachers provided children with music that related to mathematical concepts such as counting and patterning. Three teachers offered children opportunities that combined movement with mathematics. For example, one day in Teacher B's classroom, children took turns rolling a large foam die. After each roll, the child indentified the number and told the class a movement (jump, hop on one foot, jumping jacks). Then the rest of class would perform the suggested movement the number of times indicated on the die.

Five teachers also integrated mathematics with language activities. Most often these ideas appeared when reading a story to the class. Teachers would ask children questions about the mathematics that related to the pictures or the ideas in the book. Teacher F integrated language and mathematics by providing children with objects starting with two different letters. Children had to sort these materials by these beginning sounds.

Science and art integration did not occur as frequently or across most of the classrooms. Teacher A integrated science and mathematics by having children sort items of clothing according to the season when you might wear them. Teacher F created an art activity where children created patterns with different colored hands to make an earth. Sometimes math activities related to the theme for the week but the integration of the ideas was weak. For example, often math activities used items such as seashells or sea animals related to the theme when discussing the ocean.

Data source- interviews. One idea that emerged from the interview data related to providing children with extended projects associated with mathematics. In general, the teachers agreed that they did not offer extended, in depth mathematical activities. They mentioned doing math daily but did not include extended activities because of the children's age.

Teachers also discussed how they integrated mathematics with other content areas. Table 4.27 lists the different content areas teachers indicated integrated with mathematics.

Table 4.27

Teachers' Comments About Math Integration

Content Area	Number of Teachers
Language	3
Science	6
Movement	2
Art	1
Music	1

Instructional practices and teachers' comments during interviews did not completely align when discussing how teachers integrate mathematics with other content areas. All the teachers mentioned combining science and mathematics. Four of the teachers stated that they used materials related to the theme. Then children would use these materials for sorting, counting, ordering and other math activities. As mentioned in the previous section, these types of learning opportunities do not provide children with meaningful ways to connect mathematical concepts to important ideas in science. Three teachers described focusing on math ideas when reading books to children. In addition, Teacher E said that she had several books in the library center that specifically related to math concepts such as counting. Although, all teachers included music related to mathematics, only Teacher F described these activities during the interviews.

Curriculum Alignment

Data source- lesson plans. Lesson plans also included math activities integrated with other content areas. Table 4.28 displays the types of integration.

Table 4.28

Integration of Mathematics with Other Content Areas in Lesson Plans

Content Area	Number of Teachers	Number of Activities
Science	4	8
Language	5	7
Art	2	2
Music	3	6

Four teachers planned learning opportunities that integrated mathematics and science. Half of these activities required children to combine their sorting skills with their understanding of various scientific concepts. For example, one lesson plan included an activity in which children sorted items according to whether they were fruit or vegetable. Lesson plans included four language activities that included math concepts in a book. Only two of the activities listed in the lesson plans incorporated art with mathematics.

Data source- math materials. All of the various curriculum sources provided activities for children to explore mathematics in connection with another content area. Table 4.29 lists the various curriculum sources and the types of integration included in these materials.

Table 4.29

Integration of Mathematics with Other Content Areas in Curriculum Materials

Resource	Science	Social Studies	Language	Music	Movement	Art
Educator's Handbook	√	√	√			
Math/Science Binder	√		√		√	√
Mathematical Discoveries for Young Children	√		√	√	√	√
Building Language for Literacy	√		√			
Scholastic Early Childhood Program			√	√		

All of the curriculum resources integrated mathematics with language skills. These literacy activities focused on helping children understand mathematical ideas presented in a story. For example, the Educator's Handbook included several math activities for the story *The Three Billy Goats Gruff*. These learning experiences provided children time to explore ideas presented in the text such as the words *big, medium*, and *small*. Children extended their knowledge of this concept by sorting items using these categories. In *Mathematical Discoveries for Young Children* (1992), the author included a list of books at the beginning of each unit related to the math concepts addressed. For each story, the author provided an activity to do in conjunction with the reading of the book. For instance, the author suggested reading *Brown Bear, Brown Bear, What Do You See?* when learning about patterns. After reading this book, children could explore the patterns the author used in the text and then create a new verse to the story.

Four curriculum resources included activities that incorporated mathematics and science. These learning experiences often focused on sorting or measuring skills. Sorting activities included grouping items such as foods (healthy/unhealthy), rocks (size, shape, color, or texture), and animals. Sometimes activities provided children experiences to sort objects after conducting an experiment to determine certain scientific properties of the object. For example, *Mathematical Discoveries for Young Children* (1992) and the Math/Science Binder included a learning activity that required children to determine whether an item would float or sink. Other science activities focused on measuring. These learning experiences focused on different aspects of measuring such as length, height, and weight. For instance, the Educator's Handbook included a measurement connection during a lesson about dinosaurs. This activity provided children the opportunity to compare their footprint to the footprint of a dinosaur.

Two resources provided children learning experiences incorporating music and mathematics. The majority of these opportunities were songs that included mathematical ideas. For instance, the Educator's Handbook included words to several songs that incorporated counting with the monthly theme. Many of these songs followed a similar pattern. The song would start out with 5 or 10 frogs (ducks, sugar buns, latkes) and then as the song progressed the number of frogs would decrease by 1 until 0 were left. The resource *Mathematical Discoveries for Young Children* included other types of mathematical learning experiences related to music. For example, one activity required children to create rhythmic patterns.

Although this curriculum provided several quality learning experiences that required children to combine their knowledge from more than one content area, sometimes these integrated learning opportunities did not enhance the learning of the skills from both content areas. For example, the Educator's Handbook presented activities for children to complete after reading the story *Mrs. Wishy Washy*. These math activities used eggs to help children develop concepts such as measuring weight and counting. This story is about how different farm animals play in the mud. Mrs. Wishy Washy cleans the animals and shortly after all go back to play in the mud. Using eggs to relate to the ideas in the story does not seem to be a natural connection. These activities did not enrich the children's learning of the story or the math concepts since they do not build on each other.

Program Summary for Recommendation 7

Many of the activities in this preschool program's curriculum, as well as the learning opportunities observed during this study, integrated mathematics with other areas of the curriculum or daily routine. Teachers incorporated mathematics into daily activities by including math ideas when taking attendance, preparing for lunch, or going to recess. In addition, activities observed or in the program's curriculum connected mathematics to language or music. Other content areas such as science, art, and movement, the amount of integration with math, varied depending on the data source. While integrated opportunities occurred, sometimes these lessons did not provide the strongest support of the ideas in both fields because the integration of ideas was superficial or it did not strengthen a child's understanding of concepts presented. One area mentioned in recommendation 7 lacking in this program was including opportunities for children to participate in extended projects that incorporate math activities by which they can strengthen their problem solving skills as well as other process skills.

Recommendation 8

Recommendation 8 focuses on the importance of providing children with time to play so that they can explore mathematical ideas. Teachers should observe children's play and use these ideas when planning instruction. In addition, this recommendation emphasizes the importance of block play to develop various mathematical concepts.

Teacher Implementation

Data source-COEMET. Two items from the COEMET align with this recommendation. Table 4.30 provides the average ratings for these items.

Table 4.30

COEMET Averages for Items Aligned to Recommendation 8

	COEMET Item	
Teacher	5[a]	9[b]
A	4.00	3.17
B	4.00	3.60
C	4.00	3.20
D	4.00	2.33
E	4.00	3.00
F	4.00	3.60
Program	4.00	3.12

Note. Scale for COEMET items: 1 (*strongly disagree*), 2 (*disagree*), 3 (*neutral or not applicable*), 4 (*agree*), 5 (*strongly agree*). COEMET = Classroom Observation of Early Mathematics—Environment and Teaching. [a]Math materials provided in classroom. [b]Teacher connected math to ideas from play.

Item 5 related to the math materials in the classroom. As mentioned earlier (See Recommendation 3), all classrooms provided a variety of developmentally appropriate math materials accessible to children daily. Providing children with these types of materials will allow them the opportunity to grapple with math concepts during play.

Item 9 (See Recommendations 1 and 7) indicated whether teachers identify math in real world situations. These connections may occur during children's play. Teacher ratings for item 9 ranged from 2.33 to 3.60 (M = 3.12).

For each SMA, the COEMET required the observer to indicate the type of organizational structure for the activity. One of the choices included was play. These activities indicated times when children would initiate an activity without the direction of the teacher; however, the teacher would engage the child in a mathematical discussion about the activity. Table 4.31 indicates the percentage of SMAs related to children's play.

Table 4.31

Percentage of SMAs Identified as Play

Teacher	SMAs Indentified as Play
A	1.72%
B	9.09%
C	3.45%
D	10.00%
E	13.64%
F	10.26%
Program	7.28%

Note. SMA = specific math activity.

The percentage of SMAs that related to children's play ranged from 1.72% to 13.64% (*M* = 7.28%). These percentages indicate that the teacher initiated the majority of SMAs in these classrooms. When teachers did engage children in mathematical discussions during play activities, they often encouraged children to think about how to use play items in a math way. For example, Teacher E sat with two children who were playing with snap cubes and suggested that they should make color patterns with the cubes. Other times, teachers engaged children in mathematical conversations. Teachers asked questions that required children to think about their play situation such as "How many snap cubes did you use or whose castle is taller?"

Data source- field notes. Sometimes teachers did not comment on children's mathematical thinking during play. Table 4.32 lists mathematical activities children engaged in during these observations without the guidance of the teacher.

Table 4.32

Children's Mathematical Activity Without Teacher

Teacher	Mathematical Activity
A	Points out shapes in book Counts number of rectangles in journal Counts number of markers Plays math game Indentifies pattern in song
B	Makes pattern with bracelets
C	Discuss number of children allowed in block center Sort crayons by color after they spilled on to the floor Sings *Five Speckled Frogs* Sorts flashcards by color
D	Counts backwards from five to zero Uses pattern blocks to make shapes
E	Sorts plastic teddy bears by color Counts number of children in circle Uses snap cubes to make patterns
F	Plays Oreo™ shape match game Counts number of stars in book Describes objects in book as small, medium, and large Counts number of bags in dramatic play area Counts number of pegs Plays store during recess

Children developed various mathematical concepts including counting, patterning, sorting, and recognizing shapes during play situations where teachers did not observe or comment about the mathematics. Some of these opportunities were brief interludes with mathematics while others lasted for longer periods of time. For instance, one day during center time in Teacher E's class, two boys decided to play with the snap cubes.

One child used two different colors to make several ABA patterns. Several times during this activity, the boy making the patterns said to his playmate, “I am doing a pattern” or “This is a pattern.” As the child made the patterns, he lined up the snap cube towers to see if his patterns were the same height. He added more blocks if he noticed there were not enough snap cubes.

Data source- interviews. When talking about play and mathematics, four of the teachers discussed how they used observations of children’s play to help them develop math activities. Sometimes teachers used these observations to introduce new concepts. For example, when Teacher A saw that children were interested in measuring each other’s heights, she decided to introduce measuring tapes. Other times teachers used these observations to determine which concepts children didn’t understand. After observing these situations, they would create an activity for a future lesson about this concept.

Teachers mentioned that they used questions to help children think about mathematics in play situations, especially during center time. Five of the teachers discussed that mathematical ideas were present in many of the centers available to children such as dramatic play, writing, and library. Teachers used these learning activities to engage children in mathematical discussions. Teacher F explained,

> When they play…for example, if they are in the block center and they make a cage for the dinosaurs. I ask them, “How many dinosaurs do you have? If you put two more, how many more would you have?”...As they are playing, we try to go around as much as we can, and it depends on the schedule, what is going on. I try to go around and encourage their thinking and help them to extend their use of math in play, and also in language.

Curriculum Alignment

Data source- lesson plans. Lesson plans did not incorporate many instances of how teachers encourage children's mathematical thinking during play. Some opportunities for teachers to engage children during play in mathematical conversations may occur in some of the centers. Table 4.33 lists centers in lesson plans that may promote these opportunities.

Table 4.33

Play Opportunities Encouraging Mathematical Thinking in Planned Center Activities

Teacher	Dramatic Play	Block Area	Sensory Table
A	Recycling Center Vegetable Stand		
B	Pizza Parlor Seafood Restaurant	Pizza Delivery	
C		Recycling Store Piñata Factory	Rice, spoons, cups, bowls Sand castles
D		Be an Architect! Build Aquarium	
E	Recycling Center Seafood Restaurant	Building Fence	Sand castles
F	Market Recycling Center Flower Shop		

Note. Activities in these centers changed weekly. Each teacher submitted six weekly lesson plans.

Dramatic play, the block area, and the sensory table were centers that included materials that may facilitate these mathematical opportunities. For example, some lesson plans transformed the dramatic play area into a recycling center or restaurant.

Depending on the children's interactions and how the teachers responded to these conversations, there might be a variety of mathematical thinking occurring in these areas.

Data source- math materials. Few activities promoted children's play within the curriculum materials. The Math/Science Binder described the use of math tubs. Each tub had a different math manipulative for children to explore during center time. After an introduction from the teacher, children would have the opportunity to use the math materials to create their own meaning. Math items included pattern blocks, buttons, stamps, bears and unifix cubes.

The *Building Language for Literacy* (2000) and *Scholastic Early Childhood Program* (2003) resources provided suggestions for different learning centers in the classroom. Centers included math, dramatic play, blocks, sensory table, art, and language. For example, one dramatic play suggested creating an area for children to pretend they were at the supermarket. Preparing learning activities such as this one may encourage children to develop mathematical understandings during play.

Program Summary for Recommendation 8

Few examples in the data sources supported this program's use of play opportunities to encourage mathematical thinking. Observational data indicated that teachers sometimes engaged students in mathematical conversations about their play. Curriculum sources presented relatively few situations that may lend themselves to these types of discussions. Interview data supported the use of play to help inform instructional practices.

Recommendation 9

Recommendation 9 focuses on the importance of introducing concepts to children using a variety of strategies and activities. These opportunities should be planned and use various organizational methods. Teachers should revisit concepts explored earlier in the year. In addition, teachers should include games and computer activities that support these mathematical ideas.

Teacher Implementation

Data source-COEMET. Four items from the COEMET aligned with this recommendation. Since item 16 is from the extended protocol it is not discussed in this section. Table 4.34 includes the averages of the other three items from the *COEMET*.

Table 4.34

COEMET Averages for Items Aligned to Recommendation 9

	COEMET Item		
Teacher	4[a]	14[b]	15[c]
A	2.33	3.43	3.26
B	1.50	4.25	3.75
C	1.17	3.87	3.71
D	2.40	2.83	3.67
E	2.20	3.52	3.74
F	2.33	4.00	3.67
Program	1.97	3.67	3.60

Note. Scale for 4 and 15: 0 (0%), 1 (1-25%), 2 (26-50%), 3 (51-75%), 4 (76-100%). Scale for 14: 1 (strongly disagree), 2 (disagree), 3 (neutral or not applicable), 4 (agree), 5 (strongly agree). COEMET = Classroom Observation of Early Mathematics—Environment and Teaching. [a]Time spent on computers engaging in math activities. [b]Teahcer's management strategies. [c]Percentage of time teacher involved in activity.

Item 4 indicated the percentage of time children spent each observation on the computer using math software. Children had access to the computer during center time for about 45 minutes to an hour each morning. In general about half of this time children spent on math activities.

Item 14 related to how well the teacher managed each SMA. Indicators of this item included: preparing the materials prior to starting the activity, organizing the children in an appropriate manner, and interacting with children to encourage their involvement in the activity. Ratings ranged from 2.83 to 4.25 (M = 3.67). These ratings suggest that on average most teachers seemed to be prepared and organized children effectively, albeit not on a consistent basis. One example that met these requirements was when Teacher F decided to share a new math game with the children. Prior to making this activity available for center time, the teacher showed the children how to play the game during circle time. Also, when the children start playing the game, the teacher monitored the children's understanding and helped children who needed a review of the rules.

Item 15 related to the percentage of time a teacher was actively involved in a SMA. The averages listed in the Table 4.27 indicate that for most activities teachers were involved between 50-100% of time leaning toward the higher end of this range.

One component tracked by the COEMET for each SMA was the way a teacher organized the children for this activity. Table 4.35 presents the percentage of SMAs for each type of organization listed on the COEMET.

Table 4.35

Organization Used By Teachers During Observations

	Teachers						
Type	A	B	C	D	E	F	Program
Whole Group	63.79%	51.52%	50.00%	66.67%	50.00%	46.15%	54.79%
Small Group	3.44%	3.03%	10.34%	0.00%	9.09%	5.13%	5.75%
Individual[a]	1.72%	3.03%	5.17%	0.00%	0.00%	0.00%	1.92%
Center	20.69%	21.21%	20.69%	20.00%	22.73%	35.90%	23.37%
Game	5.17%	6.06%	0.00%	3.33%	0.00%	2.56%	2.68%
Play	1.72%	9.09%	3.45%	10.00%	13.64%	10.26%	7.28%
Other	3.45%	6.06%	10.34%	0.00%	4.55%	0.00%	4.60%

[a]Individaul Activity with Teacher

Overall teachers used whole group instruction the most (*M* = 54.79%) followed by centers (*M* = 23.37%). Although, recommendation 9 indicates that small group instruction is an appropriate way for teachers to introduce concepts to young children, overall only 5.45% of SMAs used this type of organizational strategy. Teacher D did not use small group instruction.

Data source- field notes. There were no additional items from the field notes that aligned with this recommendation.

Data source- interviews. Two themes emerged from the interviews related to this recommendation. First, teachers discussed introducing math concepts to the students. Teachers C and F stated that at the beginning of the year most of the concepts are new to the students and then as the year goes on the teachers spend time revisiting skills presented earlier in the year. There did not seem to be a consensus on the amount of time spent on a new skill prior to introducing a different concept. Teachers said that they introduced about one to three math skills in a week. Teacher A discussed how she let the children determine the length of time they spent on various math skills. She stated,

> For example, if I start to introduce a new concept, I need to make sure that they can catch the concept. Maybe it is going to take 2 or 3 weeks, not everyday, twice a week. Then when I notice they are ready to change the concept, I am going to change it. If not, I need to keep with that concept in different ways not with the same activity, other activities until they get ready for another concept. Maybe it is going to take 3 or 4 weeks.

In addition to discussing the introduction of new concepts, all the teachers stated how they reviewed skills from earlier in the year. Teacher C mentioned that towards the end of the school year most of the mathematics was review.

Teachers also described the use of computers during center time. All the teachers indicated that they did not have control over software decisions and used what the school provided them for math activities. Teachers A, B, and F stated the limitations of the computer activities. First, the age of computer prevented the loading of new software. Second, some of the current software didn't always relate to the weekly themes. The other teachers did not express any concerns about the software. Teachers D and E seemed uncertain of what math activities their children had access to on the computer.

Curriculum Alignment

Data source- lesson plans. Lesson plans indicated that there were at least two small group activities every week related to mathematics and at least one center activity per day that focused on a math skill. In addition, math concepts introduced during small group time in the morning were reviewed in the afternoon after naptime. Lesson plans indicated that teachers revisited math concepts learned earlier in the year. Table 4.36 displays the number of skills appearing more than once in each teacher's lesson plan.

Table 4.36

Math Concepts Revisited in Lesson Plans

Teacher	Number of Concepts Reviewed	Number of Concepts Reviewed Multiple Times
A	8	2
B	6	2
C	5	4
D	8	2
E	5	3
F	7	5

Reviewing the six lesson plans from each teacher, showed that during this time period, many of the skills were revisited often. Concepts such as patterning, sorting and counting were revisited several times across all the lesson plans.

Data source- math materials. Curriculum materials provided evidence that supported the suggestions in this recommendation. Organizing techniques such as using scope and sequences, separating math activities by monthly themes, and providing units addressing specific math skills all indicated how these resources showed mathematics in a planned and organized way. Activities demonstrated how the various math concepts would be introduced to children and how prior learning experiences connected to new concepts. In addition, the Math/Science Binder and *Scholastic Early*

Childhood Program (2003) suggested that many of these activities should be presented to children during small group time.

Several math activities from the Educator's Handbook and the Math/Science Binder were games. These games either introduced children to a math concept or extended mathematical ideas. These learning opportunities focused on a variety of skills such as counting, sorting, identifying shapes, and measuring. For example, one activity suggested modifying the game Simon Says to include position words.

Millie's Math House, a software program, provided children with opportunities to practice various mathematical skills on the computer. This software includes activities related to measurement, geometry, algebra, and numbers and operations. For instance, the characters Bing and Boing helped children to develop, extend, and identify patterns.

Program Summary for Recommendation 9

This program provided children with planned and organized mathematical opportunities, which introduced them to a variety of math concepts. Although curriculum materials indicated a sequence to these activities, lesson plans and observational data did not always support the same ideas. Teachers seemed to incorporate multiple concepts into one lesson plan instead of focusing on one major idea as suggested by the curriculum materials.

Data sources supported the use of games and computer activities to extend mathematical understanding of various concepts. All classrooms provided children time to use the computer although some teachers voiced concerns about the software, citing the need for more flexibility in creating learning opportunities that supported what they were currently teaching. Observational data indicated that children did not have many opportunities to play games that strengthen mathematical skills despite the frequency of these types of learning opportunities in the curriculum materials.

Recommendation 10

Recommendation 10 emphasizes the importance of using a variety of developmentally appropriate assessments to help determine children's mathematical understandings. Suggested assessments include observations, interviews, collection of student work and performance based assessments. Teachers should use data from these items to help plan for instruction.

Teacher Implementation

Data source-COEMET. Only one item aligned with this recommendation. Since, Item 27 is from the extended protocol it is not discussed in this section.

Data source- field notes. During these observations, four classrooms administered the Learning Accomplishment Profile-Third Edition (LAP-3) or the Developmental Indicators for the Assessment of Learning- Third Edition (DIAL-3) to individual students for the final assessment of the school year. Usually, the assistant teacher would administer these individual assessments to a child while the lead teacher would continue with the regular schedule with the rest of the class.

Data source- interviews. Two themes emerged from the interview transcripts related to this recommendation. First, teachers discussed the different types of assessment they used to help them learn about children's mathematical understandings. Table 4.37 lists the types of assessments teachers described during interviews.

Table 4.37

Types of Mathematical Assessments Identified by Teachers During Interviews

	Teacher					
Type of Assessment	A	B	C	D	E	F
Checklist	√	√	√			√
LAP-3	√	√	√	√	√	√
Observations	√	√		√	√	√
DIAL-3		√		√	√	√
Portfolio		√		√	√	
Informal						√

Note. LAP-3 = Learning Accomplishment Profile-Third Edition. DIAL-3 = Developmental Indicators for the Assessment of Learning- Third Edition.

All the teachers described using the LAP-3 (2003). According to the teachers, they administered this individualized assessment 3 times a year (beginning, middle, end). Another individualized assessment some of the teachers mentioned was the DIAL-3. This assessment was only given to students when they enter and exit the program.

Five teachers described their use of observations or anecdotal notes (both terms used to describe the same situations). The frequency of these observations varied from when an important event occurred in the classroom to a couple times a month. In addition, three of the teachers indicated that these observation notes were one part of the child's portfolio, which also included the child's learning goals and work samples. Four teachers discussed using checklists to help them assess children on concepts such as number recognition and shapes. Teacher F mentioned using informal assessments to evaluate children’s understanding.

All the teachers described how they used data from these assessments to help plan for instruction. The focus of this discussion revolved around the data from the LAP-3 (2003) assessments. Teachers stated that after they administered this assessment, they generated reports about each child’s performance. Using these results, the teachers created learning goals for each child. Two teachers mentioned using a combination of these test results and observational data to help develop these goals. Teacher B described how she used the LAP-3 (2003) to help her develop various activities for her classroom. She stated,

> For instance, we do LAP-3. That is one of the tests we do. So, we try to get some of our ideas from there that we are going to ask and try to…not exactly what it says on the test but a little bit different so they can understand the concept. So when we go back and take the test, they are like, “We kind of do that” so . . .

Teachers described using these ideas for whole group instruction, small group instruction, centers, and “I care” centers. “I care” centers offered opportunities for teachers to work with one or two students who needed help with the same skill.

Curriculum Alignment

Data source- lesson plans. Lesson plans did not indicate how the teachers assessed children’s knowledge of the different mathematical concepts listed. Many of the items on the lesson plan appeared to be linked to the LAP-3 (2003) assessment. Activities related to this assessment had a notation indicating which item on the LAP-3 (2003) connected to this material.

Data source- math materials. The curriculum materials included a variety of assessment options for teachers. First, the program purchased two individually administered assessments, the DIAL-3 (1998) and the LAP-3 (2003). The DIAL-3 (1998) is a screening assessment given to children when they first enter the program and when they leave or graduate from the program. This assessment screened children in five areas: motor, language, concepts, self-help, and social development. The concept area included math skills such as identifying shapes, counting, sorting shapes, and understanding position words.

The LAP-3 (2003) was a criterion-referenced assessment administered 3 times (beginning, middle, and end) a year to the children. Developed for children 36-72 months, this assessment had 383 developmental skills that addressed six areas of development: gross motor, fine motor, pre-writing, cognitive, language, self-help, and personal/social. The majority of the math related items came from the cognitive section of this assessment. Items in each section were organized chronologically. Math skills included: identifying shapes, counting, recognizing numbers, comparing amounts, measuring, and patterning. For example, item 40 had the teacher place 10 cubes in front of the child and then the teacher asked the child to give three cubes.

When administering this assessment, teachers first determined the child's basal by starting at a point where they believed the child could successfully answer eight items in a row. Once a child answered eight items correctly, the teacher continued administering the assessment until the child reached his/her ceiling (missed three items out five items). The teacher tracked a student's progress on a PDA that was synced to a computer later. After assessing students, reports informed teachers of how each child did on the assessments as well as gave teachers summarized information pertaining to the whole class.

Other types of assessment evident in the curriculum materials included observation, checklist, and portfolio. *Scholastic Early Childhood Program* (2003) curriculum provided teachers with items to observe during various lessons. For example, when children learned about sorting, each lesson related to this concept provided a new skill to focus on while the children completed the activity. At the beginning of the unit, the curriculum suggested to monitor whether children were able to sort items into two groups. As the child's knowledge progressed, the observations focused on more complex skills such as the child's ability to name these groupings.

The resource, *Mathematical Discoveries for Young Children* (1998), provided teachers with two additional ways to assess children's mathematical knowledge. First, this book included an assessment checklist. This tool allowed teachers to keep track of children's progress on the various math skills presented in the book. In addition, throughout the text, the author suggested activities that will help teachers to assess the knowledge of these skills. For example, one concept addressed in this material is patterning. At the end of this unit, there was a performance-based task that children do individually with the teacher to assess whether they could identify a pattern, read a pattern, extend a pattern, and create a pattern.

Another way the author incorporated assessment into *Mathematical Discoveries for Young Children* (1998) was by suggesting items to put in the child's portfolio. Throughout the text, the author marked activities that would be good examples of the students' understanding of the various mathematical concepts. For instance, one activity had children sort paper items and then glue them in their groups on to a piece of paper.

Program Summary for Recommendation 10

As suggested in recommendation 10, this preschool program's curriculum had several developmentally appropriate ways to assess children's emerging mathematical development. Conducting observations, creating portfolios of student work and individual performance assessments are supported by NAEYC and NCTM's position statement. During interviews, teachers described many of these assessments however the primary focus was given to the LAP-3 and observational data. As mentioned earlier, lesson plans and observations did not indicate the same variety as the curriculum materials. In these data sources, the only assessment appearing on a regular basis was the LAP-3. When analyzing lesson plans, observing math activities, and interviewing teachers, it is apparent that teachers use assessment data to inform instructional practices.

Overall Summary

After analyzing the data, it is apparent that this preschool program incorporated several of the suggestions provided by NAEYC and NCTM (2002) for high-quality mathematics instruction. Two research questions guided this study. The first research question focused on how the preschool teachers' instructional practices followed the recommendations. Table 4.38 provides an overview of how the teacher's instructional practices aligned with NAEYC and NCTM's suggestions for engaging young children in mathematical learning.

Table 4.38

Instructional Practices' Alignment with NAEYC and NCTM Recommendations (2002)

Recommendation	Strengths	Gaps
1		Inconsistent support of children's connections to mathematics in the world around them
2	Support for ELL Modifications to instruction Use of mathematics vocabulary	Few indications of how teachers support different learning styles
3	Developmentally appropriate activities	Few indications of how activities align with children's motor, social, and emotional development
4	Mathematical connections	Few problem solving activities that allowed children to develop various process skills
5		Lack of information pertaining to big ideas and learning trajectories
6	Time for mathematics everyday Activities to encourage family involvement	Lack of sustained learning opportunities related to one concept in classroom
7	Mathematics in daily routines Language integration Music integration	Lack of consistent and meaningful integration in all content areas Lack of extended mathematical projects
8	Discussion of play informing instruction	Few examples of how teachers connect mathematics to play situations
9	Planned, organized instruction Computer time	No logical sequence of mathematical skills in classroom activities Few mathematical games provided by teachers
10	Developmentally appropriate assessments	Lack of variety in assessments used by teachers

The teachers planned, daily, developmentally appropriate math activities for the children. Learning experiences included opportunities for children to connect their emerging mathematical knowledge to formal mathematics terminology, to other mathematical concepts, to their developing language skills, to the music in their environment, to activities on the computer, and to daily classroom routines. Teachers suggested ways to include families in helping their children to extend these learning experiences at home and described ways that play informed their instructional practices.

Teachers incorporated few opportunities for sustained learning of math concepts in a coherent sequence. Instructional practices provided inconsistent support to help children connect mathematics to their world, including during play. Observations indicated a lack of diversity in the assessments used by teachers. Instructional activities provided few opportunities for children to engage in problem solving activities. Evidence did not support the use of extended mathematical projects or learning trajectories by the teachers. Although some integration of content areas occurred, not all of these opportunities provided meaningful learning experiences for children across all subject areas.

The second research question focused on how this preschool program's curriculum followed the recommendations provided by NAEYC and NCTM. Table 4.39 indicates the curriculum's alignment with these guidelines.

Table 4.39

Curriculum's Alignment with NAEYC and NCTM Recommendations (2002)

Recommendation	Strengths	Gaps
1	Support of mathematics in children's world	
2	Support for ELL Modifications to instruction Use of mathematics vocabulary	
3	Developmentally appropriate activities	Few indications of how activities align with children's motor, social, and emotional development
4	Mathematical connections	Few problem solving activities that allowed children to develop various process skills
5	Concept based curriculum materials	Lack of information pertaining to big ideas and learning trajectories
6	Time for mathematics everyday Units of study allowing for sustained learning about a concept	
7	Language integration Music integration	Lack of consistent and meaningful integration in all content areas Lack of extended mathematical projects
8		
9	Planned, organized instruction Computer time Math games	
10	Developmentally appropriate assessments	

Multiple aspects of this program included ideas for making modifications to the curriculum activities to support learners. Inclusion of developmentally appropriate assessments provided opportunities to evaluate children's mathematical understandings. Curriculum documents included a concept-based sequence of activities that supported the use of math games and helping children make mathematical connections to the world around them.

Program activities provided few suggestions of how to support children's developing problem solving abilities and variations in approaches to learning. Evidence did not support the use of extended mathematical projects or learning trajectories. Although some integration of content areas occurred, not all of these opportunities provided meaningful learning experiences for children across all subject areas.

Chapter 4 provided a summary of the results from this study. First, a discussion of the descriptive statistics provided an overall picture of the mathematics environment in the classrooms. Next, I provided a description of how the data from each of the sources aligned with NAEYC and NCTM's (2002) recommendations. Lastly, the overall summary presented several strengths and gaps in this program's alignment. Chapter 5 includes a discussion of these findings, limitations to these findings, and suggestions for future research.

CHAPTER 5

DISCUSSION

> Because young children's experiences fundamentally shape their attitude toward mathematics, an engaging and encouraging climate for children's early encounters with mathematics is important. It is vital for young children to develop confidence in their ability to understand and use mathematics—in other words, to see mathematics as within their reach.
>
> *Early Childhood Mathematics*

This study investigated a preschool program's use of the recommendations outlined by the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics (NCTM) (2002) in their position statement, *Early Childhood Mathematics: Promoting Good Beginnings*. This chapter provides a summary of the procedures for this research. Next, the focus turns to a discussion of the findings as well as connections to prior research and suggestions for instructional practice. Lastly, limitations and ideas for future research are presented.

Summary of Study

The focus of this research was to determine how a preschool program incorporated the recommendations provided by NAEYC and NCTM (2002) for high-quality mathematical learning experiences. Two components of this program, the teachers and the curriculum, provided insight into the strategies used for instructing young children about mathematical ideas. The following research questions guided this study:

1. To what extent do the preschool teachers' instructional practices follow the recommendations outlined in NAEYC and NCTM's position statement *Early Childhood Mathematics: Promoting Good Beginnings* (2002)?

2. To what extent does the preschool program's curriculum align with the recommendations outlined in NAEYC and NCTM's position statement *Early Childhood Mathematics: Promoting Good Beginnings* (2002)?

A review of the literature presented information about the history of mathematics education with an emphasis on practices that shaped the field of early childhood education. This content along with theoretical connections for pioneers such as Piaget and Montessori provided the context for current practices in mathematics education for young children. Next, a review of articles relating to the recommendations (NCTM & NAEYC, 2002) indicated support for many of the ideas in this document. Lastly, research-based early childhood curricula provided indications of some alignment across many of the recommendations.

To gain insight into teaching practices, I observed each participant (*N* = 6) 6 times using the Classroom Observation of Early Mathematics—Environment and Teaching (COEMET) observation protocol, wrote field notes of these observations, and interviewed each teacher 3 times during the study. Reviewing math curricular documents and lesson plans provided information pertaining to the math curriculum used at this preschool program. All of these data sources were analyzed using the framework presented in NAEYC and NCTM's position statement.

Discussion of Findings

All the teachers in this study indicated they were unfamiliar with NAEYC and NCTM's (2002) joint position statement, *Early Childhood Mathematics: Promoting Good Beginnings*. Despite this lack of knowledge about these recommendations, teachers followed aspects of these guidelines. There are several possible explanations for this alignment. First, curriculum materials provided teachers with learning activities that followed many of NAEYC and NCTM’s (2002) suggestions. Since teachers indicated using these materials to help plan for math activities in their classrooms, it is not surprising that there is some alignment between these two components of this program. Second, their prior experiences working with young children inform their understanding of instructional approaches and the math activities that children need to help develop mathematical understanding. Throughout the interviews, teachers mentioned how observing the children helped them to understand what activities to include in the curriculum. Third, professional development opportunities and other educational experiences may have included information pertaining to practices that are beneficial to children’s emerging mathematical development. During one observation, Teacher E introduced a new strategy to help the children learn the days of the week. As she presented this activity to the class, she mentioned that she learned these ideas from a professional development session she went to that weekend.

Sometimes teachers’ instructional practices did not align with NAEYC and NCTM’s (2002) recommendations. There are several possible reasons for these gaps in implementation. The preschool program’s curriculum did not align completely with all the guidelines. Teachers often relied on these materials to develop mathematical learning opportunities for children. For instance, this preschool program’s curriculum provided limited activities related to engaging children in problem solving opportunities. This lack of focus may lead teachers to believe that it is not important. Also, this limited information may not provide teachers with the needed support to incorporate these learning experiences into classroom activities. Although there were some gaps in alignment, the preschool program's curriculum supported many of these recommendations. Still, instructional practices did not always support the ideas presented in the curriculum. Therefore, there must be other explanations for why teachers did not incorporate these guidelines.

First, the teachers' knowledge of pedagogy may not support incorporating all of these recommendations. Many of the teachers in this program did not have an associate's or bachelor's degree in early childhood education. Although all teachers had at least a CDA, perhaps this preparation did not provide the teachers with enough opportunities to incorporate all the ideas from the mathematics curriculum into their instructional practices. A second explanation for this lack of alignment may relate to the teacher's previous experiences with mathematics. If the teacher is not comfortable with mathematics or does not understand the concepts fully, it will be difficult to provide adequate support to children's developing mathematical understanding. During a few of the observations, some teachers asked the assistant teacher in the classroom to clarify mathematical ideas when uncertain about the specifics of a concept. To help support gaps in teachers' pedagogical and mathematical knowledge, this preschool program's administrators could provide teachers with additional learning opportunities. This preschool program's administers could offer on-going professional development activities that include mentoring opportunities for teachers. Also, supporting teachers' pursuits of obtaining college degrees in early childhood, may further these teachers' knowledge of how to teach mathematics to young children.

One last explanation for the teachers' lack of alignment with curriculum practices provided by NAEYC and NCTM (2002) may relate to differences between this program's implicit and explicit curriculum. The written curriculum is one component that informs teachers' instructional practices. The unwritten curriculum also influences what a teacher decides to include in lesson plans. Perhaps, messages in the implicit curriculum contradicted aspects of the written curriculum. These conflicts in message may interfere with teachers' implementation of NAEYC and NCTM's (2002) recommendations.

Two aspects of the curriculum did not align with teaching practices. These examples might support differences in expectations between the implicit and explicit curriculum. First, the written curriculum provided teachers with several examples of developmentally appropriate assessments; however, observations of teachers and lesson plans indicated a focus on one assessment, the Learning Accomplishments Profile (LAP-3). Factors such as expectations of administrators or the amount of time needed to complete this assessment may stress to teachers the importance of this particular evaluation. Second, the written curriculum organized mathematical ideas by concepts. Weekly lesson plans, indicated that teachers presented several different math concepts during a week that often did not relate to each other conceptually. Requirements for lesson plans and the need to integrate mathematical ideas with thematic units may have influenced teachers' decisions to include a disconnected approach to mathematics instruction.

The observation protocol used in this study was the COEMET. When observing a specific math activity (SMA), the observer only completes part of this observation tool if “the activity called for no extensive discussion of concepts or strategies” (Sarama & Clements, 2007, COEMET SMA, p. 1). This section of the protocol was left out of the analysis because few of the SMAs required the completion of the full instrument. Many of the items addressed in this section related to the process skills addressed in Recommendation 4 (NAEYC & NCTM, 2002). This lack of data indicated that teachers did not provide many opportunities for children to engage in meaningful problem solving opportunities in which they had the opportunity to discuss possible solution strategies. Also, many of the math concepts children confronted during these observations did not require teachers to engage children in comprehensive discussions of these ideas.

There are several possible reasons for this situation. First, teachers indicated that as the school year progresses, more of the math content presented to the students is review from earlier in the year. Since these observations occurred during the last 2 months of the school year, many of the math activities may have been review items. Teachers may not have seen the need to engage children in long discussions about these ideas because they had been presented earlier in the year. Second, as mentioned earlier, the curriculum materials did not include a plethora of problem solving activities. In addition, these activities did not always include suggestions of how to develop mathematical conversations with children about their strategies or approaches to solving these situations. This lack of support from the curriculum may have hindered the teachers’ ability to provide these learning experiences for children. Lastly, teachers own experiences with problem solving may influence how they incorporate these ideas into their classroom. Teachers uncomfortable with solving problems or with their mathematical ability may struggle to engage children in discussion about the strategies they used or their reasoning for approach a problem in a certain way.

Significance of Study

The data collected in this study offer evidence of the extent to which this preschool program follows the recommendations by NAEYC and NCTM (2002). Overall, this preschool program provided children with many mathematical learning experiences. Considering that a review of the literature (See Chapter 2) did not reveal any similar studies that investigated a preschool program's use of these recommendations, this current research presents an example of how preschool teachers implement these ideas. This study helps to lay the foundation for future investigations of how preschool programs might follow these guidelines.

Limitations

There are several limitations to this study. First, this study only investigated one preschool program and therefore the conclusions presented in this dissertation can only help to inform instructional practices at this particular early childhood environment. Second, the time of year when the study took place may influence the teaching practices observed. All observations occurred during the last 2 months of the school year. If these observations had occurred throughout the school year, a more complete picture of the mathematical activities of these teachers could have been developed.

Third, the number of observations and the time of day when I observed the teachers may have influenced the results of this study. Including more than 6 observations could have provided a more extensive portrayal of the teaching practices of each of the participants in the program. In addition, all the observations occurred in the morning from approximately 8:30 to 11:30 because of the amount of time required by the COEMET protocol for each observation. Varying the times when I observed the teachers may have presented a more complete picture of their mathematics instructional practices throughout the day.

Fourth, by not conducting interviews with administrators of this preschool program, some aspects of this program were not uncovered. Including interviews with program leaders could help to answer the following questions:

- How do program leaders influence teachers' decisions about their mathematics instruction?
- How do administrators support the teachers' understanding of engaging children in mathematical thinking?
- What knowledge do program leaders have of the recommendations provided by NAEYC and NCTM?
- What types of professional development activities do administrators provide to develop teachers' knowledge of effective teaching strategies?

These interviews could provide a better understanding of how this program followed NAEYC and NCTM's (2002) recommendations.

Suggestions for Future Research

To gain a better understanding of the mathematical instruction in early childhood programs, more research needs to be conducted. Several suggestions for future studies are outlined in the following paragraphs. Follow-up studies of this program would allow for a greater understanding of the use of these recommendations. For example, research could focus on how teachers' use of these ideas influences children's mathematical understanding. Another study could investigate how a teacher's instructional practices, which align with these recommendations, influence a child's interest in mathematical activities. Finally, an in-depth case study analysis of one or two teachers could provide insight into how successful teachers implement the NAEYC and NCTM's suggestions for high-quality mathematical learning environments.

Increasing the number of participants and including multiple types of preschool programs will help to provide a better understanding of how preschool teachers implement the suggestions outlined in NAEYC and NCTM's (2002) position statement *Early Childhood Mathematics: Promoting Good Beginnings*. With more variation in the sample, researchers could investigate differences in the implementation of these ideas among the various programs. Furthermore, differences among various teacher characteristics such as level of education or teaching experience could be explored.

When observing the instructional practices of the teachers, I often considered ways to help these educators to improve their mathematics lessons. Another research area would be to investigate how staff development opportunities influence a teacher's use of these recommendations. This study could follow one of the models for professional development and coaching outlined in previous research (Hardin et al., 2010; Lieber et al., 2009; Onchwari & Keengwe, 2008; Thornton, Crim, & Hawkins, 2009; Rudd, Lambert, Satterwhite, & Smith, 2009). Research could focus on how these experiences help teachers to provide new learning opportunities for their students and examine any obstacles in implementation.

As a second grade teacher, I encountered 7- and 8-year-old children who had developed feelings of dislike towards mathematics or lack of confidence in their mathematical abilities. This situation frustrated me and caused me to question how children so young could have such negative feelings for mathematics already. What happened earlier in their academic career that influenced these opinions? In addition, I was concerned about how these feelings may influence their future success in mathematics. Longitudinal studies can provide information pertaining to the influence of early instructional practices with later outcomes. For instance, a study could identify students according to how their preschool experience aligned with the recommendations provided by NAEYC and NCTM (2002). These participants could be tracked into elementary school to determine whether differences in these early learning programs influenced long-term mathematical achievement and interest in mathematics.

Conclusion

Although the position statement *Early Childhood Mathematics: Promoting Good Beginnings* was published in 2002, evidence from this study seems to indicate that some early childhood educators are unaware of these recommendations. As indicated in interview data, none of the teachers were familiar with this document. Despite this unfamiliarity, many aspects of these suggestions appeared in the instructional practices of this program. This finding seems to indicate that several aspects of NAEYC and NCTM's (2002) recommendations align with preschool practices already in place. Teachers provided frequent mathematical learning experiences for children in a developmentally appropriate environment. In addition, assessment informed instructional practices. Nevertheless, key components of these recommendations were missing such as high-quality problem solving experiences, frequent opportunities for children to discuss mathematics in the world around them, and extended projects in which children had time to develop deep understandings of mathematical concepts. These missing elements and the teachers' lack of knowledge of this document raise the question whether the professional organizations NAEYC and NCTM (2002) are informing early childhood educators about these recommendations.

High-quality professional development experiences could provide teachers in this program the support they need to include more of the recommendations suggested by NAEYC and NCTM (2002). Research suggests that creating these high-quality learning environments provides children the experiences needed to be successful later in school (Lopez, Gallimore, Garnier, & Reese, 2007; Slaby, Loucks, & Stelwagon, 2005). These positive early learning experiences may also help to provide the necessary foundation for success in mathematics, which in turn will help create children with more positive mathematical views.

APPENDIX A

KEY QUOTATIONS FROM EARLY CHILDHOOD MATHEMATICS: PROMOTING GOOD BEGINNINGS (2002)

1. “**Enhance children's natural interest in mathematics and their disposition to use it to make sense of their physical and social worlds” (p 4).**

- *“play and daily activities, children often explore mathematical ideas and processes” (p. 4)*
- *“enhance children’s natural interest” (p. 4)*
- *“to develop confidence in their ability to understand and use mathematics” (p. 4)*
- *“curiosity, imagination, flexibility, inventiveness, and persistence” (p. 4)*

2. “Build on children's experience and knowledge, including their family, linguistic, cultural, and community backgrounds; their individual approaches to learning; and their informal knowledge” (p. 4).

- *“young children have varying cultural, linguistic, home, and community experiences on which to build mathematics learning” (p. 4)*
- *“Building on children’s individual strengths and learning styles” (p. 4)*
- *“new experiences that call on them to relate their knowledge to the vocabulary and conceptual frameworks of mathematics” (p. 4)*
- *“provide many such opportunities for children to represent, reinvent, quantify, abstract, generalize, and refine” (p. 5)*

3. “Base mathematics curriculum and teaching practices on knowledge of young children's cognitive, linguistic, physical, and social-emotional development” (p. 5)

- *“teachers need broad knowledge of children’s cognitive development-concept development, reasoning, and problem solving , for instance- as well as their acquisition of particular mathematical skills and concepts” (p. 5)*
- *“To determine which puzzles and manipulatives” (p. 5)*
- *“In deciding whether to let a 4-year-old struggle w/a particular mathematical problem or to offer a clue” (p. 5)*
- *“teacher’s understanding of young children’s emotional development and her sensitivity to the individual child’s frustration tolerance and persistence” (p. 5)*
- *“based generalizations about what many children in a given grade or age range do or understand are key in shaping curriculum and instruction although they are only a starting point…individual variation” (p. 5)*
- *“They tend to focus teachers’ attention on getting children to perform narrowly defined skills by specified time, rather than on laying the conceptual groundwork that will serve children well in the long run” (p. 5)*

4. “Use curriculum and teaching practices and reasoning processes as well as representing, communicating, and connecting mathematical ideas” (p. 5).

- *“Problem solving and reasoning are the heart of mathematics” (p. 5)*
- *“helping children connect mathematics to other subjects, such as science, develops knowledge of both subjects as well as knowledge of the wide applicability of mathematics” (p. 6)*

5. "Ensure that the curriculum is coherent and compatible with known relationships and sequences of important mathematical ideas" (p. 6).

- *"teacher also must stay focused on the 'big ideas'" (p. 6)*

6. "Provide for children's deep and sustained interaction with key mathematical ideas" (p. 6).

- *"early childhood educators need to plan for children's in-depth involvement w/mathematical ideas, including helping families extend and develop these ideas outside of school" (p. 7)*
- *"number and operations, geometry, and measurement as areas particularly important for 3-to6- year-olds…algebraic thinking and data analysis/probability receive somewhat less emphasis in the early years" (p. 7)*
- *"patterning merits special attention" (p. 7)*

7. "Integrate mathematics with other activities and other activities with mathematics" (p. 7).

- *"children's everyday activities and routines can be used to introduce and develop important mathematical ideas" (p. 7)*
- *"Also important is weaving into children's experience w/literature, language, science, social studies, art, movement, music, and all parts of the classroom environment" (p. 7)*
- *"Extended investigations offer children excellent opportunities to apply mathematics as well as to develop independence, persistence, and flexibility in making sense of real-life problems" (p. 7)*
- *"concepts should be developed in a coherent, planful manner" (p. 8)*

8. "Provide ample time, materials, and teacher support for children to engage in play, a context in which they explore and manipulate mathematical ideas with keen interest" (p. 8).

- *"significant benefits are more likely when teachers follow up by engaging children in reflecting on and representing the mathematical ideas that have emerged in their play. Teachers enhance children's mathematics learning when they ask questions that provoke clarifications, extensions, and development of new understanding" (p. 8)*
- *"Block building offers one example of play's value for mathematical learning" (p. 8)*
- *"sustained periods of time that allow children to learn mathematics through playful activities that encourage counting, measuring, constructing with blocks, playing board and card games and engaging in dramatic play, music, and art" (p. 8)*
- *"the teacher can observe play to learn more about children's development and interests and use this knowledge to inform curriculum and instruction" (p. 8)*

9. “Actively introduce mathematical concepts, methods, and language through a range of appropriate experiences and teaching strategies” (p. 9).

- *“carefully planned experiences that focus children’s attention on a particular idea or set of related ideas” (p. 9)*
- *“concepts can be introduced and explored in a large and small group activities and learning centers” (p. 9)*
- *“revisiting concepts that they have previously explored” (p. 9)*
- *“teachers introduce and modify games can promote important mathematical concepts and provide opportunities for children to practice skills” (p. 9)*
- *“Teachers need to intentionally select and use research-based computer tools that complement and expand what can be done with other media” (p. 9)*

10. “Support children's learning by thoughtfully and continually assessing all children's mathematical knowledge, skills, and strategies” (p. 9).

- *“Early childhood mathematics assessment is most useful when it aims to help young children by identifying their unique strengths and needs so as to inform teacher planning” (p. 9)*
- *“child observation, documentation of children’s talk, interviews, collections of children’s work over time, and the use of open-ended questions and appropriate performance assessments to illuminate children’s thinking are positive approaches to assessing mathematical strengths and needs” (p. 9)*
- *“Reliance on a single-group administered test to document 3-to6-year-old children’s mathematical competence is counter to expert recommendations on assessment of young children” (p. 10)*
- *“They recognize that even young children invent their own mathematical ideas and strategies and that children’s ideas can be quite different from those of adults” (p. 10)*

APPENDIX B

INTERVIEW QUESTIONS

Interview #1

1. How do you select what software/computer activities to include as part of your mathematics instruction? What are some of the programs you use? (Recommendation 9)

2. How do you incorporate mathematics into the children's daily routine? (Recommendation 7)

3. Describe how you integrate mathematics into other content areas such as language arts, science, social studies, art, music, and movement? (Recommendation 7)

4. How often do children have opportunities to work on in depth mathematical investigations? How long do these extended projects last? (Recommendation 7)

5. How do you incorporate children's daily mathematical experiences into your math lessons? (Recommendation 1)

6. Describe how you help children connect their mathematical experiences to the formal mathematical language. (Recommendation 2)

7. How do you help children build a strong conceptual understanding of various mathematical skills? (Recommendation 3)

8. How often do you include problem-solving activities into your mathematics lessons? (Recommendation 4)

9. What types of assessments do you use to determine your student's understanding of mathematical concepts? (Recommendation 10)

10. How do you use these assessments to help plan for mathematics instruction? (Recommendation 10)

Interview #2

1. What activities do you provide for children to help them explore their interest in mathematics? (Recommendation 1)

2. How do you incorporate students' different learning styles into your mathematics instruction? (Recommendation 2)

3. When planning mathematics lessons, how do you take into account for children's varied backgrounds (cultural, linguistic, home, community)? (Recommendation 2)

4. When planning math lessons, how do you take into account children's social, emotional, and motor development? (Recommendation 3)

5. When planning mathematical activities, how do you help children make connections among various math concepts?
   For example, children can connect number to geometry by counting the number of sides on a triangle. (Recommendation 4)

6. How often do you revisit concepts taught earlier in the year? (Recommendation 9)

7. Describe how you engage children in mathematical thinking when they play. (Recommendation 8)

8. How do your observations of children's play guide your curriculum planning? (Recommendation 8)

9. What types of math activities do you send home to support what you are doing in the classroom? How often do send home these activities? (Recommendation 6)

10. What types of family events do you provide at the school related to mathematics? How often do you have these opportunities? (Recommendation 6)

Interview #3

1. Describe your educational background.

2. How many years have you taught at this school? How many years have you taught preschool? How many years have you taught?

3. What are the three most important math concepts your students should understand by the end of the year to be successful in kindergarten? (Recommendation 5)

4. In an average month, about how many mathematical concepts do you introduce to your students? (Recommendation 9)

5. Are you a member of NAEYC? Are you a member of NCTM?

6. Have you read the position statement “Early Childhood Mathematics: Promoting Good Beginnings”?

7. Do you read Young Children, Teaching Young Children, or Teaching Children Mathematics?

8. After reading an article from one of these journals, do you try to incorporate these ideas into your mathematics instruction?

APPENDIX C

LIST OF CODES

Recommendation #1- Interest/Disposition
ID: Children's Natural Interest
ID: Connection to Real World

Recommendation #2- Individual Child
IC: Learning Styles
IC: Children's Background
- IC-CB: Culture
- IC-CB: Linguistic
- IC-CB: Religion

IC: Prior Knowledge
IC: Math Vocabulary

Recommendation #3- Development
DV: Cognitive
DV: Linguistic
DV: Motor
DV: Social/Emotional
DV: Conceptual Understanding

Recommendation #4- Problem Solving
PS: Meaningful
PS: Mathematical Connections

Recommendation #5- Big Ideas
BI: Major Concepts
BI: Coherent

Recommendation #6- Depth
DE: Family
DE: Number & Operations
- DE-NO: Adding
- DE-NO: Counting
- DE-NO: Estimation
- DE-NO: Fractions
- DE-NO: Subtraction

DE: Geometry
- DE-GE: Shapes
- DE-GE: Spatial Relationships

DE: Measurement
- DE-ME: Length
- DE-ME: Time
- DE-ME: Weight

DE: Algebra
    DE-AL: Patterns
    DE-AL: Sorting
DE: Data Analysis
DE: Depth of Mathematical Activities

Recommendation #7- Integration of Mathematics
IM: Routines
IM: Language
IM: Science
IM: Social Studies
IM: Art
IM: Movement
IM: Extended
IM: Music

Recommendation #8- Play and Mathematics
PM: Children's
PM: Blocks
PM: Teacher's Observations
PM: Teacher's Questions

Recommendation #9- Introduction of Math Concepts
IMC: Planned
IMC: Small Group
IMC: Revisit Concepts
IMC: Games
IMC: Computers
    IMC-CO: Limitations
    IMC-CO: Software

Recommendation #10- Assessment
AS: Mathematics Planning
AS: Types
    AS-TY: Anecdotal notes
    AS-TY: Checklist
    AS-TY: DIAL-3
    AS-TY: Informal
    AS-TY: LAP-3
    AS-TY: Observations
    AS-TY: Portfolios
    AS-TY: Progress report
AS: Children's Perspective

APPENDIX D

VISUAL REPRESENTATION OF RECOMMENDATIONS

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