Understanding Children's Mathematical Learning:
the Relationship to Instruction in Preschool Classrooms

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UNDERSTANDING CHILDREN'S MATHEMATICAL LEARNING:
THE RELATIONSHIP TO INSTRUCTION IN PRESCHOOL CLASSROOMS

BY

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APPROVAL FOR SUCCESSFUL DEFENSE

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ABSTRACT

The purpose of the current study is to investigate the influence of implementing a performance-based assessment in mathematics on instruction in preschool classrooms. The Early Learning Assessment System – Mathematics (Whelan, Frede, & Boyd, 2006) was implemented in three districts with randomly selected teachers serving 4-year old children from lower socioeconomic backgrounds. A total of 21 teachers participated in the experimental group and 20 teachers in the control group. The teachers' instructional skills in both groups were measured in the fall and spring with the Preschool Classroom Mathematics Inventory (Frede, Weber, Hornbeck, Worth, & Boyd, 2005) to investigate if changes in teaching practices were related to the use of the performance-based assessment.

Teachers' understanding of children's mathematics development through the use of performance-based assessment was proposed to improve instruction in the content area. Improved instruction for young children in New Jersey's poorest districts can possibly increase children's learning, thus providing a stronger foundation for children to succeed in mathematics throughout their schooling careers. The past and present achievement gap in mathematics in the nation has been evident. The problem may lie in teachers' understanding of how children develop and learn in the domain. The performance-based assessment in this study provided teachers with a guide to understand children's mathematical development. By understanding how each child learns, teachers were empowered to make instructional decisions to increase learning.

A mixed methodology design was used to investigate teachers' instructional skills in relation to the use of the performance-based assessment. The quantitative elements
included independent \( t \)-tests, paired sample \( t \)-tests, and an analysis of descriptive statistics in relation to the scores on the PCMI. The qualitative research included the ELAS-M teachers’ responses to feelings about teaching mathematics.

The analyses of the findings showed a correlation between using performance-based assessment and the improvement in instructional skills in mathematics. The data imply that early childhood classrooms implementing a performance-based assessment in mathematics can improve the quality of instruction.
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I am grateful to the educators who participated in this study. The district supervisors, master teachers, and teachers provided commitment and valuable time to understand early childhood mathematics in relation to the implementation of a performance-based assessment in mathematics. Their dedication to this study represented interest in improving supports for children’s math learning and development. I also want to thank my advisor, Dr. Walker, for all her support and interest in this study as well as Dr. Gutmore’s advisement.

The two Ellens in my life are not only my readers in this study but true friends, educators, mentors, and leaders in the field of early childhood education. Dr. Wolock’s commitment to our youngest learners in the state is admirable and contagious. Our long discussions have provided me with a researcher’s perspective on early childhood education. Dr. Frede, a researcher who has an amazing ability to teach and guide while critically examining the work that I conducted, will always be someone I strive to emulate.

Most importantly, my family was always there for me. My mother and father woke every morning to provide me with love and support as well as that freshly brewed cup of coffee. My husband, Steve, has never doubted my ability and knowledge in the early childhood education field and encouraged me throughout my career to never lose sight of what I am passionate about... children. Thank you.
DEDICATION

This dissertation is dedicated to my husband, mother, and father. Thank you for your love, support, laughter, and patience. You are an integral part of my cherished memories during the obtainment of my doctoral degree. I love you.
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Chapter 1: Statement of the Problem

Introduction

The major goal of a preschool program is to prepare children to succeed in school and ultimately in life. Research has shown that this goal can be achieved only if the preschool program is of high quality (Barnett & Boocock, 1998). A high-quality program includes teachers who understand children’s development in all domains and therefore are able to provide children with meaningful experiences on which to build. Teachers’ support of children’s mathematical learning through performance-based assessment is a critical component of understanding and teaching the whole child (Clements, 2004).

The lower mathematics achievement shown by American students compared to other nations’ students has led to greater attention to building mathematical skills early in education (Clements & Sarama, 2004). The achievement gap in mathematics between poor and middle-income children is prevalent within the United States in early childhood as well as in upper grades (Klein & Starkey, 2004). Research has demonstrated that children from low-income families have lower test scores (Barnett, Tarr, & Frede, 1999) and are at increased risk of learning difficulties, particularly in mathematics (Bowman, Donovan, & Burns, 2001). These children need high-quality early childhood mathematical experiences for future success in the area (Clements & Sarama, 2004).

Research indicates that higher-quality programs facilitate children’s learning in mathematics (Clements & Sarama, 2004). Early interventions in mathematics, such as a preschool program integrating developmentally appropriate mathematics practices differentiated to the learner, can combat later learning difficulties in the domain (Fuson, Smith, & LoCicero, 1997). Because of this connection, attention has been paid to
preschool teachers' understanding of what is developmentally appropriate in mathematics for each child. Early childhood educators' increased understanding of and support in mathematical development and learning in the preschool years can provide all children with the confidence and proficiency to tackle mathematical problems throughout their schooling and in life-long events (NAEYC & NCTM, 2003).

Effective instructional skills in preschool programs depend on teachers' knowledge of early childhood development and learning, and their ability to understand and support each child's individual growth. Standardized measures do not provide authentic or comprehensive information about each child's learning needs (Meisels, 1999). In a time when public school administration is consumed with the results of standardized testing because of political pressures, performance-based assessment at the early childhood level must be the evaluation tool used to make instructional decisions (Madeja, 2004). Performance-based assessment provides teachers with a guide to learn about children's abilities through ongoing observations, documentation, and evaluations of their work (Bowman et al., 2001). Smith and Levin (1996) state that a performance-based assessment system provides teachers with information to improve their instruction. In response to the testing craze, administrators of early childhood classrooms have the responsibility of making appropriate assessment decisions, based on the best interests of the children. Performance-based assessment is appropriate at the early childhood level and can enhance children's learning by improving the quality of instruction (Bowman et al., 2001).

The purpose of this study is to determine the extent to which New Jersey Abbott preschool teachers' use of performance-based assessment in mathematics is related to
instructional effectiveness. The data from this study are based on a pilot project conducted by the College of New Jersey and the National Institute of Early Education Research (NIEER) in conjunction with the New Jersey Department of Education, Division of Early Childhood Education (DECE), in which teachers of 4-year-old children in three Abbott districts were randomly assigned a performance-based assessment, the New Jersey Early Learning Assessment System – Mathematics (ELAS-M). The districts' early childhood supervisors supported the teachers' participation in the study, and the master teachers were trained and implemented a technique called reflective practice with each teacher to support the implementation of the ELAS-M.

By improving instructional practices in mathematics, the quality of the preschool program improves, resulting in possible positive outcomes for children, especially those coming from lower socioeconomic backgrounds (Clements, 2004). Performance-based assessment provides teachers with developmental strands to assist in differentiated instruction and supportive learning. The ultimate goal of a high-quality mathematics program for all children is the interdependence of teaching and learning, in which when one develops, it influences the other (Simon, 1997).

**Background of the Study**

The New Jersey Supreme Court mandated in 1998 that all eligible children residing in New Jersey’s Abbott school districts have access to a high-quality preschool education in N.J.A.C. 6A:10A-2.1. This mandate was derived from the *Abbott v. Burke* court decision, 119 N.J. 287 (1990, *Abbott II*) and N.J.A.C. 6A:10A-1.2, which determined that all children in poor urban school districts should receive the educational entitlements affirmed by the New Jersey Constitution. The *Abbott v. Burke* court decision
then set out standards in 2000 for the implementation of high-quality preschool programs in New Jersey Abbott districts. Regulations were adopted to ensure that the children in the Abbott districts receive an education comparable to that of children in suburban and affluent districts.

The vision of early childhood education in the Abbott districts is to provide children with the knowledge and skills necessary to meet the NJ Preschool Teaching and Learning Expectations: Standards of Quality and the Core Curriculum Content Standards (New Jersey Abbott Preschool Program Implementation Guidelines, 2006). Several components to improve quality in Abbott early childhood programs that are addressed in the New Jersey Preschool Abbott Implementation Guidelines (2006) include increasing family involvement, implementing a developmentally appropriate curriculum, including children with disabilities in the general education classrooms, supporting teachers through professional development opportunities with support from master teachers, and using performance-based assessment.

The Early Learning Assessment System – Mathematics (ELAS-M), a performance-based assessment, was developed by the New Jersey Department of Education in collaboration with the College of New Jersey and National Institute of Early Education Research (Whelan, Frede, & Boyd, 2006). The assessment system stemmed from the development of the Early Learning Assessment System – Literacy (ELAS-L), which has been implemented in New Jersey Abbott districts since 2002. Both the ELAS-M and ELAS-L were created to provide a performance-based system derived from state learning standards that ties directly to the NJ Preschool Teaching and Learning

Preschool teachers use the ELAS-M (Whelan et al., 2006) as a guide to obtain an understanding of how to support children’s mathematical development. The instrument has anchors for levels of performance on a developmental continuum, called Age-by-Age Accomplished, and is based on the New Jersey Preschool Teaching and Learning Expectations: Standard of Quality – Mathematics (2004). The performance-based assessment offers an in-depth view of children’s learning in mathematics to inform instruction.

The Early Learning Improvement Consortium (ELIC), made up of a group of New Jersey universities, has annually evaluated Abbott preschool classroom quality. For the past 5 years, the ELIC has evaluated approximately 11% to 13% of the Abbott preschool classrooms using the Preschool Classroom Mathematics Inventory (PCMI) (Frede, Weber, Hornbeck, Worth, & Boyd, 2005). The PCMI measures the extent to which teachers support children’s learning in mathematics and corresponds to the New Jersey Preschool Teaching and Learning Expectations: Standards of Quality – Mathematics. The PCMI has two subscales that measure math-related materials in the classroom environment and teachers’ encouragement of children’s mathematical learning of various mathematics concepts. The inventory is based on a Likert scale with 1 defined as minimal evidence of math-related materials and support and 5 as strong evidence. The Abbott districts’ average scores on the PCMI for each year have been hovering in the 2 range, indicating that there is only slightly higher than minimal evidence of mathematics occurring in these preschool classrooms. Therefore, Abbott preschool programs in New
Jersey have focused on children’s mathematical learning through informed instruction by using a performance-based assessment.

*Purpose of the Study*

This study examines Abbott preschool teachers’ use of a performance-based assessment in mathematics, the ELAS-M, and the impact of this use on preschool teachers’ instructional skills measured by the PCMI. “Portfolio and other performance assessments can be only one part of the future agenda to transform teaching. But they are the heart of a vision of teacher education for a profession” (Lyons, 1998, p. 20). The ELAS-M offers teachers a reflective tool to inform their mathematics instruction and to grow professionally within the mathematics field.

The ELAS-M provides teachers with a comprehensive guide to understanding children’s growth in mathematics, such as in number, numerical operations, spatial relations, geometry, measurement, classification, and patterning. This system entails collecting documentation of children’s mathematical learning in the form of observation notes and work samples, reflecting on the documentation and one’s instruction, and planning methods for continuously supporting each child’s mathematics learning using the Age-by-Age Accomplishments, a developmental continuum in mathematics, the crux of the ELAS-M. Critical questions that preschool teachers are asked to think about when using the ELAS-M are as follows: “What do I know about each child in mathematics? What are my next steps as a teacher to support each child’s development in mathematics?”

*Research Questions*

*Primary Question*
How has instruction in mathematics changed for preschool teachers who implemented the ELAS-M system compared to those who did not implement the performance-based assessment system?

Subsidiary Questions

Question 1. How have math-related materials in the classroom environment changed after preschool teachers implemented the ELAS-M compared to the materials of teachers who did not implement a performance-based assessment in mathematics?

Question 2. How has teachers' support of mathematical concepts changed after they implemented the ELAS-M compared to support of mathematical concepts by teachers who did not implement a performance-based assessment in mathematics?

Question 3. How is overall training in early childhood mathematics associated with mathematics instruction?

Question 4. What are preschool teachers' feelings about teaching mathematics after having the experience of implementing the ELAS-M?

Propositions

Proposition 1

Teachers' instructional skills in mathematics will improve when they implement the ELAS-M, a performance-based assessment.

Proposition 2

Teachers who implement a performance-based assessment, the ELAS-M, will have significantly better instructional skills in mathematics compared to teachers who do not implement a performance-based assessment in mathematics.
Significance of the Study


The ELAS-M provides preschool teachers with strands of children’s development in various mathematical concepts to guide instructional practices based on mathematical development. Understanding what each child knows in mathematics and how to build upon that knowledge in a meaningful manner is a primary component of high-quality instruction. While high-quality instruction is important for all children, it is imperative for our poor children in order to reduce the achievement gap. Providing preschool children in Abbott districts with high-quality instruction can close early achievement gaps and produce life-long benefits (Barnett, 1995; Clements & Sarama, 2004; Schweinhart, Barnes, & Weikart, 1993; Schweinhart, Weikart, & Lerner, 1986). The Perry Preschool Study (Schweinhart et al., 1986) found that a high-quality preschool program can close early achievement gaps for lower-income children as well as reduce retention, increase graduation rates, and reduce crime. In this study, using the ELAS-M
offers teachers a tool to guide instruction and support preschool children's mathematical learning in the Abbott districts.

Teachers can identify their own strengths and weaknesses through reflection by using performance-based assessment. The ELAS-M provides an opportunity for teachers to reflect upon their practices and make necessary adjustments to support each child's mathematical learning. Through the use of performance assessments, teachers have asked themselves, "What do I want the kids to get out of this? Why am I doing this?" (Lyons, 1998, p. 248). The ELAS-M promotes the same reflective questions. Teachers are encouraged to understand where each of their children is developmentally in mathematics and what to do next instructionally to support each child's learning in mathematics. "Assessment serves to guide instruction and learning" (Clements, 2004, p. 61).

Limitations

The major limitation was that the study was conducted in three Abbott districts with a total sample size of 41 teachers for only 1 year. Effective implementation of a new performance-based assessment system usually requires a considerable amount of time to understand how to organize one's information on students' learning and plan for instruction. Using the system seamlessly can take several years depending on the teachers' level of understanding regarding performance-based assessment. The outcomes may be influenced by the lack of time implementing the system and the limited power to assess effects given the small sample size.

In addition, the study was not designed to track the amount of time teachers individually reflected upon their anecdotes on children's mathematical learning. Master teachers were required to meet with each teacher on a monthly basis to discuss children's
mathematics learning in relation to the ELAS-M; however, the depth of discussion during the master teachers' reflective cycle with teachers varied based on the teachers' and master teachers' knowledge base. The reflective cycle sessions may have also affected the effect of the ELAS-M on teachers' instructional skills in mathematics; however, the logs were not extensively analyzed in this study. In addition, the impact of the amount of time their administrators dedicated to discussing early childhood mathematics with teachers outside the instructional day was not explored; however, the participants were asked before the study to limit their mathematics professional development to that provided by their ELAS-M participation.

Although teachers reported general background training, the quality and depth of early childhood mathematics coursework or training the teachers previously received were not collected as part of this study. Therefore, teachers may have had various levels of understanding regarding children's development in mathematics and how to support children's learning in mathematics before or during their teaching experiences. Their depth of understanding early childhood mathematics is another variable that may contribute to the quality of teachers' instructional skills in this domain.

Definitions of Terms

For the purpose of the study, the major terms are defined as follows:

Abbott Preschool Program

The New Jersey Supreme Court mandated in Abbott v that all children residing in New Jersey's Abbott school districts be given the opportunity for a high-quality preschool education beginning at age 3. The purpose is to prepare these children to enter
kindergarten with skills and abilities more comparable to those of their wealthier suburban peers and thus to prepare them for educational success N.J.A.C. 6A:10A-2.1.

Abbott School District

There are 31 Abbott school districts in New Jersey, which were determined because of the Abbott v. Burke decisions and are promulgated pursuant to P.L. 2006 c. 45 to ensure that all students in poor urban school districts receive the educational entitlements guaranteed to them by the New Jersey Constitution. Regulations were developed to ensure that the instructional needs of students are continuously assessed and that all school districts operate in a cost-effective and efficient manner pursuant to N.J.A.C. 6A:10A-1.1.

Division of Early Childhood Education (DECE) – Office of Preschool Education (New Jersey Department of Education)

This is the New Jersey state office responsible for state-funded preschool programs.

Early Learning Assessment System – Mathematics (ELAS-M)

The ELAS-M is a performance-based system in mathematics derived from the New Jersey Preschool Teaching and Learning Expectations: Standards of Quality – Mathematics. Teachers observe and collect anecdotes on children’s abilities in mathematics to evaluate performance and support further learning.

Early Learning Improvement Consortium (ELIC)

In 2002, the Office of Early Childhood Education, New Jersey Department of Education, brought together a group of the state’s top early childhood education faculty from New Jersey institutions of higher education to form the Early Learning
Improvement Consortium (ELIC) to measure and assess progress in Abbott preschool programs. The ELIC is responsible for collecting and reporting on data annually concerning classroom support in various areas.

**Master Teacher**

Master teachers are funded in New Jersey’s Abbott districts’ early childhood programs to support and maintain high levels of preschool program quality by helping preschool teachers improve instructional effectiveness. The master teachers’ primary role is to visit classrooms and act as coaches using reflective practice (New Jersey Abbott Preschool Program Implementation Guidelines, 2006).

**New Jersey Abbott Preschool Program Implementation Guidelines**

This document provides guidance for early childhood Abbott preschool programs to support the order imposed by the New Jersey Supreme Court. These guidelines help Abbott school districts plan and implement high-quality preschool programs for 3- and 4-year-old children.

**Performance-based Assessment**

This “is best understood in the context of learning about children’s knowledge, skills, and accomplishments through observing, recording, and evaluating their performance or work” (Bowman et al., 2001, p. 247).

**Preschool Teaching and Learning Expectations: Standards of Quality**

This department publication, also called simply “Expectations,” notes expectations for preschool children’s learning outcomes and expectations for high-quality preschool teaching and programming 6A:10A-1.2.

**Reflective Cycle**
This is a peer coaching model, used by master teachers and teachers, similar to Costa and Garmston's (1994) cognitive coaching model, that encourages a collaborative establishment of strategies for improvement by reflecting on teachers' thinking about their practices and their influence on students' learning.

Reliable Independent Observer

This is an individual trained in the use of the program quality instrument identified by the department as the standard for independent observation of preschool classrooms 6A:10A-1.2.

Structured Observation Tools

Used in the New Jersey Department of Education, Division of Early Childhood Education, Office of Preschool Education, and administered by the ELIC to measure preschool program quality, these tools include the Early Childhood Environmental Rating Scale-Revised –ECERS-R (Harms, Clifford, & Cryer, 2005), Supports for Early Literacy Assessment –SELA (Smith, Davidson, Weisenfeld, & Katsaros, 2001), and the Preschool Classroom Mathematics Inventory–PCMI (Frede et al., 2005).
Chapter 2: Review of Literature

Introduction

As early as the preschool years, children from lower socioeconomic backgrounds tend to perform less well in mathematics compared to their middle-class counterparts (Klein & Starkey, 2004). Teachers’ understanding of early childhood mathematics is crucial in supporting all children’s development and learning in this domain, especially for our youngest learners. Performance-based assessment provides teachers with a framework to understand how children develop mathematically and how to adjust their instruction based on where each child is on the developmental continuum. As Clements (2004) stated, “The primary goal of assessing young children should be to understand children’s thinking and to inform ongoing teaching efforts” (p. 63). This continuous adjustment of practices, based on each child’s needs, can improve outcomes both short- and long-term for children coming from impoverished families (Bowman et al., 2001). The support of each child’s learning through effective instruction is a critical component in high-quality preschool programs (Klein & Starkey, 2004). High-quality programs are especially important for children coming from lower socioeconomic households (Bowman et al., 2001).

There is clear evidence indicating the presence of a socioeconomic gap in mathematics achievement as early as the preschool years. This study focuses on the use of a performance-based assessment in preschool classrooms to improve instruction and support of children’s learning in the Abbott school districts, some of the most impoverished communities in New Jersey. In an attempt to address this potential achievement gap, teachers concentrated on children’s mathematical learning while using
the assessment to guide their instructional decisions. The teachers provided children with mathematical experiences based on their level of development. Children were provided with math-enriched experiences in relation to the ELAS-M to determine if instruction would improve.

Mathematics development in the preschool years is also discussed in this study. Using a performance-based assessment allows understanding of children’s mathematical development in relation to benchmarks. Teachers’ support of children’s learning in mathematics is a component of providing children with high-quality mathematical experiences. The importance of providing those math-related experiences is explored further in this chapter as well as how performance-based assessment may impact instruction.

The literature review concludes with research regarding teachers’ feelings about teaching mathematics and how professional development can affect those feelings. Differentiated professional development, such as cognitive coaching, is discussed to determine if feelings can change instruction positively. If feelings about teaching mathematics are positive because of a better understanding of mathematics learning and development, instruction may improve for all young learners to encounter meaningful mathematical experiences.

*Mathematics Learning and Socioeconomic Status*

Mathematics achievement in the United States varies based on children’s socioeconomic status. The socioeconomic achievement gap in mathematics has been found in early childhood classrooms as well as other grades (Clements & Sarama, 2004; Franco, Sztajn & Ortigão, 2007; Ginsberg & Goldbeck, 2004). Many children from lower
socioeconomic backgrounds appear to experience difficulties in mathematics in school yet opportunities to narrow the gap are evident (Clements, 2001). Clements (2001) explained that the socioeconomic status differences as early as the preschool years are either widened or narrowed based on instructional practices in school.

According to Ginsburg and Russell (1981), children from low socioeconomic households have an understanding and use strategies to solve mathematical problems similar to those of their middle-class counterparts. When observed before preschool to the preschool-age level, children have an informal or predisposed developmental basis from which they explore and solve mathematical problems despite their differences in backgrounds. The authors asserted that lower-income children’s school failure in mathematics cannot be explained entirely by a predisposed lack of cognitive skills. Findings mentioned that both low- and middle-income children in the early childhood years used an “area strategy” to determine more and less in groups of items by visually scanning the groups to determine general quantity. In addition, the children performed well on simple numerical operations tasks, were able to recite counting words, and similarly used written symbols. The two large income-level differences pertained to equivalence and conservation (Ginsburg & Russell, 1981). Children from lower socioeconomic backgrounds were less likely to recognize or create equivalent quantities or be able to solve conservation tasks. Conservation is defined by the ability to grasp that items or the number of items can remain the same despite alterations in their appearance or when repositioned (Piaget, 1959).

However, previous research found that even though the children from the two socioeconomic status groups were similar mathematically, low-income children were
delayed significantly in their understanding of numbers when they reached preschool-age (Ginsberg & Russell, 1981; Griffin, Case, & Siegler, 1996). Preschool children (3 to 4 year olds) from middle-income families performed as well as kindergarten-age children (5 to 6 year olds) from low-income families in a number knowledge test (Ginsberg & Russell, 1981). Tests of conceptual number knowledge were conducted in which children’s understanding of counting, understanding of one-to-one correspondence, cardinal values (the number of objects is represented in the written or stated number), and more or less concepts were examined. Children from low-income families had less familiarity with these concepts; therefore, their mathematical development was behind in relation to their middle-income counterparts. Experiences before school provide the foundation for learning. The mathematics delay of lower-socioeconomic-income children can significantly push them back in school, especially if expectations are not met at a particular grade level (Arnold & Doctoroff, 2003; Bowman et. al, 2001). Therefore, the importance of providing quality preschool experiences in mathematics to poor children is crucial in reducing the existing achievement gap (Ginsberg, Lee, & Boyd, 2008).

Other studies have indicated that the understanding of numerical concepts is developed more in middle-income children than in their lower socioeconomic status peers (Klein & Starkey, 2004). Starkey and Klein (2000) found through their research the same lower level of numerical cognition among poor preschool children in a Head Start study.

In two related studies, the researchers investigated whether low-income parents could contribute to children’s readiness in mathematics when provided with training and home-based math activity kits. The children in both experimental and control groups
were from low-income African American and Latino families living in San Francisco. The parents and children in the treatment groups participated in a mathematics course, which met every other week and lasted for 4 months. There were eight classes in total. These parents also were able to access materials through a math library at home to support their children’s learning. The control group received no intervention. The initial study consisted of 28 mother-and-child pairs, mostly African American, and the secondary study consisted of 31 mother-and-child pairs, mostly Latino, who were randomly selected to participate in either the control or experimental group to determine if the intervention had an impact on students’ math learning.

The experimental and control group families were assessed for counting skills, numerical reasoning, and spatial references in the fall and spring. Initially no difference existed in children’s mathematical knowledge. However, at the end of the program, the children in the experimental group, who received the intervention, demonstrated extensive mathematical learning compared to the control group.

The children whose parents participated in the course performed better on posttests that assessed enumeration, numerical reasoning, and spatial processing than children whose parents did not take the math course. Children in the experimental group also demonstrated increased mathematical abilities from the pretest to the posttest. The findings of this study indicated that improved instruction by parents can increase children’s learning in mathematics. The children in the intervention group gained more mathematical knowledge than a comparable low-income group of preschool children (Starkey & Klein, 2000).
Children enter school with a predisposed knowledge base in mathematics, otherwise known as informal mathematical knowledge, which is established from home and life experiences. Informal mathematical knowledge depends on the mathematical experiences in which these children were given early in life. These experiences can be enriched during the child’s upbringing and schooling. Each child may have a different way of counting, adding, etc., which should be appreciated and supported by teachers, especially during the preschool years. In Starkey and Klein’s study (2000), there were recognizable differences between the lower- and middle-income children’s informal mathematical knowledge in numerical concepts upon school entry. Since there are differences in school achievement, interactions in school play a crucial role in providing mathematical experiences to support each child’s math learning by understanding each child’s informal mathematical base. These differences in mathematical knowledge between socioeconomic groups can be lessened depending on the mathematical experiences provided through effective instruction in school (Klein & Starkey, 2004).

The Berkeley Math Readiness Project, conducted by Klein and Starkey, studied preschool children’s mathematical development based on their socioeconomic status to further determine the influence of effective instructional practices on children’s predisposed delays in mathematics (Clements & Sarama, 2004). A math curricular intervention was implemented in classrooms with middle- and low-income children to determine the outcomes of both groups of children and the gap between them. Because the socioeconomic gap has been noted in the early grades, this study presented relevant findings.
This project studied preschool children's math achievement before and after they participated in a mathematics curriculum. The math curriculum was designed to enrich children's informal mathematical knowledge in spatial-geometry and numeracy. The curriculum was based on the National Council of Teachers of Mathematics' (NCTM) new Principles and Standards for School Mathematics as well as research on mathematical development in children. Teachers and parents were given guided activities along with concrete materials to use with their children. The curriculum provided individualized methods of support depending on the children’s level of development. Ten preschool classrooms were involved. Five classrooms were in the control or nonintervention group, and 5 had the curricular intervention. In both treatment groups, children came from low- and middle-income families. The children in the intervention group and the control group were tested in the fall and spring using the Child Math Assessment (CMA).

There was a clear gap in scores between the two socioeconomic groups before the intervention. The middle-income children answered approximately one-half of the CMA questions correctly whereas the low-income children answered only a third of the questions correctly. After receiving the curriculum intervention, the low-income children demonstrated a significant increase in pre- to post-CMA scores in relation to their middle-class counterparts. While both groups exhibited an increase in scores, the lower-income children developed mathematical knowledge more quickly during the implementation of the math curriculum. The findings indicated that the low-income children's scores on the CMA increased 29% from the fall to spring whereas the middle-income children's scores rose 21%.
Both the low- and middle-income children’s mathematics development was influenced by the curricular intervention when compared to children who did not have the intervention. The gap between the low- and middle-income students was significant in the fall; however, with the curriculum intervention, the low-income children progressed more mathematically when compared to their counterparts. Therefore, after 1 year of preschool, the mathematical learning gap between children of different socioeconomic backgrounds was reduced significantly. Klein and Starkey stated, “Cross socioeconomic status differences in young children’s mathematical thinking develop during the preschool years, and then these differences are either increased or reduced by instructional practices in school” (as cited in Clements & Sarama, 2004, p. 344).

*Early Childhood Mathematics Development*

Young children’s mathematics development in preschool programs has gained national attention recently. In 2000, preschool standards were included in the NCTM standards. Since approximately one million children in the United States attend state-funded preschool programs (Barnett, Hustedt, Hawkinson, & Robin, 2006), educators stress the importance of understanding children’s development, especially in mathematics, in the early years of schooling (Ginsberg, Lee, & Boyd, 2008).

Supporting children’s mathematical development in the preschool years is an integral part of producing confident, critically thinking children prepared for later success in mathematics (Duncan et al., 2007; Gormley, 2007). Research shows that children’s learning in the first 6 years of life has implications for lasting outcomes (Bowman et al., 2001). As early as infancy, children notice changes in number, which indicates a certain predisposition to learning simple mathematics (Gelman & Gallistel, 1978; National
Research Council, 1999). Young children use informal mathematics in their everyday lives in a sophisticated manner before they even enter school (Clements, 2001). Preschool children can functionally count, create patterns, identify shapes in the environment, sort objects as well as other mathematical tasks if they are provided with experiences and their learning is supported early on in life (Piaget, 1959).

Play is the primary means of learning and developing mathematic understanding for young children (Elkind, 2007; Seo & Ginsburg, 2004). High-quality mathematical experiences for young children involve learning through play (Ginsburg, 2006). Providing children access to a variety of unit blocks, asking open-ended purposeful math-related questions, and posing mathematical problems that children must solve are part of the supports children need to enhance mathematical development (Clements, 2001).

Exposing children to mathematics throughout the day in a meaningful manner builds children’s confidence to succeed (NAEYC & NCTM, 2002). Preschool teachers should encourage children’s mathematical learning based on established interests and assist in the development of positive attitudes in solving math-related problems (Resnick, 1992). Positive attitudes and learning established early on in children’s education may significantly influence future learning in school (Bowman et al, 2001; Duncan et al., 2007).

Preschool children’s expected learning outcomes in mathematics are provided nationally and at the state level. These standards or expectations during the preschool years provide educators with a guide to inform instruction based on developmental milestones or expected learning. The New Jersey’s Preschool Teaching and Learning Expectations: Standards of Quality (2004) state that children are expected to demonstrate
an understanding of developmentally appropriate number and numerical operations; develop knowledge of spatial concepts; understand patterns, relationships, and classification; develop knowledge of sequence and temporal awareness; and use mathematical knowledge to represent, communicate, and solve problems in their environment. The document stresses preschool children's variability in development and meeting their needs based on differentiated support. For the purposes of this study, children's development in the first three New Jersey Expectations in Mathematics (number and numerical operations; spatial concepts, measurement, and geometry; patterns, relationships, and classification) is emphasized with the assumption that the last expectation, "Using mathematical knowledge to represent, communicate and solve problems in their environment," is embedded throughout the other expectations.

Preschool children's development in number and numerical operations include concepts such as one-to-one correspondence, functional counting, reciting counting words, simple adding and subtracting, comparing amounts in groups, and reading and writing numbers (Baroody, 2002). Variability in development in functional counting is common in preschool children. For instance, a 4-year-old child may be able to assign a number to only three of his five blocks whereas another 4-year-old may be able to assign a number to seven of her blocks as well as communicate that there are seven blocks in total.

Preschool children's development in spatial concepts includes the following concepts: geometry/shapes, measurement, positional words, and spatial relations. Children at the preschool level may be starting to recognize familiar shapes whereas other children may be recognizing most shapes in their environment (Clements, 2001).
Again, variability in development is expected, and a developmental continuum for this concept provides teachers with a guide on how to support the learning for particular expectations.

Patterns and classification are covered in New Jersey’s third mathematics expectation. Children’s development in patterning begins with noticing and imitating patterns and then develops into reproducing and discussing patterns. Classification begins with children identifying similar attributes in objects, separating identical objects into groups to then hierarchically classify and sort objects into groups and subgroups based on nested attributes and being able to discuss the rationale with others (Clements & Sarama, 2004).

The National Council of Teachers of Mathematics and National Association for the Education of Young Children (NAEYC) developed a position statement in 2003 for all preschool children, which included research-based recommendations for high-quality mathematics education at the preschool level. The most relevant recommendation for the purposes of this study is the 10th recommendation, which states, “In high-quality mathematics education for 3- to 6-year-old children, teachers and other key professionals should support children’s learning by thoughtfully and continually assessing all children’s mathematical knowledge, skills, and strategies.”

*Performance-based Assessment*

The key to effective instruction is appropriate assessment of what children know and can do (NAEYC & NAECS, 1991). As stated in the NCTM and NAEYC position statement (2003), teachers who understand each child’s mathematics development and learning inform their practices through developmentally appropriate assessment.
Performance-based assessment is developmentally appropriate at the preschool level and is defined as when the teacher regularly observes over time, collects samples of children’s work, and uses meaningful questioning and interactive techniques to understand children’s thinking (Jablon, Dombro, & Dichtelmiller, 1999). Effective teachers use the evidence collected to plan and adjust their teaching practices to best support each child’s learning (Messick, 1992).

Dependence on a single group-administered test to document 3- to 6-year-old children’s mathematical skills is counter to expert recommendations on early childhood assessment (NAEYC & NAECS, 1991). National organizations and early childhood experts discourage standardized testing for formative assessment because the 1-time measure may not reflect the variable nature of children’s development of skills, which emerge over time and in natural settings (Meisels, 1999; National Goals Education Panel, 1998). “Multiple-choice tests fail to measure complex cognitive and performance abilities” (Darling-Hammond & Ancess, 1996, p. 52). Standardized tests measure only children’s mathematical thinking in a 1-time fashion with influences from the assessor and the environment; therefore, the test may not genuinely represent the child’s ability. Performance-based assessment is known as an authentic assessment since it involves systematic observation and interaction with children in their natural environments to determine their development (Jablon et al., 1999).

Preschool children’s development in mathematics varies. Preschool teachers must understand how children learn mathematics at this age in order to support and scaffold their learning (Vygotsky, 1986). High-quality mathematics is not elementary arithmetic pushed down to the preschool level (Clements, 2001; NAEYC & NCTM, 2002).
Performance-based assessment provides teachers with continuums of children’s development and learning in various domains and provides them with a guide to understand mathematics development and learning to differentiate instruction. When a performance-based assessment is implemented well, teachers act as researchers in their classrooms, examining each child’s growth on a continual basis.

With performance-based assessment, teachers study each child by observing on a daily basis, studying work samples, and interacting to discover the child’s abilities and knowledge base (McAfee & Leong, 2001). Authentic performance-based assessment looks at each child over a period of time in the everyday, natural setting before reaching conclusions about the child’s development and learning, because children’s development is extremely uneven at the preschool age (McAfee & Leong, 2001). Teachers are continually looking at each of their children’s development and learning to determine where their children fall on a continuum of development in various domains. As a result, teachers reflect on their documentation for each child in relation to the expectations to determine how to instruct so each child’s needs are met.

The Professional Standards for School Mathematics (NCTM, 1991) state that teachers are responsible for analyzing student learning in mathematics in order to inform instructional decisions. Children’s development is documented in a performance-based assessment that allows teachers to reflect on each of their children’s performance; this process contributes to teachers’ pedagogical development in which instruction becomes informed and more meaningful (Curtis & Carter, 2000). Bowman et al. (2001) stated that assessment and instruction are representative of effective teaching. Using a performance-
based assessment provides teachers with guidance on what to observe in their classroom and how children develop in order to support their learning through instruction.

The critical component to performance-based assessment is the appropriate use of the evidence collected for each child (Messick, 1992). Teachers’ use of the information from the collected evidence depends on their understanding of mathematics development and how to adjust their teaching practices to guide children’s learning. Teachers’ understanding of each child’s development is heightened when the performance-based assessment provides benchmarks or incremental levels of development for each objective and concept (Dodge, Colker, & Heroman, 2002). Teachers then determine instructional next steps to foster each child’s learning on this continuum of growth. Effective teachers develop plans in their classroom environments, which may involve problem-solving situations or intentional interactions to support each child’s mathematical thinking (Clements, 2001). Training in assessment is necessary for teachers to effectively use their evidence on children to inform their instruction (Meisels, 1999).

The Work Sampling System (Meisels, 1987; Meisels, Jablon, Marsden, Dichtelmiller, & Dorfman, 1994), Child Observation Record (High/Scope Research Foundation, 1992), Creative Curriculum Developmental Continuum Assessment (Dodge et al., 2002), and the Early Learning Assessment System (New Jersey Abbott Preschool Program Implementation Guidelines, 2006) are several approaches to performance-based assessment. For the purposes of this study, the concentration is on the ELAS-M since it is aligned to the New Jersey Teaching and Learning Expectations: Standards of Quality – Mathematics. If performance-based assessment in mathematics is effectively
implemented, then teachers’ instruction is informed by understanding children’s learning in mathematics.

Impacts of Instruction

With increased accountability demands at the national, state, and local levels, teachers must understand each of their children and how they learn as well as the content matter being taught. Performance-based assessments or portfolios drive teachers’ own professional development through the reflection on teaching and learning transactions (Bonilla-Bowman & Gordon, 1996). Portfolios provide evidence of children’s learning and outcomes and make teachers accountable for each child’s progress. As Clements (2001) stated, how teachers instruct each child in mathematics is just as essential as the topics they plan to teach.

Bonilla-Bowman and Gordon (1996) conducted many clinical observations regarding the use of portfolios and concluded that middle school teachers were using portfolios to review children’s learning styles and abilities and adjusted their instruction accordingly. Children felt that teachers got to know them better after spending substantial amounts of time looking at their work. Families from lower socioeconomic minority groups felt that the portfolios were advantageous, with one parent reporting that the portfolio system gave her child extra attention and a feeling of success. Special education teachers’ comments were mainly positive as well as indicating that portfolios allowed the student and teacher to see progress over time.

Seidel (1998) explained the development of teachers’ learning about their children through the process of reviewing students’ work. Looking through a descriptive rather than an interpretive lens has been determined to be crucial when observing children and
their work. The study concentrated on kindergarten through fifth-grade teachers’
investigation of children’s work to provide an understanding of the learning occurring
within the classroom. An objective perspective in reviewing children’s work was
stressed. Teachers regularly discussed children’s work and how their instruction impacted
their work. Five meeting sessions with 10 elementary school teachers and professional
staff at an elementary school in Gloucester, Massachusetts, focused on discussing
children’s work. Two or three pieces of children’s work were discussed at each session
using a protocol called the collaborative assessment conference.

Seidel’s study in Gloucester opened teachers’ minds to how to be better
observers, assessors, and teachers. Teachers became more objective in their observations
and reflections because they learned to see beyond judgments. Knowing the child’s work
to understand the child was the teachers’ mission. Teachers focused on providing
opportunities for children to learn and determined if skills and concepts were mastered.
The results of this study indicated that the time to examine children’s work holistically
was just as important as the time to objectively see the learning that was occurring. By
providing the time, teachers decreased their subjectivity and increased their instructional
effectiveness with a better understanding of the children’s work. Performance-based
assessment allows teachers to examine what children have learned based on opportunities
that they have provided them.

In one of the few preschool studies, a preschool teacher who implemented the
performance-based assessment, Primary Language Record (PLR), stated that the:

- PLR has supported my view of children and of learning by encouraging
- observation of students’ reading, writing, speaking, and listening in the context of
classroom activities. It offers me a framework . . . provides me with concrete information about each student’s learning process which then guides my teaching in a way that standardized tests . . . simply cannot do.” (Darling-Hammond & Ancess, 1996, p. 67)

Standardized tests do not provide authentic evaluations of children’s learning and abilities; thus, initiatives such as the PLR were created. Research has shown that standardized tests have produced instruction that targets lower cognitive skills or rote memorization (Darling-Hammond, Ancess, & Falk, 1995). Teachers using the PLR adjusted their instruction differentiated to the learner to increase children’s success in a purposeful and constructivist manner.

In 1991, more than 50 elementary schools in New York City observed the same professional growth by implementing the PLR (Darling-Hammond & Ancess, 1996). The learner-centered approach provided opportunities for children to demonstrate their competence their own way with teachers’ support rather than just the evaluation of the learning that had occurred. Teachers should encourage learning that is a process of “. . . conceptualizing, constructing, evaluating, refining, and reconstructing their ideas and products; of writing and rewriting; of striving and refining” (Darling-Hammond & Ancess, 1996, p. 70).

In Vermont, the state’s Department of Education’s goal was to change mathematics instruction in kindergarten through 12th-grade classrooms to concentrate on NCTM standards such as problem-solving, communicating, and using mathematical terminology. Assessment through the use of portfolios had to be one with instruction for this endeavor to unfold. Since Vermont focused on improving children’s performance
and being able to discuss each child’s performance, portfolios provided the evidence for children and teachers to discuss a wide range of learning. Another concentration was on showing the public what quality looked like when using portfolios. In order for portfolios to represent children’s genuine abilities, training had to be continuous, which was difficult since time was always a factor. The teachers were empowered to make portfolio design decisions, which empowered the overarching goal to make assessment a part of purposeful instructional decisions.

In 1992, the RAND Corporation put forth two reports evaluating how the Vermont’s portfolio assessment has changed instructional practices. “Among fourth grade teachers, 82% reported spending ‘somewhat more’ or ‘much more’ time on problem solving and 49% report spending ‘somewhat less’ or ‘much less’ on computation and algorithms” (Mills, as cited in Baron & Wolf, 1996, p. 206). A major finding was that the NCTM standards were apparent in classroom practice as a result of the focused attention on performance measures. Teachers were more enthusiastic about teaching mathematics, were able to see mathematics in other content areas, and improved their own instructional goals. The statewide focus on improving teaching benefited teachers and children.

Performance-based assessments offer an objective guide to teaching that provide teachers with benchmarks for the knowledge and abilities that children should demonstrate. These assessments have the ability to influence improvements in instruction by increasing teachers’ understanding of the children’s sequence of development and the domain, since children’s performances in mathematics are regularly analyzed. Effective teachers see mathematics through each child’s point of view (Clements, 2001).
Performance-based assessment provides teachers with a guide to support each child’s learning. The impact of an assessment process has been very powerful for teachers to see how their practices drive learning (Baron & Wolf, 1996). In many states nationwide, performance-based assessments have critically changed the way of thinking about assessment and have had an impact on teaching behavior.

*Feelings Affected by Professional Development*

Early childhood teachers have expressed a fear of mathematics that stems from lack of preparation and professional development to effectively instruct in this domain (Copley, 2004). Fear is usually triggered by the unknown. Many early childhood educators have concentrated their own professional development in language arts and literacy without much attention to the mathematical field. Data collected from a 5-year study indicated that early childhood teachers feel most comfortable teaching reading and feel as if teaching mathematics is difficult (Copley, 2004). Without a genuine understanding of underlying mathematical knowledge and development, educators will continue to shy away from the immense amount of learning possibilities for children in this domain.

New Jersey’s 2006 ELIC evaluations of classroom activities, interactions, and materials related to mathematics found that while there is some evidence of math materials, support for learning in various mathematical concepts is minimal (Frede, Jung, Barnett, Lamy, & Figueras, 2007). The one area most apparent in preschool classrooms in New Jersey as well as across the nation is in counting. Understanding how to represent, communicate, and problem-solve mathematically in the early childhood classroom is rarely visible. The teachers’ own lack of understanding of math may cause
frustration among teachers in the field. Educators’ dispositions regarding mathematics are likely to influence how they behave as well as their professional development experiences (Goldsmith & Schifter, 1997). In the previous 20 years, studies have shown that teachers’ feelings about mathematics significantly impact their instruction (Jones, 1997). If educators are aware of their feelings about mathematics, conscious realization for change may occur.

Teachers cannot attend to their children’s mathematical thinking if the teachers do not know how. “As teachers learn more about thinking mathematically themselves, they become better able to make principled judgments about the purpose and value of the mathematical activities and problems they choose for their students” (Goldsmith & Schifter, 1997, p. 390). Feelings of being underqualified to teach mathematics and hating the subject may eventually dissipate. Studies have linked teachers’ beliefs about mathematics to change in the classroom (Thompson, 1984).

Labinski and Jaberg (1997) conducted a study to change teachers’ knowledge and beliefs in mathematics. The teachers participated in six 2-hour spring sessions, a summer intensive training series, a fall session, and classroom visits from a mathematics professor for all teachers in the fall and spring. The results of the belief survey indicated that after the intervention, beliefs significantly changed toward a cognitively based perspective on mathematics instruction and learning. Similarly in another study, the Mathematics Teaching Cycle (MTC) provided a framework for teachers to respond to their children’s needs by reflecting upon and planning for purposeful instruction and encouraged change in teachers’ beliefs and practices (Simon, 1997).
The Cognitively Guided Instruction (CGI) examined teachers' beliefs about the knowledge required to teach mathematics in kindergarten through the third grade through a 5-year project by the National Science Foundation. The project focused on having teachers use research on children's mathematical development to understand each child's thinking and therefore adjust instructional practices accordingly. The results of this intervention did not show any pattern of change; however, the relationship between beliefs and teaching practices was indicated at the higher levels (Franke, Fennema, & Carpenter, 1997).

Research supports that the most effective method of training and improving teachers' instructional practice is the coaching model. Several studies by Joyce and Showers (1995) showed that high-quality staff development in forms of workshops, lectures, and presentations transfer around only 5% to classroom practice. This percentage increases when coaching becomes a continuous process and part of the school's culture (Costa & Garmston, 2002). Costa and Garmston (1994) stated that coaches can support teachers in improving attitudes and instruction; and that coaching, consulting, and collaboration define the instructional improvement process.

Reflective practice with New Jersey master teachers and their preschool teachers includes a cyclic cognitive coaching model that provides a systematic plan to improve teaching practices and dispositions. The master teachers' reflective coaching cycle is based on Costa and Garmston's (2002) cognitive coaching cycle approach. The cycle consists of a planning conference in which the master teacher and teacher meet to share information and discuss focus areas within the teacher's practices, their vision for a high-quality classroom and how evidence will be obtained during the event or observation;
they conduct an observation, and establish a time for discussion of the observation. Both the teacher and master teacher reflect on the observation and ask questions. The master teacher presents feedback in relation to the evidence obtained during the observation, and both determine goals for the next visit. And the cycle continues. During the conferences, the master teacher and teacher collaborate to establish a focus and shared vision to improve teaching practices and student outcomes.

Costa and Garmston (2002) stated that cognitive coaching enhances teachers' intellect, which produces greater intellectual development in students. Cognitive coaching truly influences another person's thinking regarding instruction skills (Costa & Garmston, 2002). The coaches' relationships with teachers are foundational in supporting their self-directed learning in improving teaching practices. The successful coach also uses strategic tools and techniques with teachers for various situations when conversing, planning, reflecting, and problem-solving, built around an observation of an event or lesson.

Teacher efficacy has been studied frequently in conjunction with cognitive coaching. Effective teaching is described as refined and purposeful, with limited use of rote or didactic approaches. Studies demonstrate that teachers who were involved in cognitive coaching used more effective practices than teachers who were not involved (Edwards & Newton, 1995). Teachers tend to grow professionally when they feel that their practices contribute to students' learning. Edwards and Newton (1994) found that teachers who were trained in cognitive coaching compared to those teachers who were not trained reported more learning and growth, the opportunity to make a lasting difference and more allowance to be creative. Teachers who were cognitively coached
had higher rates of satisfaction with teaching as a profession and were more motivated and enthusiastic about their work with children.

Other studies by Edwards and Newton (1994, 1995) demonstrated higher satisfaction levels in the teaching profession when the teachers participated in a cognitive coaching approach. As a result, school cultures also become more professional. Ushijima (1996) stated that teachers who used cognitive coaching for more than 1 year took more risks when teaching, shared ideas and problem-solved with others more often, accepted differences because of mutual respect, articulated with others in various grade levels, and focused on their work with children. Teaching became reflective and meaningful, and the teachers’ attitudes were optimistic.

When coaches help teachers analyze their instruction by attending to the what, why, and how they teach, they become empowered. Collaborative learning occurs because of the constant examination of existing, new, and innovative teaching practices by the teacher and master teacher. While the teacher profession concentrates on the diverse needs of children, the needs of the adult learners are too often forgotten. If emphasis is not placed on the teaching quality and beliefs about early childhood developmental domains, especially mathematics, how can children’s learning experiences be optimized?
Chapter 3: Methodology

Introduction

The College of New Jersey and the National Institute of Early Education Research (NIEER) in conjunction with the New Jersey Division of Early Childhood Education (DECE), Office of Preschool Education, conducted a project during the 2006–2007 school year and examined the impact on teaching and children’s learning in mathematics when a performance-based assessment, the ELAS-M, was implemented in three Abbott districts. The three Abbott districts volunteered to participate in the study with approval from each district’s administration. Professional development in understanding the ELAS-M was provided through workshops, reflective individualized sessions on the ELAS-M, and the use of performance-based assessment. The performance-based assessment, the ELAS-M, was proposed to improve teaching and learning. In addition, the PCMI was administered in the fall and then again in the spring in all participating classrooms to measure the effects of the ELAS-M on teaching practices.

Preschool classrooms serving 4-year-old children in each of the three districts were randomly assigned to one of two treatment groups: mathematics enhancement only or mathematics enhancement plus implementation of the ELAS-M. In the first scoring period, the ELAS-M teachers administered the ELAS-M to 2 of the randomly selected study children; and then in the second and third scoring periods, the teachers administered the ELAS-M to all 5 of the randomly selected study children. Instructional skills in mathematics were investigated by comparing pre- and post-PCMI scores in relation to the ELAS-M implementation.
TCNJ and NIEER conducted this project with the DOE as members of the Early Learning Improvement Consortium (ELIC). In the New Jersey DOE, preschool program quality has been measured since 2002 in the Abbott districts by the ELIC using several structured observation tools such as the Preschool Classroom Mathematics Inventory-PCMI (Frede et al., 2005). The ELIC does extensive research on classroom quality as well as longitudinal studies looking at children’s outcomes beyond the preschool years. For the past several years, the results of the PCMI have indicated that mathematical practices are minimal (Frede et al., 2007). Therefore, attention has been given at the state and district levels to improve early childhood instruction in mathematics. Districts are intentionally concentrating on early childhood mathematics through professional development, emphasizing how to support children’s mathematical learning through their performance-based assessment and curriculum.

Two of the study districts in this study implemented the Curiosity Corner curriculum (Chambers, Madden, & Slavin, 1999), and the other Abbott district implemented the Creative Curriculum (Dodge, 2002). The study’s research team created a survey that provided information regarding teachers’ math training and feelings about math. A mixed-methodology design was implemented using quantitative and descriptive methods in the research. For the purposes of this study, instructional skills in mathematics were mainly investigated to determine the impact of implementing a performance-based assessment, the ELAS-M.

Population

Thirty-one New Jersey Abbott districts serve preschool children. The total number of preschool teachers serving these children in 2006–2007 was 2,549 (1,001
district teachers and 1,548 private provider teachers). The total number of Abbott preschool children was approximately 43,500.

There were 193 master teachers in the 31 Abbott districts’ early childhood departments. Each master teacher was assigned anywhere from 13 to 17 teachers to coach. Each Abbott district has an early childhood supervisor.

Three of the Abbott districts volunteered to be a part of the study. One district is located in central New Jersey, District A, in a city with more than 16,930 residents: 3,147 White (non-Hispanic), 10,515 Black (non-Hispanic), 2,637 Hispanic, 119 Asian, and fewer than 1,000 Other, according to the U.S. Census Bureau (2000). The student population is 2,362; 1,760 students receive free lunch, and 175 students receive reduced lunch (District, New Jersey State Report Card, 2006–2007). There are 519 students participating in the full-day preschool program with 266 3-year-olds and 265 4-year-olds (New Jersey Department of Education, Division of Early Childhood Education, 2006). There are a total of 37 classrooms in the preschool program with 29 in provider settings, one in the district setting, and seven in Head Start.

The second study district, District B, is located in northern central New Jersey. The city has approximately 47,303 residents: 8,919 White (non-Hispanic), 4,749 Black (non-Hispanic), 33,033 Hispanic, 723 Asian, and fewer than 1,000 Other, according to the U.S. Census Bureau (2000). The student population is 9,534; 5,951 students receive free lunch, and 1,289 students receive reduced lunch (District, New Jersey State Report Card, 2006–2007). There are 1,187 students participating in the full-day preschool program with 537 3-year-olds and 650 4-year-olds (New Jersey Department of Education, Division of Early Childhood Education, 2006). There are a total of 83
classrooms in the preschool program with 210 in provider settings, 69 in district settings, and none in Head Start.

The third study district, District C, is located in southern New Jersey. The city has more than 19,012 residents: 3,402 White (non-Hispanic), 10,969 Black (non-Hispanic), 4,158 Hispanic, 371 Asian, and fewer than 1,000 Other, according to the U.S. Census Bureau (2000). The student population is 3,423; 1,524 students receive free lunch, and 375 students receive reduced lunch (District, New Jersey State Report Card, 2006–2007). There are 548 students participating in the full-day preschool program with 237 3-year-olds and 311 4-year-olds (New Jersey Department of Education, Division of Early Childhood Education, 2006). There are a total of 37 classrooms in the preschool program with 16 in provider settings, 20 in district settings, and one in Head Start.

Sample

Within the three participating Abbott districts, the teachers in 41 classrooms serving 4-year-old children were randomly assigned to one of two groups: mathematics training only and differentiated professional development plus the implementation of the ELAS-M (21 teachers) or mathematics workshop only (20 teachers).

The ELAS-M (experimental) group consisted of 6 teachers and 3 master teachers in the first Abbott district, 7 teachers and 1 master teacher in the second Abbott district, and 8 teachers and 3 master teachers in the third district. The non-ELAS-M (control) group consisted of 6 teachers and 3 master teachers in the first Abbott district, 7 teachers and 1 master teacher in the second Abbott district, and 7 teachers and 3 master teachers in the third Abbott district.
A full-day workshop for all teachers of 4 year olds was presented in early fall based on the New Jersey Preschool Teaching and Learning Expectations: Standards of Quality – Mathematics and teaching mathematics in preschool. All teachers of 4 year olds were included in the training to provide all participants in the experimental and control groups of the study with an understanding of quality mathematics instruction and mathematics expectations in preschool. The math plus ELAS-M, the experimental group, received an additional full day of training on understanding and implementing the ELAS-M. The training sessions for all teachers and the ELAS-M group were standardized. The research team presented for both training sessions in each district to ensure that the same message was delivered.

Throughout the school year, on a monthly basis, each teacher in the ELAS-M group participated in the reflective coaching cycle with his or her assigned master teacher. The master teachers were required to keep reflective logs of these observations and interactions to document teaching practices and discussions regarding students’ mathematical learning using the ELAS-M as a guide. On a monthly basis, the research team met with each participating master teacher individually and one of their assigned teachers during a postconference session to provide support or clarification in relation to the implementation of the ELAS-M.

In the first scoring period (ending mid-December), the teachers in the experimental group administered the ELAS-M to 2 randomly selected children. In the second scoring period (ending mid-March) and the third scoring period (ending early June), teachers administered the ELAS-M to the previously selected 2 children as well as
an additional 3 randomly selected children. The total number of participating children from each 4-year-old classroom in the experimental group was 5.

Master teachers and teachers in two of the districts implemented the Curiosity Corner curriculum. Curiosity Corner emphasizes language arts and literacy and includes objectives for children’s emotional, physical, and interpersonal development. According to the developers, the scripted program infuses cooperative learning opportunities in each weekly topic unit with a main focus on problem-solving (Chambers, Madden, & Slavin, 1999).

The remaining district implemented the Creative Curriculum model developed by Teaching Strategies, Inc. The Creative Curriculum for Preschool includes student learning standards on literacy, mathematics, science, social studies, arts, and technology. The program focuses on the preschool classrooms’ interest areas where teachers determine how children learn based on individual interests (Dodge, 2002).

The experimental group total consisted of 20 female teachers and 1 male teacher. The control group total consisted of 19 female teachers and 1 male teacher. All master teachers were female.

All teachers had an early childhood certificate or had obtained P-3 status. The total number of teachers with an alternate route certification was 18; 9 participated in the experimental group, and 9 participated in the control group. The 1 teacher who had a special education certification was in the experimental group. Table 1 presents the background characteristics of the participating teachers.
Table 1

*Teachers’ Treatment Group, Gender and Certification*

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*Implementation*

The ELAS-M (Whelan et al., 2006) is a performance-based assessment and measures preschool children’s development in mathematics. The Age-by-Age Accomplishments, the main component of the instrument, includes the following three child outcomes from the Preschool Teaching and Learning Expectations: Standards of Quality – Mathematics (2004): 1) child demonstrates an understanding of number and numerical operations, 2) child demonstrates emerging knowledge of spatial concepts, measurement, and geometry, and 3) child demonstrates an understanding of patterns, relationships, and classification. Each expectation contains strands of development for mathematical concepts relevant to the overarching expectation. In expectation 1, strands of development or benchmarks are included for the following mathematics concepts: one-to-one correspondence, counting words, functional counting, numerical operations, and
written numbers. In expectation 2, strands of development are included for the following mathematics concepts: identifying and using shapes, measurement, positional relationships, and spatial relationships. In expectation 3, the classification and patterning strands of development are included. The continuum begins with 1 (emergent) and ends with 4 (competent). These numbers on the continuum are used to score each child’s development for each mathematics expectation by referring to the documentation collected and the descriptors for each strand. The competent benchmark defines the expectations for preschool children at the end of a preschool program or at an entry kindergarten level.

The ELAS-M provides teachers with a guide to record observations and collect work samples about each child’s mathematical development and learning in everyday situations. In the fall, winter, and spring, the anecdotes are analyzed, synthesized, and evaluated based on the strands of development in each expectation and then used to score each child’s development in mathematics. These scores, as well as periodic reviews of the evidence collected, allow teachers to adjust their teaching practices according to each child’s needs and development (Jablon et al., 1999). The ELAS-M participants collected anecdotes on their 2 randomly selected children for all three mathematics expectations in the Age-by-Age Accomplishments and scored each expectation in mid-December. In mid-March and early June, the ELAS-M participants scored each expectation for all 5 of their randomly selected children.

During the course of the school year, the ELAS-M participants met with their assigned master teacher each month for approximately 1 hour using the reflective cycle. Each ELAS-M teacher determined a mathematics focus using the Age-by-Age
Accomplishments as a guide. Teachers selected a specific expectation that included mathematical concepts in which they expressed interest during the planning conference with their master teacher. The master teacher then observed the child for approximately 45 minutes in relation to this focus area during a predetermined time using the Age-by-Age Accomplishments as the observation tool. Within 48 hours, the master teacher and teacher met to discuss the observation using the teacher’s written anecdotes based on the particular lesson(s) regarding students’ learning in the mathematical domain. Again, the Age-by-Age Accomplishments were used to guide the post-conference discussion in relation to the anecdotes collected. The master teacher and teacher followed the same protocol each month using the reflective cycle log (see appendix D). The reflective cycle log included an action plan with the following questions: “What will I do to move the children along the ELAS-M Age-by-Age Accomplishments?” “Can I add new materials, revise activities, or engage in specific interactions with children?” Answers to these questions were documented by master teachers and teachers.

After meeting with the teacher, on the same day of the conference, master teachers answered a couple of questions regarding the postconference: “What did I learn about the teacher?” “What do I need to do to increase my understanding of math development?” The master teacher’s answers to these questions as well as each teacher’s action plan were documented on the reflective cycle log each month for all participating ELAS-M teachers and master teachers. The logs were copied and provided to the research team after each scoring session to ensure that appropriate procedures were followed. A member of the research team attended one postconference session per master teacher per month to also examine if the protocol was followed as the study intended.
Master teachers in all three districts met with the research team as a group twice throughout the study to discuss any concerns with the implementation of ELAS-M as well as successes.

**Instrumentation**

All classrooms were observed in the fall and spring, using the PCMI. The PCMI (Frede et al., 2005) measures the materials and teachers’ methods used to support and enhance preschool children’s mathematical skills. The standards of the National Council of Teachers of Mathematics and the National Association for the Education of Young Children (2002) informed the development of the measure, which consists of 11 items on a 5-point Likert scale, from *minimal evidence*, or low quality (1) to *strong evidence*, or high quality (5) in two subscales – Materials and Mathematical Concepts. The Materials subscale in the PCMI measures the extent to which math-related materials are available for children to explore mathematical concepts. The Mathematical Concepts subscale measures the extent to which teachers support children’s use of mathematical materials and provide the interactions necessary for children to become familiar with mathematical concepts.

Throughout the study, teachers were encouraged to provide materials and other instructional supports to meet each child’s mathematical needs in a purposeful and developmentally appropriate manner. Teachers in each of the districts were provided $2,000 for the year to spend on classroom supplies, per Abbott preschool funding and state budget guidance. Examples of developmentally appropriate materials as well as interactions are provided in the performance-based assessment. The PCMI also provided
teachers with examples of math-related materials and other supports appropriate for preschool classrooms.

The PCMI items are listed in Table 2 to specify areas in mathematics instruction measured.

Table 2

Preschool Classroom Mathematics Inventory (Frede et al., 2005)

Materials

1. Materials for counting, comparing, estimating and recognizing number symbols.
3. Materials for classifying and seriating.
4. Materials for geometry and spatial positions/relations.

Numeracy and other Mathematical Concepts

5. Teachers encourage one-to-one correspondence.
6. Teachers encourage children to count and or write numbers for a purpose.
7. Teachers encourage children to estimate and compare numbers.
8. Teachers encourage children’s use of mathematical terminology and reflection on mathematical problems.
9. Teachers encourage children to measure and compare amounts, volume, weight, length, height, distance, and area.
10. Teachers encourage children to classify and seriate.
11. Teachers encourage concepts of geometry and spatial positions/relations.

In previous research, internal consistency among the test items as measured by Cronbach’s alpha was .86. Concurrent validity was measured by observing 318 classrooms using the ECERS-R and the PCMI on the same day. The PCMI total score has a correlation of 0.65 ($p \leq .001$) with the ECERS-R. In addition, the PCMJ total score
predicts children's gains on Woodcock-Johnson Applied Problems scores ($F = 5.64$, $p = .02$, $B = .52$) (Freda, Lamy, & Boyd, 2005).

A survey was also used in the study and included the following open-ended questions: "Have you had any specific courses or training in early childhood math?" "What are your feelings about or experiences with math and teaching math?" The survey was collected toward the end of the implementation of the ELAS-M in April and May.

**Data Collection**

The PCMI was used to assess instructional skills in mathematics. Inter-rater reliability on the use of the measure was attained before the study was conducted. Trained data collectors had established reliability by achieving 70% exact agreement for the PCMI for three observation sessions. Records were kept on standard reliability forms and entered into a database.

Once reliable, the data collector scheduled observations in the three districts during typical days when the teacher did not have scheduled planned events such as field trips or assemblies. Schools or centers were not informed which teacher would be observed that day. Researchers were at the sites 15 minutes before the children's arrival. During the day of the observation, researchers introduced themselves to the teachers and assistants and briefly explained the purpose of the visit. While observing, the researchers attempted not to interfere with the classroom activities. No conversations during the evaluation period occurred between the researcher and teacher. After the 3-hour observation, when the teacher was available during nonchild-contact time, the researcher asked any interview questions not addressed by the PCMI observation.
The PCMI (Frede et al., 2005) was administered from late September to early October 2006 by reliable observers from NIEER to all 41 teachers in the control and experimental groups. This served as the pretest in the study. The PCMI was administered again by the same observers throughout April and May as a postmeasure of the same two groups of teachers. This provided information on mathematical instructional practices in the beginning of the school year and the end of the school year as well as a comparison of the two groups.

The survey was distributed and then collected from all participating teachers by the research team toward the end of the implementation of the ELAS-M study. The data were coded and aggregated for further analysis.

To determine if the teachers could reliably score the ELAS-M, inter-rater reliability sessions were conducted in April or May 2007. The ELAS-M teachers had approximately 1 hour to score five standardized portfolios on the three mathematics expectations for one scoring period. Anecdotes were based on folios collected by teachers not included in the study, and researchers made clarifications to the anecdotes to ensure that they were understandable. Reliability scores were determined by having experienced project staff score the folios and then discuss individually determined scores with each other. Where differences existed, revisions were made in the anecdotes to make the score clearer. Teachers were asked to score each child’s learning on the three items in the ELAS-M. Teachers scored individually without consultation and indicated their scores on the provided reliability scoring document in the appendices (see appendix E).

Reliability sessions were conducted by the research team to ensure that reliability scoring procedures were the same and data were collected in a confidential manner. The
data were compared to the experts’ scores. Seventeen out of 18 teachers (94%) scored the ELAS-M reliably. Three teachers were unable to attend the reliability scoring session for the ELAS-M due to personal circumstances. Reliability was determined to be 80% and above. The results indicated 80% to 89% reliability (n=8), 90% to 99% reliability (n=7), and 100% reliability (n=3). The highest reliability score was 100%, and the lowest reliability score was 67%.

Potential Threats to Reliability and Validity

All teachers in the experimental group as well as master teachers were provided with training on how to score reliably. Reliability was established if teachers were able to score the same developmental anecdotes repeatedly with the ELAS-M benchmarks and get similar or the same results. Anecdotes and work samples were collected and analyzed against the ELAS-M benchmarks or Age-by-Age Accomplishments to determine if teachers were able to determine children’s learning level consistently compared to the other teachers’ findings. Since the teachers in the study had to determine scores for the participating children, this understanding is crucial for teachers’ true evaluation of each child’s performance in mathematics. Scoring procedures were provided to participants for consistency purposes. During the fall training session on the ELAS-M, teachers scored sample folios and then compared their scores with other teachers for inter-rater reliability purposes. During the late spring months, teachers were then tested for inter-rater reliability by the research team. The teachers were tested for purposes of reliable scoring by using the folios and then tested for inter-rater reliability against predetermined scores. As indicated earlier, 94% of teachers in the experimental group scored the folios reliably in the spring.
When using a performance-based assessment, attention to the developmental benchmarks and the psychometric properties need to be considered. Teachers should be able to analyze and interpret children’s learning along the ELAS-M continuum in which preschool children’s mathematics development is authentically represented. The assessment should measure what it is designed to measure, otherwise known as the content validity of the system. The validity of the ELAS-M was investigated by a panel of experts during the last phase of development of the performance-based assessment. The early childhood mathematics experts who reviewed the ELAS-M are nationally and internationally known in the early childhood field for their research in mathematics. Their research, assistance, and time in refining the benchmarks for the ELAS-M Age-by-Age Accomplishments helped create an assessment that genuinely represents children’s mathematical development in an array of math concepts matched to the state’s expectations in preschool.

The concurrent validity for the ELAS-M was measured by administering a pretest and a posttest to randomly selected children in the experimental and control groups to measure learning in mathematics. The Child Math Assessment (CMA) (Klein & Starkey, 2000) was used to measure children’s abilities in concepts such as counting and numerical operations. Trained assessors from NIEER administered the assessment in the fall and spring for the selected sample. Children’s scores on the teachers’ folios, which are categorized by expectation, did not significantly relate to their ability on the CMA. Concurrent validity needs further exploration. The problem is the lack of a diagnostic comprehensive math assessment in early childhood mathematics that looks at all mathematical strands of development used in the ELAS-M.
Furthermore, internal and external validity concerns have been considered. Even though the content of all the professional development for the experimental group was similar in every district, the follow-up conversations varied in depth and time, which was not accounted for in this study. The support in early childhood mathematics outside the ELAS-M study was not accounted for; however, master teachers were advised to follow the study’s terms to determine if the performance-based assessment changed teaching behavior. Additional teacher training, fidelity of the use of the instrument, and instructional interventions were not investigated. The reflective cycle experiences were also not rated in terms of overall depth of discussions in using the assessment to individualize instruction.

In addition, the teachers of 4 year olds were randomly selected to participate in the experimental or control group; however, the three districts volunteered to partake in the study. Therefore, the districts’ interest in improving teaching and learning in mathematics may have promoted a culture within the schools or centers to concentrate on this improvement endeavor. The small sample size in each district resulted in thorough and timely manageability of the study, yet limited the ability to determine causal effects. Findings are presented in chapter 4.

Data Analysis

A paired-sample t-test was used to first determine initial differences between the ELAS-M group’s and the control group’s pre- and post-PCMI scores. The data were analyzed to determine differences in improvement between teaching practices from the fall to the spring for both experimental and control groups in the study. Teaching practices specifically relating to the PCMI subscales were also examined in the
experimental and control groups using a paired-sample $t$-test. Significant differences between the ELAS-M and non-ELAS-M groups were investigated to determine whether districts might have differential effects. A significant value of .05 was used in all statistical tests.

An independent $t$-test was used to test the differences in teaching practices in the fall and spring between the experimental and control groups in each district to determine if the performance-based assessment significantly changed practices. In addition, the change in practices were related to the PCMI subscales; providing math-related materials and the encouragement of mathematical concepts with children were explored in each district.

The impact of the treatment status on instruction was measured by the PCMI. The treatment status consisted of the ELAS-M (experimental group=1) and non-ELAS-M participants (control group=0). The three districts were coded Districts A, B, and C.

Descriptive statistics were calculated to provide a picture of the teachers’ responses in the survey. The participating teachers’ responses to “Have you had any specific courses or training in early childhood math?” were analyzed in relation to their PCMI mean score differences from fall to spring. The researcher looked for emerging themes in the ELAS-M participants’ responses to “What are your feelings about or experiences with math and teaching math?” in relation to the implementation of the ELAS-M. These data were organized into categories while searching for patterns to provide purposeful information regarding all participants’ feelings after implementing the performance-based assessment in mathematics, the ELAS-M.

Chapter 4 provides the findings, analysis, and summary of the data.
Chapter 4: Data Analysis

Introduction

The purpose of this study was to determine if using a performance-based assessment in mathematics would change preschool teachers’ instructional skills. Teachers were randomly selected to participate in either an experimental or control group. The experimental group implemented the performance-based assessment in mathematics, ELAS-M, to promote improvement in mathematical learning. By improving instructional skills in mathematics, preschool children are provided with a stronger foundation in the subject; previous research had shown minimal quality of math instruction statewide (Frede et al., 2007). Therefore, the state implemented a performance-based assessment in preschool classrooms in an effort to strengthen teaching practices and learning in this domain.

In this study, the teachers in the experimental group used the performance-based assessment to understand the developmental levels of children’s mathematical learning. By reflecting upon the learning that was occurring while referring to the performance-based assessment, teachers enhanced and individualized their teaching practices to support each child’s mathematical thinking. Conversations between master teachers and teachers possibly added to the depth in understanding early childhood mathematics. Master teachers asked teachers where each child fell on the developmental continuum, using the ELAS-M Age-by-Age Accomplishments, which encouraged teachers to reflect on children’s development and learning and then plan their instruction accordingly to further math development.
The master teachers acted as coaches by assisting teachers in understanding the various mathematical concepts and developmental milestones. Assessment, instruction, and learning were discussed as a whole, where one influences the next in a cyclical process. Teachers and master teachers used the anecdotal evidence collected on each child to determine how to best support development. Master teachers assisted teachers in examining pedagogy and math-related materials and activities within the classroom environment. The discussions provided teachers with time to reflect and plan for purposeful instruction.

The performance-based assessment used in the study, the ELAS-M, sought to build instructional skills in mathematics. The instrument used to measure teaching practices was the PMCI, which is divided into two subscales: math-related materials and teachers’ encouragement in supporting children’s mathematical learning. The average PCMI scores as well as average scores for each subscale were examined to determine the impact of using the performance-based assessment.

To evaluate the impact of ELAS-M on teaching practices, three Abbott districts volunteered to participate in the study. Preschool teachers who had 4 year olds in their classrooms were then randomly assigned to either the experimental group or the control group. The districts varied in location and size, but all served children from lower socioeconomic households. (Refer to chapter 3 for a more in-depth discussion of the methodology.)

The central district, renamed District A, consisted of 6 teachers in the experimental group and 6 teachers in the control group. One teacher spoke Spanish, and another teacher spoke Chinese and Tagalog fluently in addition to English. The northern
central district in New Jersey, renamed District B, consisted of 7 teachers in the experimental group and 7 teachers in the control group. Two teachers spoke Spanish, and one spoke Polish in addition to English. The southern district, renamed District C, consisted of 8 teachers in the experimental group and 7 teachers in the control group. One teacher spoke Bulgarian, Russian, and German, another teacher spoke Japanese, and another teacher spoke Spanish in addition to speaking English.

The experimental group in total consisted of 20 female teachers and 1 male teacher. The control group consisted of 19 female teachers and 1 male teacher. All master teachers were female. The total number of teachers with an alternate certification was 18, with 9 participating in the experimental group and 9 in the control group. The 1 teacher who had a special education certification was in the experimental group.

Preschool teaching experience with the most experience of the sample ranged from 26 years to 2 years with a mean of 9.3 years. District A’s mean preschool teaching experience was 7 years, District B’s mean preschool experience was 12.9 years, and District C’s mean experience was 7.8 years. This information is presented by district in Table 3.

Table 3

*District and Years of Preschool Experience*

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<td>C</td>
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<td>B</td>
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<td>7</td>
</tr>
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Control Group

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**Reflective Practice through the Use of Performance-based Assessment**

Before the data that compare outcomes for the experimental group with that of the treatment are presented, a discussion of the reflective practices that occurred among the preschool teachers in the intervention is presented. This provides the necessary backdrop for understanding how changes in teacher practices were engendered by the intervention.

Despite years of preschool teaching experience, all teachers’ understanding of early childhood mathematics was explored through reflective practice, using the cognitive coaching model. The time to reflect on children’s learning in mathematics with master teachers provided teachers with an opportunity to understand children’s development in this domain. By conversing with master teachers about their children’s mathematical experiences in relation to the performance-based assessment, teachers were able to determine ways to enhance the learning in the classroom by providing certain math-related materials and opportunities to discuss mathematical concepts with children. The conferences between master teachers and teachers provided time to discover teachers’ instructional challenges and supports in mathematics for each child through focused and goal-oriented conversations. Master teachers guided the teachers in determining how to purposefully individualize their instruction to increase their children’s learning based on their data. The reflective process assisted teachers with understanding their influence on the mathematical learning that occurred in their classrooms.
Master teachers used a reflective log to record their planning conferences, classroom visit experiences, and postvisit discussions regarding performance-based assessment. Teachers were asked to develop an action plan with their master teacher during postclassroom visit discussions. The action plan asked what teachers could do to better collect mathematical anecdotes and work samples to determine students’ development and how to then increase children’s learning in mathematics through instruction. Question 1 asked, “What can I do to collect better evidence and move the children along the Age-by-Age Accomplishments?” This question promoted discussion on collecting objective anecdotal notes on each child provided rich evidence on the child’s level of development within certain areas in math. Data were always used in the discussions between the master teacher and teacher to determine a child’s mathematical development. The development was matched to the Age-by-Age Accomplishments in the performance-based assessment. By understanding the child’s development, teachers were then able to make instructional decisions to enhance the child’s learning on the developmental continuum.

The reflective process helped master teachers and teachers understand how to effectively use the performance-based assessment. Specific examples of how the teacher would support a child’s learning in conjunction with the assessment were discussed with the master teacher, such as discussing how a child was ready to use standard tools to measure as well as make connections to the quantity. For instance, a teacher mentioned that she would provide opportunities for a child to measure by incorporating intentional activities in water play to promote measurement concepts. Water play was suggested because of the child’s interest in the activity center. Materials, such as funnels and
measuring cups, were added to the center to encourage children's exploration. Another teacher discussed her need to use more positional words throughout the course of the school day to encourage learning of vocabulary related to spatial concepts. Overall, the teachers noted in the logs particular mathematical concepts to explore with children and how to adapt instruction based on children's interests and level of ability to further support learning.

Since the master teachers coached the teachers in using the performance-based assessment, the master teachers also completed individual reflections to determine how to best support each teacher's understanding of assessment and early childhood mathematics. Questions included knowledge regarding teachers' skills as well as the next steps for the master teacher to support the teacher's ability to support each child mathematically. The final question asked the master teacher what was needed to increase her own understanding of early childhood mathematics development.

Teachers' understanding of early childhood mathematical development, performance-based assessment, and math-related instructional skills varied in this study. One master teacher noted that a teacher was in the early stages of understanding the value of referring to collected evidence on her children and how this evidence is used in planning instruction. Another master teacher noted that her teacher needed more support in understanding the Preschool Mathematics State Expectations. Specific examples of teachers' needs in the classroom to promote mathematics were documented, such as developing methods for purposefully counting and writing numbers, using open-ended questions, and planning for measurement and classification opportunities.
Master teachers' next steps for their teachers included continued support in reviewing documentation and planning for individual growth. In reviewing anecdotes and work samples, master teachers were made aware of teachers needing more organizational support to use the performance-based assessment. Master teachers considered ways to collect evidence and offered ideas to plan for instruction. In addition, master teachers helped plan meaningful activities that addressed specific mathematical concepts with children and helped teachers find evidence of math learning embedded in other documentation (i.e., anecdotes that were used for the language arts literacy domain).

In their reflective logs, master teachers considered ways to increase their own understanding of early math development. Several master teachers stated that they needed to become more familiar with the Age-by-Age Accomplishments to understand the developmental continuum in mathematics, attend more math trainings, review resources from the National Council of Teachers of Mathematics, research strategies for special needs children, and concentrate on listening to offer meaningful support.

Overall, the reflective cycle experiences between master teachers and teachers provided time and focus for improving understanding of early childhood mathematics and performance-based assessment. The discussions allowed for opportunities to reflect upon instruction and relate those practices to children's learning. Improving instruction through the use of the performance-based assessment was a focus that was discussed throughout the school year.

Findings: Research Questions

The following discussion involves the results of the research and subsidiary questions regarding the impact of performance-based assessment on instructional skills in
mathematics; in addition to specific areas such as materials and concepts, previous math
teaching and feelings about teaching mathematics were analyzed during the
implementation of the performance-based assessment system.

Research Question

How has instruction in mathematics changed for preschool teachers who
implemented the ELAS-M system compared to those who did not implement the
performance-based system?

Observations using the PCMI were conducted in the fall and again in the spring in
all participating classrooms. Again, inter-rater reliability on the administration of the
PCMI was attained before the study. Trained data collectors had already established
reliability by achieving 70% exact agreement for the PCMI for three observation
sessions. Spearman's correlation was used to determine if there was a significant
relationship between the spring and fall scores for both groups in the study. Overall, there
was a significant relationship with $r = .580$ and $p \leq .00$. The data indicated a moderate
correlation or relationship between the fall and spring PCMI scores for the entire sample.

In addition, the pre- and post-observations provided data to determine if there was
a significant change in instruction after the performance-based assessment was
implemented. A paired-sample $t$-test (one-tailed) was used to study the instructional
differences in the experimental and control groups from the fall to the spring. Table 4
presents the mean PCMI scores in the fall and the mean PCMI scores in the spring for
each group, respectively. This table allows us to answer the following questions: Was
there a significant improvement in teaching practices from the fall to the spring in each
group? What was the rate of improvement for each treatment group?
The experimental and control groups had relatively similar mean PCMI scores in the fall. The experimental group’s mean score is 2.33 with a standard deviation of .59, and the control group’s mean score is 2.37 with a standard deviation of .54. In the spring, the experimental group’s mean score is 2.77 with a standard deviation of .48, and the control group’s mean score is 2.55 with a standard deviation of .56. The difference between the fall and spring scores in the experimental group is .44, and the difference between the fall and spring scores in the control group is .19. The experimental group had a greater difference in PCMI scores, therefore showing more improvement in instruction in mathematics from the fall to the spring. The experimental group’s significance level is .00, and the t value is 4.27. The control group’s significance level is .05, and the t value is 1.79. Both groups showed a significant improvement in teaching practices; however, the experimental group showed greater improvement in practices from the fall to the spring. Teachers who used the ELAS-M had improved instruction in mathematics more than the teachers who did not use the performance-based assessment.

Table 4

*Paired t-tests: Changes in PCMI Score from Fall to Spring by Treatment*

<table>
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<tr>
<th>Group</th>
<th>Fall Mean</th>
<th>SD</th>
<th>Spring Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>t value</th>
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<td>2.55</td>
<td>.56</td>
<td>.19</td>
<td>1.79</td>
<td>.05</td>
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</tbody>
</table>

Note: sample size experimental=21, control=20
An independent $t$-test was used to test the differences in teaching practices in the fall and then spring between the experimental and control groups in each district to determine if implementation of the performance-based assessment significantly changed practices by group. Table 5 shows the results of this analysis.

Table 5

*Independent $t$-tests: Differences between Treatment on PCMI Scores in Fall and Spring by District*

<table>
<thead>
<tr>
<th>District</th>
<th>Experimental</th>
<th>Control</th>
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<th>Significance</th>
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<td>Mean SD</td>
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<td></td>
</tr>
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<tr>
<td>Spring</td>
<td>2.73 .56</td>
<td>2.29 .41</td>
<td>1.56</td>
<td>.08</td>
</tr>
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</table>

Note: sample size experimental=6, control=6

<table>
<thead>
<tr>
<th>District</th>
<th>Experimental</th>
<th>Control</th>
<th>$t$ value</th>
<th>Significance</th>
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</thead>
<tbody>
<tr>
<td>B</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>2.25 .43</td>
<td>2.69 .48</td>
<td>1.82</td>
<td>.05</td>
</tr>
<tr>
<td>Spring</td>
<td>2.69 .26</td>
<td>3.08 .52</td>
<td>1.79</td>
<td>.05</td>
</tr>
</tbody>
</table>

Note: sample size experimental=7, control=7

<table>
<thead>
<tr>
<th>District</th>
<th>Experimental</th>
<th>Control</th>
<th>$t$ value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>2.30 .83</td>
<td>2.29 .65</td>
<td>.03</td>
<td>.50</td>
</tr>
<tr>
<td>Spring</td>
<td>2.88 .60</td>
<td>2.26 .33</td>
<td>2.41</td>
<td>.02</td>
</tr>
</tbody>
</table>

Note: sample size experimental=8, control=7
A one-tailed independent $t$-test was conducted separately in the fall and spring for each district. District A showed a significant difference in fall PCMI scores between the experimental and control groups. The $t$ value is 1.81, and the significance is .05. However, there was no significant difference between both groups' spring scores. District B showed significant differences in both fall and spring teaching practices between the experimental and control groups. In the fall, the $t$ value is 1.82, and the significance is .05. In the spring, the $t$ value is 1.79, and the significance is .05. District C showed no significant difference in the fall teaching practices between the experimental and control groups. However, there was a significant difference between the experimental and control groups' spring scores. The $t$ value is 2.41, and the significance is .02.

Even though there were no significant differences in District A's experimental and control groups' spring scores, there was a larger mean difference between the experimental group's fall to spring scores when compared to the control group's fall to spring scores. The experimental group's mean difference is .26, and the control group's mean difference is .20. Therefore, teaching practices in mathematics improved slightly more for those using the performance-based assessment.

District B showed significant differences between the experimental and control groups' spring and fall scores. The experimental group's mean difference from fall to spring is .44, and the control group's mean difference from fall to spring is .39. The experimental group did improve their teaching practices at a higher rate than the control group. However, the results indicate that for both the fall and spring, teachers in the control group had higher performance on the PCMI than teachers in the experimental group.
In District C, the mean difference from the fall to the spring in the experimental group is .58, and the mean difference from fall to spring in the control group is -.03. The experimental group improved their teaching practices more than the control group. The control group’s teaching practices did not improve from the fall to the spring.

Overall, the teachers in District C improved their instructional skills in mathematics when implementing a performance-based assessment compared to the control group without the intervention, since the spring scores between groups are significant. The performance-based assessment did significantly improve teaching practices, although the performance of the control group remained higher. In District A, there is a significant difference in the fall scores between the control and intervention, and in District B, there is a significant difference in the fall and spring scores between the control and intervention groups.

The districts’ scores were examined further by analyzing PCMI mean scores for each item as well as the two PCMI subscale mean scores. The next discussion involves areas in which teachers changed their instruction in either providing math-related materials or encouraging mathematical concepts with children.

Subsidiary Questions 1 and 2

How have math-related materials in the classroom environment and teachers’ encouragement in supporting mathematical concepts changed after the implementation of the ELAS-M compared to the teachers who did not implement a performance-based assessment in mathematics?

Initially, the experimental and control groups’ differences between the fall and spring scores for each indicator in the PCMI were studied to distinguish the
improvements specific to certain mathematical materials and concepts. Tables 6 and 7 present the experimental and control groups' overall PCMI fall and spring means for each indicator as well as differences to demonstrate where improvements in instruction or lack of improvement occurred.

The greatest differences between the experimental groups' mean fall and spring PCMI scores for each indicator appeared to occur in the Encouragement of Mathematical Concepts subscale of the PCMI. Specifically, instructional skills in relation to teachers' encouragement of geometry and spatial positions/relations showed the most improvement, with a .95 mean difference; teachers' encouragement of counting and writing numbers for a purpose showed a .91 mean difference between the fall and spring PCMI scores. However, the score for the experimental group teachers' encouragement of one-to-one correspondence decreased from the fall to the spring, with a difference of -.33.

Table 6

*Experimental Group Differences in Instruction from Fall to Spring Using the PCMI*

<table>
<thead>
<tr>
<th></th>
<th>Fall</th>
<th>Spring</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Materials</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Materials for counting, comparing, estimating, and recognizing number symbols.</td>
<td>3.76</td>
<td>4.10</td>
<td>.34</td>
</tr>
<tr>
<td>2. Materials for measuring and comparing amounts: volume, weight, length, height, distance.</td>
<td>3.05</td>
<td>3.62</td>
<td>.57</td>
</tr>
<tr>
<td>3. Materials for classifying and seriating.</td>
<td>2.95</td>
<td>3.24</td>
<td>.29</td>
</tr>
<tr>
<td>4. Materials for geometry and spatial positions/relations.</td>
<td>3.52</td>
<td>3.67</td>
<td>.15</td>
</tr>
<tr>
<td><strong>Subscale Mean Score</strong></td>
<td>3.49</td>
<td>3.65</td>
<td>.16</td>
</tr>
<tr>
<td><strong>Mathematical Concepts/Interactions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Teachers encourage one-to-one correspondence. 2.00 1.67 -.33
6. Teachers encourage children to count and/or write numbers for a purpose. 2.76 3.67 .91
7. Teachers encourage children to estimate and compare numbers. 1.62 2.24 .62
8. Teachers encourage children's use of mathematical terminology and reflection on mathematical problems. 1.62 2.05 .43
9. Teachers encourage children to measure and compare amounts, volume, weight, length, height, distance, and area. 1.38 1.95 .57
10. Teachers encourage children to classify and seriate. 1.52 1.90 .38
11. Teachers encourage concepts of geometry and spatial positions/relations. 1.43 2.38 .95
Subscale Mean Score 1.76 2.27 .51

The greatest differences between the control groups' mean fall and spring PCMI scores occurred in the Mathematical Concepts subscale, with a mean difference of .70 in the item related to the encouragement of measurement and comparing amounts. The second biggest gain in instruction was a .60 mean difference in the encouragement of counting and writing numbers for a purpose. Mean scores for two PCMI indicators did not change from the fall to the spring. Those indicators were related to the encouragement of classification and seriation as well as materials for geometry and spatial relations. The least amount of gain in instruction occurred in the encouragement of one-to-one correspondence, with a -.80 decrease in the score for the item from the fall to the spring.

Table 7

Control Group Differences in Instruction from Fall to Spring Using the PCMI
<table>
<thead>
<tr>
<th>Materials</th>
<th>Fall Mean</th>
<th>Spring Mean</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Materials for counting, comparing, estimating, and recognizing number symbols.</td>
<td>3.65</td>
<td>4.10</td>
<td>.45</td>
</tr>
<tr>
<td>2. Materials for measuring and comparing amounts: volume, weight, length, height, distance.</td>
<td>3.10</td>
<td>3.30</td>
<td>.20</td>
</tr>
<tr>
<td>3. Materials for classifying and seriating.</td>
<td>2.95</td>
<td>3.15</td>
<td>.20</td>
</tr>
<tr>
<td>4. Materials for geometry and spatial positions/relations.</td>
<td>3.65</td>
<td>3.65</td>
<td>.00</td>
</tr>
<tr>
<td>Subscale Mean Score</td>
<td>3.34</td>
<td>3.55</td>
<td>.21</td>
</tr>
<tr>
<td>Mathematical Concepts/Interactions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Teachers encourage one-to-one correspondence.</td>
<td>2.05</td>
<td>1.25</td>
<td>-.80</td>
</tr>
<tr>
<td>6. Teachers encourage children to count and/or write numbers for a purpose.</td>
<td>2.70</td>
<td>3.30</td>
<td>.60</td>
</tr>
<tr>
<td>7. Teachers encourage children to estimate and compare numbers.</td>
<td>1.55</td>
<td>2.05</td>
<td>.50</td>
</tr>
<tr>
<td>8. Teachers encourage children's use of mathematical terminology and reflection on mathematical problems.</td>
<td>1.70</td>
<td>1.95</td>
<td>.25</td>
</tr>
<tr>
<td>9. Teachers encourage children to measure and compare amounts, volume, weight, length, height, distance, and area.</td>
<td>1.45</td>
<td>2.15</td>
<td>.70</td>
</tr>
<tr>
<td>10. Teachers encourage children to classify and seriate.</td>
<td>1.45</td>
<td>1.45</td>
<td>.00</td>
</tr>
<tr>
<td>11. Teachers encourage concepts of geometry and spatial positions/relations.</td>
<td>1.80</td>
<td>1.75</td>
<td>-.05</td>
</tr>
<tr>
<td>Subscale Mean Score</td>
<td>1.81</td>
<td>1.99</td>
<td>.18</td>
</tr>
</tbody>
</table>

Overall, both the experimental and control groups' itemized scores show high rates of instructional improvement in the encouragement of counting and writing numbers for a purpose, estimating and comparing numbers, and measuring and
comparing amounts as well as providing materials for counting and comparing. Both groups demonstrated a lack of or minimal instructional improvement in providing materials for geometry and spatial relations and encouraging one-to-one correspondence. There may have been a lack of evidence in encouraging one-to-one correspondence throughout the preschool day because children were already functionally counting. There may have been a lack of understanding of what materials are needed to promote geometry and spatial relations. Also, the ELAS-M may have not provided a clear understanding of both areas. Continued investigation in these areas is needed.

The study further explored the overall differences in fall to spring PCMI scores for the control group compared to the experimental group to determine if implementing the performance-based assessment resulted in significant change in the improvement of teaching practices specifically related to the two PCMI subscales, Materials and Encouragement of Mathematical Concepts (Interactions), compared to not implementing a performance-based assessment. A paired-sample $t$-test was used for this analysis. Findings are provided in Tables 8 and 9.

Table 8

**Paired $t$-tests: Changes in Experimental Group’s Subscale Scores from Fall to Spring**

<table>
<thead>
<tr>
<th></th>
<th>Fall</th>
<th>Spring</th>
<th>Mean diff.</th>
<th>$t$ value</th>
<th>Sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>3.32</td>
<td>.73</td>
<td>3.65</td>
<td>.37</td>
<td></td>
</tr>
<tr>
<td>Interactions</td>
<td>1.76</td>
<td>.62</td>
<td>2.27</td>
<td>.71</td>
<td></td>
</tr>
</tbody>
</table>

Note: sample size, experimental=21, control=20

Table 9
Paired t-tests: Changes in Control Group’s Subscale Scores from Fall to Spring

<table>
<thead>
<tr>
<th></th>
<th>Fall</th>
<th>Spring</th>
<th>Mean Diff.</th>
<th>t value</th>
<th>Sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>3.34 .79</td>
<td>3.55 .55</td>
<td>.21</td>
<td>1.47</td>
<td>.08</td>
</tr>
<tr>
<td>Interactions</td>
<td>1.81 .50</td>
<td>1.99 .71</td>
<td>.17</td>
<td>1.30</td>
<td>.11</td>
</tr>
</tbody>
</table>

Note: sample size experimental=21, control=20

A paired-sample t-test (one-tailed) was used to study the instructional differences in providing math-related materials and encouraging mathematical concepts in the experimental and control groups from the fall to the spring. The tables present the mean scores for each of those PCMI subscales in the fall and the spring for each group. The table presents any significant instructional improvements in providing math materials and encouraging mathematical thinking. The rate of improvement was also examined for each group.

Both the experimental and control groups had relatively similar mean PCMI scores in the fall for each subscale. The experimental group’s mean score for Materials is 3.32 with a standard deviation of .73, and the control group’s mean score for Materials is 3.34 with a standard deviation of .79. In the spring, the experimental group’s mean score for Materials is 3.65 with a standard deviation of .37, and the control group’s mean score for Materials is a 3.55 with a standard deviation of .55. The difference between the fall and spring materials scores in the experimental group is .33, and the difference between the fall and spring materials scores in the control group is .21. The experimental group had a greater difference in the PCMI subscale scores, therefore showing more
improvement in providing math-related materials from the fall to the spring. The experimental group's significance level is .03, and the $t$ value is 1.96. The control group's significance level is .08, and the $t$ value is 1.47. The experimental group showed a significant improvement in providing math-related materials; however, the control group did not show any significance in the increase in scores from the fall to the spring. Teachers using the performance-based assessment provided significantly more math-related materials from the fall to the spring.

In the PCMI Encouragement of Mathematical Concepts subscale, the experimental and control groups again had relatively similar mean scores in the fall. The experimental group's mean score for Encouragement of Mathematical Concepts is 1.76 with a standard deviation of .62, and the control group's mean score for Encouragement of Mathematical Concepts is 1.81 with a standard deviation of .50. In the spring, the experimental group's mean score for the Encouragement subscale is 2.27 with a standard deviation of .71, and the control group's mean score for the subscale is 1.99 with a standard deviation of .71. The difference between the fall and spring encouragement scores in the experimental group is .50, and the difference between the fall and spring scores in the control group is .17. The experimental group had a greater difference in the PCMI subscale scores, thus showing more improvement in teachers' encouragement of mathematical concepts with their children from the fall to the spring. The experimental group's significance level is .00, and the $t$ value is 4.26. The control group's significance level is .11, and the $t$ value is 1.30. The experimental group showed a significant improvement in the encouragement of mathematical concepts, and the control group did not show any significant improvement in the increase of scores from the fall to the spring.
Teachers using the performance-based assessment significantly improved their instructional skills by encouraging mathematical concepts with children.

Overall, the experimental group showed significant improvements in both PCMI subscales whereas the control group did not show any significant improvements in instructional skills related to the subscales. The teachers who used the performance-based assessment improved their instruction in mathematics by providing materials and through their mathematical interactions with children; improving interactions with children can be assumed to be more difficult to achieve than providing materials. These interactions promoted the use of mathematical concepts throughout the preschool day.

In addition, teaching practices in each of the two subscales were examined in each district using independent sample t-tests to analyze the data for each district. Table 10 provides the results from the analysis.

Table 10

*Independent t-tests: Changes in Materials and Encouragement by Treatment Group in the Fall and Spring by District*

<table>
<thead>
<tr>
<th>District</th>
<th>Experimental</th>
<th>Control</th>
<th>t value</th>
<th>Sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall materials</td>
<td>3.63 .34</td>
<td>2.88 .52</td>
<td>2.95</td>
<td>.01</td>
</tr>
<tr>
<td>Spring materials</td>
<td>3.58 .30</td>
<td>3.17 .49</td>
<td>1.77</td>
<td>.06</td>
</tr>
<tr>
<td>Fall interactions</td>
<td>1.81 .49</td>
<td>1.64 .25</td>
<td>.74</td>
<td>.24</td>
</tr>
<tr>
<td>Spring interactions</td>
<td>2.24 .80</td>
<td>1.79 .63</td>
<td>1.09</td>
<td>.15</td>
</tr>
</tbody>
</table>

Note: sample size experimental=6, control=6
A one-tailed independent *t*-test was conducted separately in the fall and spring for each district for each PCMI subscale. District A showed a significant difference in fall materials between the experimental and control groups. The *t* value is 2.95, and the significance is .01. However, there was no significant difference between the experimental and control groups’ spring scores. In addition, District A did not show a significant difference in fall and spring encouragement between the experimental and control groups. District B showed a significant difference in fall materials between the experimental and control groups. The *t* value is 2.48, and the significance is .02. This district also showed a significant difference in spring materials between the experimental
and control groups. The $t$ value is 1.80, and the significance is .05. District C showed no significant difference in the fall and spring materials as well as the fall encouragement of mathematical concepts between the experimental and control groups. The district showed a significant difference in the spring encouragement between the experimental and control groups. The $t$ value is 2.41, and the significance is .02. Overall, District C's experimental group's teaching practices in the encouragement of mathematical concepts through interactions from the fall to the spring showed the most difference compared to the other districts.

The mean difference between the fall and spring materials scores for the experimental group in District A is -.05, and the mean difference between the fall and spring materials scores for the control group is .29. The control group improved their provision of math-related materials at a greater level. The mean difference between the fall and spring encouragement scores for the experimental group in the same district is .43, and the mean difference between the fall and spring encouragement scores for the control group is .15. In this case, the experimental group's teachers increased their encouragement of mathematical concepts with children more than the control group's teachers.

The mean difference between the fall and spring materials scores for the experimental group in District B is .32, and the mean difference between the fall and spring materials scores for the control group is .11. The experimental group provided math-related materials at a greater level. The mean difference between the fall and spring encouragement scores for the experimental group in the district is .51, and the mean difference between the fall and spring encouragement scores for the control group is .55.
The control group had a slightly higher level of increased encouragement of mathematical concepts.

In District C, the mean difference between the fall and spring materials scores for the experimental group is .63, and the mean difference between the fall and spring materials scores for the control group is .25. The experimental group provided math-related materials at a greater level. The mean difference between the fall and spring encouragement scores for the experimental group in District C is .55, and the mean difference between the fall and spring encouragement scores for the control group is -.19. The experimental group's teachers increased their encouragement of mathematical concepts with children at a greater rate than the control group’s teachers.

In analyzing all districts finding regarding improvement of math-related materials for children and teachers’ encouragement of mathematical concepts, the experimental group showed the most overall improvement in teaching practices related to the encouragement of mathematical concepts, such as counting, comparing, measuring, and classifying.

The next question examines teachers' math training in relation to their teaching practices. A specific type of training may have influenced instructional supports during the implementation of the performance-based assessment.

Subsidiary Question 3

How is previous training in early childhood mathematics associated with mathematics instruction?

The teachers responded to an open-ended survey question that asked about their educational exposure to early childhood mathematics. Data were compiled and related to
the PCMI scores. The results provided an impression of instructional change differences in relation to ELAS-M or other training. Did the performance-based versus other training result in more of an improvement in mathematical instructional skills from the fall to the spring?

An analysis of teachers' math training experiences was related to their changes in teaching practices in mathematics. Differences in teachers' pre- and post-PCMI overall scores were examined. All 41 participating teachers responded to this open-ended question, which asked them to indicate prior math training. Approximately 80% responded affirmatively that they had been exposed to some type of math training. The other 20%, or 8 respondents, indicated that they had had no training. The data provided evidence regarding the type of early childhood mathematics training each participant had experienced. The teachers' responses varied, indicating previous math training such as workshops (i.e., district workshops), coursework at universities such as math classes, and ELAS-M training. The responses were easily categorized but lacked specificity, except for those who responded with ELAS-M training. However, since more than 8 teachers received ELAS-M training as part of this study, the workshop category could include those who did not specify ELAS-M training.

The results are provided in Table 11 below. Table 11 represents the number of teachers who responded to each math training category. Teachers' fall and spring PCMI scores along with the differences between those scores are analyzed.

Table 11

<table>
<thead>
<tr>
<th>Math Training Experiences in Relation to PCMI scores</th>
<th>N</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Diff</th>
</tr>
</thead>
</table>
Workshops  15  2.09  2.58  .49  
Coursework  10  2.43  2.61  .18  
ELAS-M     8  2.42  2.98  .56  
No training 8  2.66  2.58  -.08

Teachers who were part of the performance-based assessment, ELAS-M, training seemed to show the greatest gains in relation to the change in instructional skills in mathematics from the fall to the spring. The difference in PCMI mean scores for those who indicated ELAS-M training was .56. The teachers who attended workshop improved their instructional skills in mathematics by .49. Those teachers who indicated some type of math college coursework improved instruction by .18, and those who indicated no early childhood math training dropped in their PCMI scores by -.08.

Since the greatest improvement in mathematics instruction occurred with teachers who noted ELAS-M training, there seems to be an indication that participation in the ELAS-M professional development opportunities increased teachers’ abilities to support children’s math learning. Teachers who participated in workshops also improved their teaching practices in mathematics, however, not to the same degree as the ELAS-M training, as indicated in the PCMI mean score differences. Teachers who had mathematics coursework at college showed even less instructional support in this content area. Teachers who responded with “no training” showed no improvement and a decline in instructional supports, as indicated by the PCMI scores.

Overall, the responses indicated that teachers who did not receive any math training did not show any improvement in their math teaching practices, whereas the teachers who indicated ELAS-M training showed the most improvement in math teaching practices. Since teachers with ELAS-M training showed the most improvement in
practices, further training in performance-based assessment may improve instruction to
best support each child's learning. Assessment training is crucial for teachers to
understand how to use evidence collected about children to effectively inform their
teaching practices (Meisels, 1999).

Preschool teachers' feelings about teaching mathematics were also investigated in
the experimental groups of all three districts. What were teachers' feelings about
mathematics during the implementation of the performance-based assessment? The
teachers' feelings regarding mathematics also may have affected their instructional skills
in this study.

*Subsidiary Question 4*

What are preschool teachers' feelings about teaching mathematics after having the
experience of implementing the ELAS-M?

The second open-ended survey question in this study asked teachers how they felt
about teaching math or their experiences with teaching math. The question was asked
during the spring months of teachers' implementation of the performance-based
assessment. The data were organized into categories to provide purposeful information
regarding participants' feelings after implementing the performance-based assessment in
mathematics, the ELAS-M. In all three districts, 95.23% of the total subject population
assigned to the experimental group responded to this survey question.

The participating teachers were asked, "What are your feelings about or
experiences with math and teaching math?" Several overarching themes have been
identified from the ELAS-M participants' responses. The statements such as "math is all
around" and "math is everywhere" emerged as a noticeable theme.
Fifty percent of the ELAS-M teachers responded to the question by stating how they now see math in everything they do. For example, teachers noted how math is everywhere in the classroom after being made aware of all the mathematical concepts from implementing the ELAS-M. Respondent F stated that, “Since ELAS-M, I now involve math in everything I do, and the kids get it” (questionnaire, May, 2007). Respondent G stated that she enjoys math and she “tries to work it in all day” (questionnaire, May, 2007). Another positive statement is from Respondent O who “likes teaching math because it’s always around us” (questionnaire, May, 2007). The responses suggest that the teachers came to view mathematics not necessarily as a subject area that should be taught in separation but content that should be embedded throughout children’s experiences. Mathematics can be emphasized in regular routines, which is more meaningful to preschool children than a block of instruction targeting certain concepts.

Greater integration of math content was evident among many teachers’ responses, indicating that mathematics can occur throughout the preschool day. Respondent A said, “Math should be hands-on and integrated into the curriculum” (questionnaire, May, 2007). Respondent F said, “Math is all around and not difficult to incorporate into the classroom” (questionnaire, May, 2007). In addition, respondent G stated, “It is good to incorporate it into everyday learning and make it a natural part of life” (questionnaire, May, 2007). Respondent H said, “I teach math through . . . conversations during free play” (questionnaire, May, 2007). Respondent Q stated, “I always try to incorporate math” (questionnaire, May, 2007). The implementation of the performance-based assessment showed a genuine understanding of how math learning can be supported in everyday events.
The survey question also generated responses related to children's learning outcomes in terms of teaching practices in mathematics after the implementation of the ELAS-M. For instance, respondent C stated that, “Now that I’m doing the ELAS, I am much more aware and likely to plan math activities for all” (questionnaire, May, 2007). Respondent D said, “Now I have more success in teaching since the study started” (questionnaire, May, 2007). Respondent E stated, “The kids are really learning with the ELAS-M” (questionnaire, May, 2007). Respondent R confirmed by saying, “I am doing more math teaching since the ELAS” (questionnaire, May, 2007). Students’ learning in relation to instruction was the focus of the implementation of the performance-based assessment, and the teachers’ responses show a greater commitment to math instruction.

Teachers’ feelings regarding mathematics usually influence their instructional skills (Goldsmith & Schifter, 1997). Another theme that was raised from the open-ended responses was the “enjoyment or love of math.” Again, when asked, “What are your feelings about or experiences with math and teaching math?,” one-third of the teachers reported a positive feeling during the implementation of the ELAS-M. Respondents B, D, and L all stated, “I love math” as well as respondent E who stated, “I like math.” “I enjoy math” or “I enjoy teaching math” was recorded in respondents’ G, K, and M’s surveys. Since research has shown that teachers’ feelings about mathematics impact their instruction, these responses may have positive implications for instruction (Jones, 1997).

The implementation of the ELAS-M seemed to positively influence the teachers’ attitudes in teaching mathematics. The teachers’ responses indicated a better understanding of “everyday, everywhere” mathematics and an enjoyment in teaching mathematics. If teachers’ attitudes are positive regarding instruction in math, can student
learning be enhanced because of the eagerness to instruct in the content area? There
seems to be a positive association between ELAS-M implementation and feelings about
teaching in the subject area.

Summary

This study explored the impact of implementing the ELAS-M on teachers’
instructional skills in mathematics. There has been heightened attention regarding
teachers’ support of children’s mathematical development to provide their students with
the confidence and skills to perform well mathematically throughout their education.
Teachers’ support, in this study, was defined as providing students with math-related
materials and encouraging mathematical concepts with children throughout the preschool
day. Since assessment and curriculum depend on each other in high-quality preschool
programs, the impact of implementing a performance-based assessment in mathematics
was explored to determine if teaching practices in mathematics improved when teachers
implemented a performance-based assessment.

Quantitative data were gathered to examine the influence of using performance
assessment by comparing pre- and post-PCMI scores for experimental and control
groups, for each of the two subscales in the PCMI: providing math-related materials and
encouraging mathematical concepts with children. Qualitatively, core concepts were
gleaned from common themes from the survey, which related teachers’ feelings about
math to the implementation of the ELAS-M. Other descriptive variables were also
obtained to provide a broader picture of the study. Findings from the research questions
are indicated below.
Instructional skills in mathematics for the experimental and control groups improved significantly from the fall to the spring with the teachers in the experimental group showing more significant improvement in teaching practices. The performance-based assessment was associated with improved teaching practices in mathematics. The study also revealed marginal differences between the pre- and post-PCMI scores after ELAS-M implementation compared to the teachers who did not use a performance-based assessment in mathematics. District B represented the most improvement in mathematical teaching practices when teachers implemented the ELAS-M. Since the district’s fall and spring mean PCMI scores were significantly different for the experimental and control groups, findings indicated that the performance-based assessment significantly improved instruction.

In addition, when the PCMI subscales were analyzed separately in this study, the experimental group showed improvement in instruction in both subscales, especially in the encouragement of mathematical concepts. Teachers who implemented the performance-based assessment were associated with encouraging children to use mathematical concepts throughout the preschool day. There was also a significant change in the experimental group’s use of math materials from the fall to the spring. Teachers provided more math-related materials for children to use in the classroom to support learning various mathematical concepts. Again, District C showed the most improvement; the teachers provided significantly greater encouragement of concepts in the spring than in the fall.

In addition, participants who participated in training in ELAS-M had a greater difference between their pre- and post-PCMI scores. Respondents noted in a survey any
previous math training in early childhood mathematics. There appeared to be a larger
difference with the respondents who indicated ELAS-M in their previous mathematics
training compared to other responses that indicated another type of training.

Distinctive themes emerged from ELAS-M respondents’ answers to another open-
ended survey question. The statements such as “math is all around,” “integrate math,”
“much more aware of math activities for all,” and “enjoyment in teaching math,”
emerged as major themes. The question generated responses indicating an overall sense
of greater understanding of math teaching practices in relation to children’s learning.
Through the understanding of math development, an apparent enjoyment and ability to
see math everyday emerged for the teachers who used the performance-based assessment.

Overall, the propositions were confirmed. Teachers’ instructional skills in
mathematics did improve overall when they implemented the performance-based
assessment, ELAS-M. Teachers who implemented the performance-based assessment had
significantly better instructional skills in mathematics.
Chapter 5:

Conclusions and Recommendations

Major Findings

The findings indicate that implementing the ELAS-M is associated with changes in instructional skills in mathematics. The districts showed significant improvements in math teaching practices, which were measured by the PCMI, when teachers used the ELAS-M as their performance-based assessment for supporting children’s mathematical development. The experimental group showed a significant improvement in teaching practices from the fall to the spring. Teachers were able to see the strong connection between their practices and children’s learning when using a performance-based assessment (Baron & Wolf, 1996). Instruction appears to be associated with improvement with the use of authentic assessment (NAEYC & NAECDS, 1991).

Teachers are responsible for adjusting their instruction based on their children’s development and learning in mathematics (NCTM, 1991). By using a performance-based assessment in mathematics, teachers reflected on anecdotes relating to children’s learning experiences. Teachers then intentionally planned for instruction, such as providing more measuring materials in their centers to support learning in measurement and asking children to measure items in the classroom. Teachers observed their children’s learning and used the anecdotes and work samples collected to adjust their instruction according to each child’s needs (Gordon & Bonilla-Bowman, 1996). Research shows that teachers learn about their individual children to a greater degree when they review and reflect upon their children’s work (Seidel, 1998). The performance-based assessment helped teachers make ongoing decisions regarding their practice in relation to children’s
learning. Clements (2004) stated that the primary goal of assessment in the early years of schooling should be focused on understanding children's development to instructionally support further learning. The adjustment of instruction based on children's development can improve children's outcomes in mathematics (Bowman et al., 2001).

In addition, teachers' feelings regarding mathematics seemed to be affected positively during the implementation of the ELAS-M. The trend in the responses to the open-ended survey question in this study showed an awareness of teachers' understanding of how mathematics can be a natural part of learning in preschool classrooms and how mathematics is embedded in many routine experiences. Teachers needed to understand children's mathematical development in order to feel confident and positive about teaching this subject in a developmentally appropriate manner (Jones, 1997). The teachers stated that they now understood how math is everywhere and learning experiences for children can be integrated throughout the preschool day. The ELAS-M provided teachers with a guide to how children's development looks in various mathematical areas, such as numerical operations, functional counting, geometry, classification, and spatial relations. The performance-based assessment helped teachers learn about early childhood mathematics, which helped the instructors provide meaningful and purposeful mathematical experiences for their children (Goldsmith & Schifter, 1997).

Using a performance-based assessment for preschool children specifically in math can possibly change instruction, which influences attitudes regarding teaching mathematics. The teachers in the experimental group for the most part expressed positive feelings about teaching mathematics while implementing the performance-based
assessment. Understanding how children learn at this age level in conjunction with using a performance-based assessment allowed teachers the opportunity to concentrate their attention on mathematics in their preschool classrooms. Teachers' positive feelings regarding mathematics may have added to the significant improvement in instruction (Thompson, 1984). The regular opportunities to reflect on evidence collected for each child may have encouraged differentiated instruction for participating children. Teachers' reflections on their evidence collected for each child naturally provided professional learning opportunities in early childhood mathematics, especially with the support of master teachers.

Meeting with master teachers on a regular basis may have a positive impact on teachers' understanding of children's math understanding. However, this was not examined extensively in the study. There could have been possible contamination based on the depth of the master teachers' conversations with teachers simply because of better discussions regarding early childhood development, and as a result, teaching practices are improved. The teachers in the experimental group met monthly with master teachers and discussed specific children's mathematical learning in relation to the assessment. The ELAS-M Age-by-Age Accomplishments were used to determine where each child fell on the continuum based on anecdotes and/or work samples. The master teacher acted as a mentor or coach, asking questions about the child's learning as well as the teaching practices that influenced mathematical thinking. The questions asked in each postconference session came from the master teachers' reflective log. The master teachers handed in their responses to these reflective log questions at the end of the study. Questions in the log can be found in Appendix D.
The conversations were reflective and open-ended, based on a cognitive coaching model (Costa & Garmston, 2002). The purpose of the monthly sessions was to have each teacher refer to the ELAS-M while discussing individual children’s mathematical learning to inform instruction. The goal was to support each child’s development and learning in mathematics by adjusting one’s instruction accordingly. Previous studies have indicated that teachers who participated in cognitive coaching improved teaching practices compared to teachers who were not involved (Edwards & Newton, 1995). The depth of reflective practice was not measured for purposes of this study; therefore, the level of the implementation of the reflective cycle is unknown beyond the mechanics of answering the questions indicated in the log.

The teachers and master teachers both felt that the time to discuss the ELAS-M Age-by-Age Accomplishments in relation to a child’s learning was valuable and offered insight on how teaching practices strongly influence children’s experiences in mathematics. Since the Age-by-Age Accomplishments are based on the New Jersey Preschool Teaching and Learning Expectations: Standards of Quality – Mathematics, the ELAS-M teachers had constant reinforcement of the state’s expectations in mathematics for preschool children by using the performance-based system and having monthly discussion with master teachers. Master teachers and teachers expressed a better understanding of early childhood mathematics after using the ELAS-M. Adjusting teaching practices to meet the needs of each child mathematically was a main component of the postconference session, which reinforced the connection between teaching practices and student outcomes. Through this process, instruction became more informed and meaningful (Curtis & Carter, 2000).
Using a performance-based assessment in mathematics can possibly improve instructional skills in this domain in the state (New Jersey Department of Education, Division of Early Childhood Education, ELIC Report, 2007). Based on the ELIC reports each year, teachers are minimally integrating mathematical practices within their preschool day; therefore, there is a lack of support of children's development in mathematics. Performance-based assessment with individualized professional development may be the solution to improve instruction in mathematics.

Recommendations for Future Research

Performance-based assessment is associated with change in teaching practices in this study; however, a larger sample size could have increased the significance of the implementation, and the ability to run analyses that allow causal conclusions. The study indicates that preschool programs throughout the state as well as in other states should implement a performance-based assessment in mathematics to support effective teaching practices for preschool children. Further research should include examining the implementation of ELAS-M or other performance-based assessment for several years. The implementation of a performance-based assessment for several years may improve teachers' beliefs and practices, which may increase children's learning.

The performance-based assessment in mathematics should be implemented in all of the Abbott districts' preschool programs along with looking at children's other developmental domains. Research has indicated that socioeconomic status can relate to children's mathematical learning (Clements & Sarama, 2004). Many studies indicate that low-income children are delayed in their mathematical skills when they enter school (Ginsburg & Russell, 1981). Clements (2001) stated that the socioeconomic status
differences as early as the preschool years are either widened or narrowed based on instructional practices in school. Therefore, the need to support children’s mathematical learning at an early age is necessary, especially with poor children (Starkey & Klein, 2000). Learning in the first 6 years of life can have lasting effects (Bowman et al., 2001). The need for longitudinal studies to track children’s mathematical performance in preschool, kindergarten, first, second, and beyond third grade is critical to truly determine the long-term outcomes of performance-based assessment in the math content area for children from lower socioeconomic backgrounds. If authentic assessment and a good attitude toward learning about children’s math development can improve teachers’ instructional skills (Darling-Hammond & Ancess, 1996), then the next steps include teachers learning to look at children’s performances at all grade levels using authentic assessment. The major problem with performance-based assessment in the present literature is that there is minimal research on long-term effects of this type of assessment, specifically in mathematics.


Studies should also be conducted to determine quality teaching practices noted by a specific classroom structured observation tool in mathematics such as the PCMI in
preschool classrooms. Mathematics scores should be aggregated each year to determine each grade level’s teaching practices in mathematics. The data will show if the performance-based measure does improve instructional skills from year to year in various grade levels.

In addition, each grade level should dedicate time to a cognitive coaching model for more of an individualized, job-embedded, professional development opportunity for teachers (Costa & Garmston, 2002). If a master teacher is not funded, teachers can coach each other if district administration provides the time within their contracted day. More research needs to be done to determine the effects of cognitive coaching on instruction and ultimately student outcomes in relation to implementing a performance-based assessment.

Policy Implications

As a result of the study’s findings, a performance-based assessment should be the main assessment for teachers to inform their instruction to meet the needs of each child in their preschool classrooms. Young children in preschool are difficult to assess because their development is varied and highly influenced by their environmental supports in and out of the school setting (National Education Goals Panel, 1998). Since young children’s learning differs considerably from older children’s learning, assessments must be adjusted to address the needs and abilities of our youngest students. “Tests given at one point in time may not give a complete picture of learning” (National Education Goals Panel, 1998, p. 4). Policies must be developed at all state and local levels to support authentic assessments in early childhood settings. In the New Jersey Department of Education, regulations have been established in relation to assessment at the preschool

Policies at the national, state, and local levels must stress the importance of using performance-based or authentic assessment in early childhood settings as well as provide guidance on the use of the system. The National Education Goals Panel (1998) stresses the effectiveness of observing and recording children's behavior in their natural environment on an ongoing basis to meet each child's needs. The alignment of developmentally appropriate assessments in the early childhood field must occur at all levels for seamless transitions for our youngest learners.

Even though much research has proved that standardized tests do not reflect children's true abilities at the preschool level (NAEYC & NAECS, 1991), the push to standardize at this grade level has unfortunately occurred because of greater accountability for children's performance, especially due to the No Child Left Behind (NCLB) Act. Standardized testing methods in early childhood settings should be highly scrutinized. Standardized tests are not appropriate to inform instruction in preschool classrooms (Meisels, 1999). "External accountability testing should be postponed until third grade because of the difficulties in testing young children" (National Education Goals Panel, 1998, p. 11). These tests do not assess children's learning in a nonthreatening, familiar context in which children feel comfortable with expressing their skills and wide range of abilities. Assessments at this grade level should consist of collections of evidence throughout the school year, which demonstrates children's
learning and development (Darling-Hammond & Ancess, 1996). Specific purposes for assessments used in preschool classrooms should be written in guidance and policy documents at local and state levels.

Administrators must be knowledgeable about best practices in relation to each state’s Administrative Code and, more importantly, follow best practice to best meet the needs of preschool children. Therefore, professional development on performance-based assessment and how to monitor children’s progress in early childhood settings should be provided by state departments of education. Since policymakers and taxpayers question children’s progress in the early grade levels, administrators must understand how to reliably collect information on children without using abused standardized measures. Performance-based assessments at the preschool level should never be used for high-stakes decisions because children’s development is so variable and reliability is questionable because of teachers’ biases. Therefore, structured classroom observation tools should be used to measure classroom quality and teaching practices. These data in conjunction with performance-based assessment can provide school districts and centers with information on program quality as well as student’s performance. Again, state departments of education nationally and internationally should, if not already, develop plans to track quality in early childhood settings and reinforce the importance of using performance-based assessments.

Master teachers or peer coaches should follow established standards in their reflective practice with teachers in using performance-based assessments to have a better understanding of the cognitive coaching process. Videotaping each component of the cycle while aligning the footage to the standards in each component of the reflective
cycle can provide teachers with a vision of how good coaching practice occurs. The planning conference, classroom visit, postconference, and follow through next steps/changes in teaching practices must be documented to align practice to a rubric rating the essentials of each component. Policies should be developed to study the impact this job-embedded professional development endeavor. Can understanding child development through a collegial learning process empower teachers to reexamine and change their practices to better meet the needs of each child they serve?

This study concentrated on a specific content area to determine the impact of a performance-based assessment on teaching practices in mathematics. However, early childhood educators should be using a performance-based assessment that not only analyzes children’s mathematical development and learning but also analyzes children’s development in other domains. By looking at the whole child while using a comprehensive performance-based assessment, teachers can obtain a better understanding of each child’s holistic development. “Assessments of young children should address the full range of early learning and development” (National Education Goals Panel, 1998, p. 6).

The purpose of focusing on one domain area in the study was a result of the need to improve instructional skills in mathematics to support children’s math learning. Understanding how to inform one’s instruction based on the child data generated from the assessment continues to be a strenuous battle to truly understand and systematically implement. Considerable time to truly understand how children develop during the preschool years is necessary for effective instruction (Ginsberg et al., 2008). Intentional
time to reflect on one's teaching practices in relation to students' learning is crucial in the implementation of performance-based assessment.

Summary

State departments' early childhood offices should, if not they have not already, develop policies on using performance-based assessments in early childhood. In searching for formative assessments, standardized measures have proved to be ineffective and not a true measure of children's abilities at these early grade levels. Therefore, why subject our youngest learners, in the beginning of their educational careers, to tests that do not genuinely measure skills in mathematics as well as other areas? The NAEYC position statement on assessment has been regarded as quality solid research and should be followed in each district's early childhood department. The testing craze effects of NCLB should be analyzed to determine if performance-based measures can replace useless standardized tests, which usually produce a lack of information, for teachers to improve their instructional skills for each child in the classroom.

Therefore, as much as there is a need to use a holistic performance-based assessment, one also needs to consider the level of teachers' understanding of how to use these authentic assessments before considering too many items one must study in their classrooms. Differentiated instruction for teachers should occur as well as for the children. Universities should align their child development and performance-based assessment-related courses to high and consistent standards. Emphasis on culturally appropriate assessments that allow a true understanding of children's learning should be required content addressed in higher education.
Teachers should use assessments to reflect upon their instructional skills and adjust practices and environmental supports accordingly to effectively support every child’s learning in the classroom (National Education Goals Panel, 1998). By developing policies for more appropriate assessments at the early childhood level to improve teachers’ understanding of students’ learning, standardized tests will be less likely to “trickle down” into preschool classrooms. Administrators can then lead through best practice for the good of the children and provide them with a strong foundation in mathematics.
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Appendix A

Early Learning Assessment System – Mathematics (ELAS-M)

Preschool Age-by-Age Accomplishments

The New Jersey Early Learning Assessment System – Mathematics (ELAS-M) was developed by Renee Whelan, Judi Stevenson Boyd & Dr. Ellen Frede. Research for the ELAS-M was funded through the New Jersey Department of Education.

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ELAS-M © 2000 Department of Education, Preschool Age by Age Accomplishments
### Expectation 1: Child demonstrates an understanding of number and numerical operations.

Which point on the continuum best describes the child's current level of performance?

<table>
<thead>
<tr>
<th>One-to-One Correspondence</th>
<th>Counting Words</th>
<th>Functional Counting</th>
<th>Numerical Operations</th>
<th>Written Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.<strong>Matches two small sets of items that go together and have the same number (e.g., puts one cup on each of the four saucers when setting the table; puts the three knobby shape pieces in their places on the puzzle; takes four easel brushes and puts one in each of the four paint cups)</strong></td>
<td>2.<strong>Recites counting words up to five</strong></td>
<td>3.<strong>Demonstrates interest in numbers and counting (e.g., says she's two years old but holds up three fingers)</strong></td>
<td>4.<strong>Experiments with combining and taking away items</strong></td>
<td>1.<strong>Identifies numerals in the environment and distinguishes them from letters (e.g., room number, phone digits)</strong></td>
</tr>
<tr>
<td>2.<strong>Demonstrates beginning understanding of one-to-one correspondence by matching two sets of items (e.g., given a pile of napkins and hands one to each child at the snack table; puts one animal on every block; places one car in each parking space)</strong></td>
<td>3.<strong>Recites counting words in a fixed order up to twenty</strong></td>
<td>4.<strong>Begins to assign a number when pointing to each item while counting (places the buttons in a row and says, &quot;One, two, three, six, ten&quot;)</strong></td>
<td>2.<strong>Understands that there are more when two sets are combined or less when some are taken away</strong></td>
<td>2.<strong>Begins to read and write numerals (e.g., child writes 1111 on clipboard and says that the plant is a lot of feet tall)</strong></td>
</tr>
<tr>
<td>3.<strong>When matching two sets of items, demonstrates beginning understanding of equivalence (e.g., puts four grapes and then five goldfish on the plate and then eats a goldfish and says, &quot;Okay, now it's the same.&quot;)</strong></td>
<td>4.<strong>Recites counting words higher than twenty and may attempt to count backwards</strong></td>
<td>3.<strong>Correctly assigns a number to each item while counting five or fewer items (e.g., counts the four ants crawling on the sidewalk outside)</strong></td>
<td>3.<strong>Adds or subtracts one item in groups of less than five items (e.g., child gets three baby socks but then puts one back before dressing the doll)</strong></td>
<td>3.<strong>Reads and writes numerals and connects to quantity (e.g., child notices the number five on the lunch sheet and tells the teacher there are five orders of pizza today)</strong></td>
</tr>
<tr>
<td>4.<strong>Uses number to explain how many items will be needed for a second set (e.g., teacher asks, &quot;How many cups will you need for your table?&quot; child says, &quot;Seven.&quot; after counting the amount of children seated; child says that she needs four dinosaurs for her four towers)</strong></td>
<td>1.<strong>Assigns a number to each item while counting and understands that the last number indicates how many (e.g., child climbs up the steps on the playground and teacher asks, &quot;How many steps did you climb?&quot; child says, &quot;Six.&quot;)</strong></td>
<td>2.<strong>Begins to compare amounts of items in different contexts by using words such as more, less and the same (e.g., breaks graham crackers into pieces and says, &quot;Now I have more!&quot;)</strong></td>
<td>4.<strong>Adds or subtracts a few items in groups of five or more items (e.g., teacher says, &quot;I need seven pencils.&quot; and only has five, child gets two and gives them to the teacher and says, &quot;Now you have seven.&quot;)</strong></td>
<td></td>
</tr>
</tbody>
</table>
Things to consider

For what purposes does the child use number words during play activities?
What counting skills does the child display independently?
In what ways does the child group together or take away objects? Does the child match sets of items?

Ways to collect evidence

Observe children as they use materials throughout the room such as buttons, bottle caps, cotton balls, unit blocks, counting bears, figurines, cars w/garage, pegs & peg boards, rocks, shells, leaves, egg cartons & beans, snap-together blocks, cash registers w/money, puzzles, board and computer games, calculators, scales, number books, plates & cups w/placemats, etc.
Look for children counting items, using number words, matching, adding and subtracting, writing and reading numbers.

Plan small group activities that encourage children to use one-to-one correspondence in various contexts throughout the day. Count within the regular routine, write numbers for a purpose, add and subtract items, and compare written numbers and amounts.

Ask questions and make comments
During play, watch for children counting and comparing objects and ask "how many"
"I wonder if you have more than me."
"How many more/less in this group?"
During greeting, ask children how many friends are absent and ask "How did you figure out two children are missing?"
"Can you get enough plates for your friends?"
"Help me write your weight on this graph."

Model new possibilities to observe how children respond to your ideas
"I'm going to write how many children are having macaroni and cheese today on the graph."

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ELAS-M © 2006 Department of Education, Preschool Age by Age Accomplishments, Page 2
Expectation 2: Child demonstrates emerging knowledge of spatial concepts, measurement, and geometry

Which point on the continuum best describes the child's current level of performance?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Identifying and using Shapes</strong></td>
<td><strong>Measurement</strong></td>
<td><strong>Positional relationships</strong></td>
<td><strong>Spatial relationships</strong></td>
</tr>
<tr>
<td>Manipulates different objects that fit together in space (e.g., pieces blocks inside containers, uses cups to fill up small and large buckets)</td>
<td>Demonstrates understanding of extreme differences in size. (e.g., on the playground, says, “I want the big bike, not the baby one”)</td>
<td>Demonstrates understanding of positional descriptions by using or responding to words such as “in,” “on,” and “under” (e.g., finds puzzle when teacher says it is on top of the shelf; tells friend her toy is under the blanket)</td>
<td>Builds block structures that extend in one direction, either horizontally or vertically</td>
</tr>
<tr>
<td>Identifies some familiar shapes by name in various circumstances (e.g., the square puzzle piece or the square cracker)</td>
<td>Identifies objects that are similar in size (e.g., looks at friend’s block structure and says, “Your tower is as big as mine.”)</td>
<td>Uses and responds to vocabulary describing positions of objects, using words such as “between,” “beside,” or “next to”</td>
<td>Builds block structures that extend horizontally and vertically</td>
</tr>
<tr>
<td>Identifies familiar shapes that are natural parts of the environment (e.g., the clock on the wall or a penny as a circle; the blocks placed on the rug make a rectangle)</td>
<td>With assistance, makes direct comparisons of length, weight, volume, height, or area of materials/objects in the environment (e.g., teacher asks, “Who do you think has more sand in their bucket?” Child points to side of bucket and says, “I have more because it goes up here.”)</td>
<td>Varies descriptions of positional relationships (e.g., child helps friend find toy by saying, “Your doll is right behind me.”)</td>
<td>Builds structures with height, depth, and width and constructs enclosures that have interior space</td>
</tr>
<tr>
<td>Begins exploring shape by putting together and taking apart different shapes</td>
<td>Uses measurement to explore length, height, or weight, using a common base (e.g., teacher suggests child find out how many unit blocks would line up on the edge of the rug. Child lines up blocks and says, “The rug is 10 blocks long” or uses balance scale to compare weights of objects)</td>
<td>Uses vocabulary accurately to describe direction, distance, position, and order from multiple perspectives (e.g., On playground, says, “I saw the squirrel run over the shed and then up the tree”)</td>
<td>Block structures include enclosures, extensions in multiple directions, and additional layers</td>
</tr>
<tr>
<td>Puts together different shapes to create new shapes</td>
<td>Uses knowledge of shapes to solve problems (e.g., decides which piece will fit into space in a puzzle)</td>
<td>Uses knowledge of shapes to illustrate relationships (e.g., decides which piece will fit into space in a puzzle)</td>
<td>Uses knowledge of shapes to illustrate relationships (e.g., decides which piece will fit into space in a puzzle)</td>
</tr>
</tbody>
</table>
Things to consider

What words does the child use to compare objects, describe positions, or identify shapes?
Does the child notice differences in shapes and sizes of objects?
In what ways does the child use various types of blocks when building?
How does the child put things together/take things apart?

Ways to collect evidence

Observe children as they play in the block area. How do they make decisions about which block to use, how to balance their structures, or when to stop adding on?
Watch children as they play on the playground. Look for opportunities to discuss how they are experiencing the space around them—high on the climbing structure, inside the playhouse, sitting under a tree.
Observe as children use manipulatives that allow them to explore geometrical concepts, such as geoboards, tangrams, and puzzles.
During cooking activities listen for understanding of measurement concepts.

Plan small group activities during which children can use geometric and measurement concepts such as comparing weights or sizes, observing and discussing new shapes, cooking, treasure hunts, or building in the block area.

Ask questions and make comments

During play, watch for children exploring spatial and measurement concepts
"I wonder if all of the stones you collected would fit in this box."
"Do you think you can line up your blocks to go around all of the animals?"
"How did you know which puzzle piece would fit there?"
"I think we'll take a long walk to the playground today. First, we'll go through the front door, then behind the building, under the big umbrella, and then around the toddler playground."

Model new possibilities to observe how children respond to your ideas.
"I'm going to line up all of my long blocks and then see how many short blocks it will take to make the same length."
"Look at what happened to my shapes when I put two triangles together!"
**Expectation 3: Child demonstrates an understanding of patterns, relationships and classification**

Which point on the continuum best describes the child's current level of performance?

<table>
<thead>
<tr>
<th>Classification</th>
<th>1</th>
<th>2</th>
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<tr>
<td>Explores and calls attention to similar attributes between items (e.g., a friend has a similar looking teddy bear; child says, &quot;I have one too&quot;); child places wooden pigs and cows in the barn; at clean up finds a Duplo in the peg bin and says, &quot;This is not a peg.&quot;</td>
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<td>Sorts or matches objects that are identical (e.g., sorts crayons by color, puts all the small saucers in one stack and all the bigger plates in another; at lunch time picks out all of the grapes in the fruit cup)</td>
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<tr>
<td>Sorts items into small number of groups based on similar attributes (e.g., in dramatic play area, puts the dishes in one bin and the food in another; at clean up time, explains that she will gather all of the long, skinny items to put away first, and then, get the fat ones; separates all of the playschool people who have yellow hair, the ones wearing hats, and the ones who have dark hair.)</td>
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<td></td>
</tr>
<tr>
<td>Given a collection of items determines a classification scheme that creates a group for every item and tells about the groups (e.g., sorts a button collection into large buttons with 4 holes, 2 holes, and no holes, medium buttons with 4, 2 and no holes, and small buttons with 4, 2 and no holes, Says, &quot;These are the race cars, these are the trucks, these are the worker trucks and these are just cars.&quot;).</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Patterning</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiates and notices patterns (e.g., repeats a teacher's simple clapping pattern)</td>
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<tr>
<td>Reproduces and talks about simple repeating patterns (e.g., on computer, Says, &quot;Square/circle/square/circle&quot; after copying the pattern on a pattern card)</td>
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</tbody>
</table>
Things to consider

How does the child group objects together?
Does the child notice similarities or differences among objects in the classroom?
Does the child identify patterns in the environment or create new patterns with toys or materials in the classroom?

Ways to collect evidence

Observe children as they use materials throughout the room such as bristle blocks, balls outside, dress up clothing, different kinds of paintbrushes, collage materials, musical instruments, etc. Look for methods of classifying.

Plan small group activities that focus on classification.

Ask questions and make comments
"Tell me about why you put these shells together."
"Marta says she put all the shiny paper strips on the outside and the bumpy ones inside, where did you put your different strips?"

Model new possibilities to observe how children respond to your ideas.
"I'm going to put the spheres that float on this side and the ones that sink on the other."
Appendix B

NEW JERSEY DEPARTMENT OF EDUCATION
DIVISION OF EARLY CHILDHOOD EDUCATION

NJ MATH ELAS Anecdote Form for All Ages
- Be sure to date every entry.
- Place your anecdotes in the box that corresponds to the Mathematics Standard.
- Note additional relevant standards.

| 1. Understanding of number and numerical operations. | 2. Knowledge of spatial concepts (e.g., shapes and measurement). | 3. Understanding of patterns, relationships, and classification. |
Appendix C

NEW JERSEY DEPARTMENT OF EDUCATION
DIVISION OF EARLY CHILDHOOD EDUCATION

NJ Early Learning Assessment System-Mathematics (ELAS-M) Score Sheet
Teacher: School/Center: Class: Year:

CHILD’S NAME

<table>
<thead>
<tr>
<th></th>
<th>1st scoring period</th>
<th>2nd scoring period</th>
<th>3rd scoring period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td></td>
<td>1</td>
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<td>3</td>
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</tbody>
</table>

(provide a score for each expectation)
Appendix D

New Jersey Department of Education
Division of Early Childhood Education

Master Teacher Log
Master Teacher Name:

SCHOOL/TEACHER:

PLANNING CONFERENCE (PURPOSE FOR VISIT):
Date: Time:

CLASSROOM VISIT (NOTE STUDENTS' LEARNING & TEACHING PRACTICES):
Date: Time:

POST-VISIT CONFERENCE (DISCUSS VISIT & NEXT STEPS- repeat cycle):
Date: Time.

Action Plan: Developed collaboratively with master teacher and teacher

What will I do to move the children along the Age-by-Age Accomplishments in math?
   (Can I add new materials, revise activities, or engage in specific interactions with children)?

ELAS Discussion Guide Feedback Questions for Master Teacher

These questions are to be answered independently by the master teacher after each conference. The master teacher should answer these questions the same day of the conference.

1. What did I learn about the teacher?

2. What do I need to do to increase my understanding of early math development?

Additional Support:
Appendix E

Early Learning Assessment System - Mathematics Reliability Score Sheet

Name ________________________________

School/Center ____________________________

Date ________________________________

Directions
1. Write the folio code below.
2. Score the folio independently and write your scores in the individual score column for the corresponding expectation.

Folio Code:

Name ________________________________

<table>
<thead>
<tr>
<th>Mathematics Expectation</th>
<th>Individual Score</th>
<th>Standard Score (Do not write in this column)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Child demonstrates an understanding of number and numerical operations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Child demonstrates emerging knowledge of spatial concepts, measurement, and geometry.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Child demonstrates understanding of patterns, relationships, and classifications.</td>
<td></td>
<td></td>
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</tbody>
</table>

Notes:
Appendix F

Education and Experience of Classroom Lead Teacher
INTERVIEWER: PLEASE PRINT CLEARLY AND COMPLETE EACH ITEM

School/Centre: _______________ District: ____________________

Teacher: _____________________ Date: ______________ Male / Female

1. How many years in total have you been the lead teacher in a preschool classroom? [INTERVIEWER: IN ALL CASES, COUNT THIS YEAR 2005–2006 AS ONE OF THE YEARS.] __________

2. What is the highest college degree that you have earned? (mark only the highest degree)
   □ BA degree not finished (currently enrolled) College: ______________
   □ BA degree College: _______________
   □ MA degree College: ______________
   □ Doctoral degree (EdD or PhD) College: ______________

3. The next five questions are to determine what teaching certificate you hold, if any.
   3(a) Are you currently working on your undergraduate degree?
      □ Yes, what college: ______________ [GO TO #5]
      □ No [CONTINUE]
   3(b) Are you currently enrolled in an alternate route program for the P-3 certificate? (do not ask if respondent is working on BA)
      □ Yes, what college: ______________ [GO TO 3(d)]
      □ No [CONTINUE]
   3(c) Do you hold an early childhood education teaching certificate? (do not ask if respondent is working on BA)
      □ Yes, which of the following:
      - Elementary with N-K
      - P-3
      - N-8 with a major in Early Childhood Education
      - Early childhood certificate not listed here. Please identify: ______________
      □ No [CONTINUE]
   3(d) Do you hold an elementary teaching certificate? (do not ask if working on BA)
      □ Yes, which of the following:
      - K-8
      - N-8 with a major in Elementary Education
      - K-5
      - Elementary certificate not listed here. Please identify: ______________
      □ No
   3(e) Do you hold a special education teaching certificate? (do not ask if working on BA)
      □ Yes
      □ No

INTERVIEWER: IF NONE OF THE OPTIONS ABOVE ARE CORRECT, THEN EXPLAIN:

INTERVIEWER: IF TEACHER ALREADY HAS A CERTIFICATE, ASK:
4. Did you get your certificate by an alternate route?
   □ Yes, what college: ______________
   □ No
5. Do you speak a language other than English fluently?
   □ Spanish
   □ Other?

**ADDITIONAL QUESTIONS:**

6. Have you had any specific training/courses in early childhood math?

7. Have you had any specific training or courses in performance-based assessment?

8. What are your feelings about/experiences with math and teaching math?