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# Effects of Family, Child, and Teacher Demographics on Prekindergarten Children's Access to and Use of Numeracy and Spatial Materials in the Early Education Setting

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FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

EFFECTS OF FAMILY, CHILD, AND TEACHER DEMOGRAPHICS ON  
PREKINDERGARTEN CHILDREN'S ACCESS TO AND USE OF NUMERACY AND  
SPATIAL MATERIALS IN THE EARLY EDUCATION SETTING

A thesis submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

in

PSYCHOLOGY

by

Shwetha Srikanth

2014

To: Dean Kenneth G. Furton  
College of Arts and Sciences

This thesis, written by Shwetha Srikanth, and entitled Effects of Family, Child, and Teacher Demographics on Prekindergarten Children’s Access to and Use of Numeracy and Spatial Materials in the Early Education Setting, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this thesis and recommend that it be approved.

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Daniel Bagner

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Anthony Dick

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Shannon M. Pruden, Major Professor

Date of Defense: October 31, 2013

The thesis of Shwetha Srikanth is approved.

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Dean Kenneth G. Furton  
College of Arts and Sciences

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Dean Lakshmi N. Reddi  
University Graduate School

Florida International University, 2014

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## DEDICATION

I dedicate this thesis to my parents and my husband. Without your unwavering love and support I would not be where I am today. Thank you for everything.

## ACKNOWLEDGMENTS

I wish to thank Dr. Shannon Pruden for her constant advice and guidance throughout this entire process. Her enthusiasm regarding research has fueled my interest in the subject to greater levels. I would also like to thank my friends who have helped me and supported me throughout this entire process.

ABSTRACT OF THE THESIS

EFFECTS OF FAMILY, CHILD, AND TEACHER DEMOGRAPHICS ON  
PREKINDERGARTEN CHILDREN’S ACCESS TO AND USE OF NUMERACY AND  
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by

Shwetha Srikanth

Florida International University, 2014

Miami, Florida

Professor Shannon M. Pruden, Major Professor

Florida’s Voluntary Pre-Kindergarten program (VPK) aims to ensure that all 4-year-olds are prepared to excel in K-12 mathematics. Early numeracy/spatial skills are predictive of success in K–12 mathematics. No research has examined whether VPK classrooms are equipped with the materials necessary to teach numeracy/spatial skill. The Pre-Kindergarten Numeracy and Spatial Environment Survey was created to examine the frequency of access to and use of numeracy/spatial materials in VPK classrooms. The 69-item survey was completed by the lead educator from a sample of 62 pre-kindergarten classrooms in Miami-Dade County. Regression analysis results suggest the location of the pre-kindergarten center, the sex distribution of the children in the classrooms or the number of years of experience that the educator has as a lead teacher along with the extra training courses undertaken by the teachers does not affect the access to or the use of, numeracy and spatial materials in the classrooms.

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## I. INTRODUCTION/STATEMENT OF PROBLEM

In 2010, nearly 64% of children were enrolled in a prekindergarten (pre-k) program in the United States (U.S Department of Education, National Center for Education Statistics, 2010). In the state of Florida, the figure is even greater than the national average with as many as 93% of 4-year-olds attending Florida's Voluntary Pre-Kindergarten (VPK) Program. The goal of Florida's VPK program is to ensure that all pre-k children, particularly those from low income/socioeconomic status (SES) families and under-privileged/under-represented populations, are equipped with early school readiness skills needed to succeed in K – 12 curricula. Upon completion of the VPK program, children are expected to demonstrate among other behavioral, social-emotional, and pre-literacy standards, early numeracy skills (Florida Early Learning and Development Standards for 4-year-olds, 2011). These early numeracy skills are predictive of success in K – 12 mathematics courses (Duncan et al., 2007; Ginsburg & Russell, 1981), and include an understanding of number sense and enumeration, arithmetic reasoning, spatial recognition and geometric reasoning, pattern recognition and construction, measurement and estimation, and understanding of logical spatial relations. Despite the importance of these early numeracy skills to later mathematics success, no studies to our knowledge have examined whether Florida VPK classrooms are equipped with the materials (i.e., manipulatives) necessary to teach early numeracy skills. This lack of research is surprising given the documented importance of the pre-k classroom environment to children's math development (e.g., Cherney & Voyer, 2010; Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; Tu, 2006). Few comprehensive measures exist that examine the availability and usage of activities and manipulatives

related to numeracy and spatial content in early childhood. Some of these existing measures, including the *Childhood Activities Questionnaire* (Cherney & Voyer, 2010) are retrospective, asking adults to *recall* their participation on a wide range of math-related activities in early childhood. To our knowledge, the *ECERS-E (The Four Curricular Subscales Extension to the Early Childhood Environment Rating Scale*; Sylva, Siraj-Blatchford & Taggart, 2011) is the only measure that seeks to examine the early education setting for access to and use of math-related materials. This subscale is quite brief and includes only a handful of items on mathematics and science activities. The larger sister scale, the *ECERS-R (Early Childhood Environment Rating Scale – Revised Edition*; Harms, Clifford & Cryer, 2005), is a widely used measure of classroom quality, evaluating the preschool setting for its use of space and furnishings, center practices relating to child personal care, and access to fine motor and literacy activities. But this measure does not attempt to identify or evaluate at-depth those math-related materials used in the early education setting, nor does it evaluate the frequency of use of these materials.

For the present study, we developed a new measure, the *Pre-Kindergarten Numeracy and Spatial Environment Survey*, with the aim of evaluating the early education setting for educator’s access to and use of math-related materials and manipulatives. To our knowledge our survey is the only *comprehensive* measure to evaluate which math-related manipulatives are present in the classroom, and how often these materials are used by early educators in Florida VPK classrooms. In addition, using this new measure, the present study seeks to examine the effect of family, child, and

teacher characteristics on educator's access to and use of math-related materials/manipulatives in the early education setting.

## THE ROLE OF MANIPULATIVES IN EARLY MATHEMATICS EDUCATION

The use of manipulatives as an educational tool has a long history in both the fields of Psychology and Education (e.g., Bruner, 1966; Piaget, 1941/1995; Montessori, 1964; also see Mix, 2009 for a review). Dating back to Piaget's work on children's numerical concepts (1941/1995), scientists argued that young children do not have the capacity for symbolic/abstract thought; symbolic thought is constructed via interactions with concrete objects or what we now call, manipulatives. Manipulatives are defined as concrete objects often used to help children understand more abstract concepts or symbols, including mathematical (i.e., number and spatial) concepts. They are tangible objects (e.g., balance beams, pegboards, rods/sticks, clock faces, linking cubes) that can be used to compare number and sets, and to perform many numerical operations including addition and subtraction. Many current theories seek to justify the continued use of manipulatives in the education setting, including the ideas that manipulatives enhance memory and understanding via physical action (i.e., an embodied cognition view; e.g., Martin & Schwartz, 2005), that manipulatives provide children with the opportunity to draw on their real-world or practical knowledge (Baranes, Perry, & Stigler, 1989), and that manipulatives provide an additional resource, among more traditional resources, for children's learning (Stenberg & Grigorenko, 2004). Taken together, there is a great deal of support, at least theoretically, for the use of manipulatives in the education setting, particularly as it relates to the learning of

mathematics. While the actual efficacy of manipulatives in the early education setting is hotly debated (McNeil & Jarvin, 2007) many educators continue to supplement their traditional curriculum with the use of these tools. Some speculate that these conflicting results on the efficacy of manipulatives are the result of individual differences in whether educators have access to the same manipulatives and how much educators use these manipulatives with children (i.e., amount of exposure children have to these manipulatives).

Use of manipulatives by educators can potentially vary considerably across a number of different dimensions. For example, manipulatives can be used in a variety of different contexts (e.g., free play, in structured games or with traditional curriculum), can vary with respect to children's degree of contact with the manipulative (e.g., children share manipulatives, have their own manipulatives or do not physically manipulate the materials) and can vary in the amount of exposure children receive with manipulatives (e.g., receiving manipulatives more than once a day, daily, several times a week, weekly or rarely). Variability in manipulative context, degree of contact, and amount of exposure may ultimately produce multiple pathways towards the facilitation of math learning.

There is reason to think that certain manipulatives and materials commonly found in the early education classroom and in the home setting, are linked to the development of math-related skills, including numeracy and spatial skills (Darcy, 1987). For example, recent work by Levine and colleagues (2012) suggests that the frequency of puzzle play in the home predicts children's performance on a spatial transformation task, a task akin to an adult mental rotation task. Similarly, research by Verdine and colleagues (2013) finds that children's spatial assembly skills with 3D blocks independently predicts

variability in children's math skill. Thus, access to and frequency of use of manipulatives, like puzzles and blocks in the home setting, relate to children's development of numeracy and spatial skills and represent an area ripe for research. In the present study, we address whether children have access to these very same manipulatives (i.e., puzzles, 3-D blocks, as well as other critical manipulatives including counting aids, technological aids, and charts and maps) in the early education setting. We also assess the frequency of use of these manipulatives so that we can begin to explore the potential variability in a dimension that may facilitate later math learning.

## II. BACKGROUND AND THEORY

With a better understanding of numeracy and spatial concepts comes a greater level of performance in the fields of science and mathematics, as well as a greater affinity to choose a career path within the disciplines of Science, Technology, Engineering and Mathematics (STEM; (Wai, Lubinski, & Benbow, 2009). Although development in formal mathematical skills begins in later school years, aspects of informal mathematical knowledge such as spatial reasoning undergo development as early as the preschool years and lay the groundwork for future learning of more formal mathematical concepts (Newcombe & Huttenlocher, 2000). We know that children vary quite dramatically in their early numeracy and spatial reasoning skills, and that these individual differences in children's numeracy and spatial reasoning skills are the result of a number of factors. Research suggests there are a number of critical factors that influence a child's numeracy and spatial skills, including family demographics (i.e., socioeconomic status), child characteristics (i.e., sex of child), and caregiver/teacher input (i.e., amount of numeracy and spatial language input). Furthermore, manipulatives used in both the home setting

and within the classroom setting, both as a part of the curriculum as well as outside the prescribed curriculum, play an essential role in the development of numeracy and spatial skills (e.g., Levine et al., 2012; Martin & Schwartz, 2005; Verdine et al., 2013). Below, we review what we know about these factors and their impact on children's numeracy/spatial development.

## FAMILY DEMOGRAPHICS

### Effect of Family Socioeconomic Status

Socioeconomic status (SES) of the family, as measured by family income and primary caregiver education level, influences many areas of child development, including development of mathematical ability. For example, a trend of low performance among children from low SES families has been observed such that a higher proportion of children from low-SES families enter school ill-equipped with the skills required for success in mathematics (Denton & West, 2002). Further, children from low-SES families are far more likely to be diagnosed with a math disability than children from high-SES families.

There is also reason to believe the SES gap begins during the earliest years of education. While most children have been exposed to or at least familiarized with certain basic numerical concepts at home, children from low-SES families arrive to the formal school setting in kindergarten already lagging behind their middle- and high-SES peers in math and numeracy concepts (Jordan, Kaplan, Ramineni, & Locuniak, 2008). Children entering first grade with weak number competencies (i.e., counting, number sense, and number operations) may never be on par with their counterparts from high SES

backgrounds (Dyson, Jordan, & Glutting, 2013). Development of informal mathematical concepts, such as spatial recognition and geometric reasoning, pattern recognition and construction, and understanding of spatial relations, begin as early as preschool and appear to precede the development of formal mathematical concepts (Newcombe & Huttenlocher, 2000). Critically, these early informal mathematical concepts lay the foundation for more formal mathematical concepts (Ginsburg, 1989).

Despite most children showing interest and enthusiasm for math-related activities, the complexity of these math-related activities differ across SES groups with children from low-SES homes engaging in less complex math- and spatial-related activities (Ramani & Siegler, 2011; Saxe et al., 1987). Parents from middle- to high-SES groups are more likely to engage children in activities with increased amount of complex calculations while parents from low-SES backgrounds are more likely to use activities that merely require simple rote counting. Informal activities with multisensory cues such as board games are also essential for early development of numerical competencies, and critically families from low-SES backgrounds are less likely to utilize these kinds of math activities in the home setting (Saxe, 2004). These differences in rate of exposure could account for the discrepancies in the performance and knowledge of math skills among children from various SES backgrounds.

Parents from different SES backgrounds also report different practices and parenting behaviors aimed at aiding children with early mathematics development (Starkey et al., 2004). Parents from low-SES backgrounds believe that children's mathematics education falls largely on the shoulders of the child's school and teachers. Parents from middle- and high-SES groups believe that the home environment is also an



important factor in children's mathematical development (Jordan & Levine, 2009). Finally, family cultural beliefs may also impact children's exposure to math- and spatial-related activities (Jordan & Levine, 2009). Parents from low-SES backgrounds show more apprehension regarding their neighborhood's safety often restricting the time that children spend outdoors (Levine et al., 2005). Yet, we now know that the amount of time children spend exploring their environment and engaging in math- and spatial-related activities can enhance one's math and spatial abilities.

The strategies utilized by children from low-SES backgrounds appear to be different from their middle- and high-SES peers. Children from middle- and high-SES homes use their fingers more frequently while working with mathematical questions; children from low-SES homes begin to use their fingers for counting later and use this technique far longer than children from middle- and high-SES homes (Jordan et al., 2008). Though children from low-SES backgrounds perform similarly to their high-SES counterparts on nonverbal tasks, they exhibit significantly lower performance when it comes to verbal mathematical tasks such as story problems. Therefore children's early numeracy skills are influenced by the amount of math talk heard by children from parents as well as caregivers such as preschool teachers (Starkey & Klein, 2010).

#### Effects of family language input

Not all types of language input are equal (Gunderson & Levine, 2011). Evidence shows that mothers (and fathers) from low-SES backgrounds provide significantly less language input (i.e., fewer words, shorter utterances as reflected by Mean Length Utterances) to their child than those families from middle- and high-SES groups (Hoff, 2003). In fact, research suggests that maternal speech mediates the relation found

between family SES and child vocabulary size. Not only is the quantity of speech (i.e., amount of language) produced different, but the quality of speech also varies by SES (Hoff-Ginsberg, 1991). Children from low-SES groups heard more prohibitions, as well as conversation that was aimed at directing their behavior rather than encouraging more conversation. In contrast, children from high-SES groups heard more language that was aimed at promoting conversation. These high-SES children were also exposed to rich vocabularies that resulted from the child's input in the conversation (Hart & Risley, 1995).

Maternal education level is also a significant predictor of child vocabulary development, and is often used along with family income as a proxy for SES. Children of high-school educated mothers hear shorter utterances and less speech directed at them when compared to children of college-educated mothers (Hoff, 2003). The mean length of the utterances (MLU) heard by children is in turn related to having a richer vocabulary as well as enriched syntax when compared to their middle- and high-SES counterparts.

These early differences in language input are also related to children's early mathematics achievement. Exposure to math-related language has been linked to children's mathematics achievement. Children from low-SES backgrounds experience specific difficulties in solving language-based math problems, a problem often attributed to children's dearth of math-related language (Jordan, Huttenlocher, & Levine, 1992). Some have even gone as far to suggest that this early math-related language input may account for the variability seen in children's math and spatial skills across SES groups (Jordan et al., 1992; Jordan & Levine, 2009; Levine, Vasilyeva, Lourenco, Newcombe, & Huttenlocher, 2005). More recent work by Pruden and colleagues lends additional

support to the link between parent spatial language and the spatial language produced by the child, with parent spatial language production across the child's first four years of life predicting children's later spatial abilities (Pruden, Levin, & Huttenlocher, 2011).

Finally, low-SES preschool children comprehend and produce fewer number words and math-related language when compared their middle class counterparts (Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010). Taken together, these language findings could begin to explain the disparities we see across low-SES children in their math skills upon entry into kindergarten (Jordan & Levine, 2009).

By intervening at the earliest possible opportunity and in other settings like preschool, the disparity in the math achievement levels between SES families can be reduced significantly (Starkey, Klein, & Wakeley, 2004). However, before designing and implementing effective interventions we need to understand the factors that contribute to the SES disparity in math achievement. In the current study, we aim to gain a better understanding of the number and spatial resources children from different SES groups have access to and how early educators are utilizing these resources in the preschool setting.

## CHILD CHARACTERISTICS

### Effects of child sex

Child characteristics, such as the sex of the child, also predict various cognitive skills, including numeracy and spatial skills. For example, preschool boys outperform preschool girls on a children's version of a mental rotation (Levine, Huttenlocher, Taylor, & Langrock, 1999). Past research claimed that the emergence of the sex difference occurred during adolescence (Petersen, 1976; 1983), however recent evidence points to

the emergence of these differences as early as the pre-school years (Levine, Huttenlocher, Taylor, & Langrock, 1999)). The sex difference appears to be the most robust in spatial tasks that include a mental rotation component.

Boys and girls also use different strategies when solving mathematical problems (Klien et al., 2009). Boys utilize more mental rotation strategies while girls utilize strategies involving the use of verbal ability when solving mathematical problems. Girls also tend to use overt methods such as counting on one's fingers, to solve math problems. Boys, on the other hand, used more abstract problem solving methods or simply relied on memory retrieval strategies (Ginsburg & Pappas, 2004).

Cultural and personal beliefs about math education can also impact boys' and girls' exposure to math- and spatial-related content and activities. Some argue that it is early preferences for and exposure to these numeracy and spatial toys and activities that explains the sex difference seen in spatial ability, including mental rotation (Nazareth, Herrera & Pruden, 2013; Newcombe, Bandura, & Taylor, 1983). The male performance advantage on mental rotation tasks could potentially be the result of boys' frequent exposure to toys and activities with increased numeracy and spatial content. Girls, on the other hand, often engage in activities involving dramatic play or pretend play, and play less with toys that have numeracy or spatial content (Tracy, 1987). Boys also engage in more spatially rich toys at home, and are often provided with more complex spatial toys such as jigsaw puzzles (Levine, Huttenlocher, Taylor, Langrock, 1999; Levine et al., 2012).

Recently, Cherney and Voyer (2010) created a spatial activities checklist that was used to examine adults' engagement in and use of spatial activities in early childhood.

The questionnaire, however, was given retrospectively, requiring the adult to recall events and activities of their childhood. Unfortunately, very few checklists have been developed to examine children's engagement in and use of numeracy/spatial activities and manipulatives in the early education setting. To our knowledge, the only checklist that exists for this purpose is the *ECERS-E (The Four Curricular Subscales Extension to the Early Childhood Environment Rating Scale*; Sylva, Siraj-Blatchford, & Taggart, 2011). The checklist is quite brief, including only a handful of questions (i.e., 4) about the environment for math pedagogy and even fewer questions about a teacher's use of math manipulatives and activities in the early education setting. Yet, it is critical to study if the early preferential exposure for numeracy/spatial toys and manipulatives is the reason that boys seem to exhibit better mathematics and spatial skills. The ideal setting for this purpose is a preschool classroom where manipulatives are made available to both boys and girls.

#### CAREGIVER/TEACHER INPUT

##### Effects of caregiver/teacher input

Early education, and thus the early educator, is critical to the development of mathematical concepts in early childhood (Lee & Ginsburg, 2009). Although teachers should not underestimate the importance of informal mathematics in the preschool setting, instruction should advance beyond the scope of identification of numbers and shapes and carry forward mathematics education from informal concepts to more formal mathematics such as understanding cardinality, learning to count, and operations on numbers. As discussed previously, the amount and type of language input prekindergarten children receive from important caregivers in their lives has been shown

to predict their numeracy and spatial abilities (e.g., Gunderson & Levine, 2011; Levine et al., 2010; Pruden et al., 2011). Parent numeracy and spatial language input is not the only caregiver language that predicts child numeracy and spatial skill. Teacher language input is also critical to children's development of numeracy (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006) and spatial concepts (Baenninger & Newcombe, 1995). It is interesting to note, however, that boys and girls report different accounts of the same experiences in classrooms. For example, boys report that they are more actively involved and have more positive teacher interactions in math classes than girls (Klien et al., 2009). These results suggest that teachers too can impact children's early numeracy and spatial development.

#### Effects of teacher professional development and training

Method of instruction utilized by teachers in the classroom can play an important role in the development of mathematical and spatial skill in children. In recent years, teachers have been encouraged to create a stimulating environment where children have access to manipulatives and activities. In some cases, some have even pressed for teachers to allow children to create their own memorable objects so that the classrooms themselves serve as a tool for instruction (Rudd et al., 2008). Regardless of the specific type of manipulative or activity, teachers have been encouraged to use manipulatives for early mathematics instruction. Yet, to date, we have no information on whether early educators have access to and use mathematics manipulatives in their classrooms.

In addition to creating an enriched milieu, the training, as well as professional development of these early educators is critical for introducing mathematical concepts to children in early childhood. Recent work suggests that early educator qualifications and

professional training/development varies considerably across schools (Rudd et al., 2008). Pre-k teachers employed by public school districts and university pre-k centers were better qualified than instructors employed in head start centers. Teachers with inadequate training possess preconceived notions about mathematics (Lee & Ginsburg, 2009). They either typically believe that free play is adequate for the instruction of math or they rely on very rigid math-concentrated curriculum for teaching purposes (Rudd et al., 2008). Yet, teachers should strive to ensure that there is seamless integration of math and science education in the classrooms since instruction in these areas not only ensures achievement in mathematics during later school years but is also closely linked to literacy and language development (Brenneman et al., 2009). Thus, early educator professional development and qualifications should be considered an important factor of interest when documenting manipulative use in the classroom.

### III. SPECIFIC STATEMENT OF RESEARCH QUESTIONS

Taken together, the research reviewed herein suggests that there are several factors that affect children's developing mathematics and spatial competence. Research suggests that family demographics (i.e., family SES), child characteristics (i.e., sex of child), and teacher qualifications (i.e., years of training; teacher professional development) could provide valuable insight into the pathways that influence numeracy/spatial skills development. Thus, in the present study, we focus on the effect of family, child, and teacher factors on prekindergarten children's access to and use of numeracy (and spatial) materials and manipulatives in the early education setting.

Utilizing a newly developed 69-item survey, to be completed by the lead teacher from prekindergarten classrooms, the present study seeks to examine the effect of family

demographics, child characteristics, and teacher professional development/training on prekindergarten children's access to and use of numeracy and spatial materials and manipulatives. Specifically, three research questions/objectives will be addressed, with each research question/objective corresponding to data obtained from the survey about: (1) the population the school serves, including the proportion of children served by the school living in poverty (i.e., family SES); (2) the child's sex; and (3) the number of years the teacher has been working in the early education setting along with the number and types of teacher professional development courses they have completed (i.e., teacher professional development).

Research Question #1a: Are there differences in the access to numeracy and spatial manipulatives/materials in early education classrooms serving primarily low-SES populations when compared to early education classrooms serving mid- and high SES populations?

Hypothesis #1a: Schools serving low-SES children and children living in poverty will have access to fewer numeracy/spatial materials and manipulatives in the early education classroom than those schools serving middle- and high-SES children.

Research Question #1b: Are schools serving primarily children living in poverty or coming from low-SES families using numeracy/spatial materials and manipulatives as frequently as those schools serving children from middle- to high-SES families?

Hypothesis #1b: Schools serving low-SES children and children living in poverty will use numeracy/spatial materials and manipulatives less often in the classroom than those schools serving middle- and high-SES children.



Research Question #2: Are classrooms with a greater proportion of boys to girls using numeracy/spatial materials and manipulatives as frequently as those classrooms with equal proportions of boys to girls or those classrooms with a greater proportion of girls to boys?

Hypothesis #2: Classrooms with a greater proportion of boys to girls will use numeracy/spatial materials and manipulatives more frequently than classrooms with equal proportions of boys to girls or classrooms with a greater proportion of girls to boys.

Research Question #3: Do teachers who have more years of experience working as a lead teacher in the early education setting and/or who have completed more teacher professional development courses use numeracy/spatial materials and manipulatives more frequently than those teachers who have fewer years of experience working as a lead teacher and/or who have completed fewer or no teacher professional development courses?

Hypothesis #3: Teachers who have more years of experience working as a lead teacher in the early education setting and who have completed more teacher professional development courses will use numeracy/spatial materials and manipulatives more frequently than those teachers who have fewer years of experience working as a lead teacher and who have completed fewer or no teacher professional development courses.

#### IV. METHOD

##### Participants

The total 62 lead preschool teachers completed *The Pre-Kindergarten Numeracy and Spatial Environment Survey*. Participants were recruited from numerous pre-school and pre-kindergarten centers in Miami-Dade County in Florida. Prospective participants

were made aware of *The Pre-Kindergarten Numeracy and Spatial Environment Survey* via emails, telephone calls, as well as personal visits to the schools. We succeeded in contacting all the public schools in Miami-Dade County through [dadeschools.net](http://dadeschools.net).

Of these 62 participants, 2 (3.2%) had obtained only a high school diploma or degree equivalent, 7 (11.3%) had attended some college but did not complete the degree, 8 (12.9%) had received an associates or an equivalent two-year degree, 28 (45.2%) had earned a Bachelors degree, 15 (24.2%) had earned a Masters degree, and 2 (3.2%) had obtained a Doctorate degree or equivalent (Figure 1).

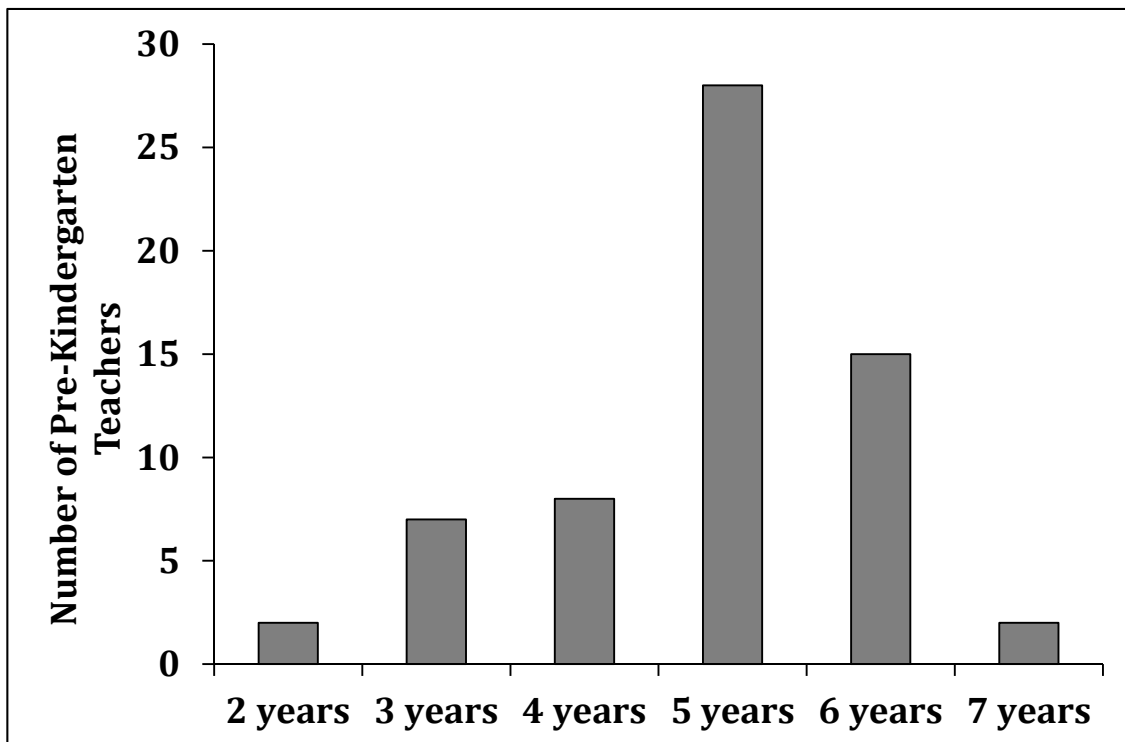


Figure 1: Years of college education undertaken by the teachers.

The number of years of employment of the participants in a pre-kindergarten classroom ranged from 0 to 45 years, with a mean of 9 years. Number of years of

experience as a lead teacher within the classroom ranged from 0 to 29 years, with a mean of 7 years (Figure 2).

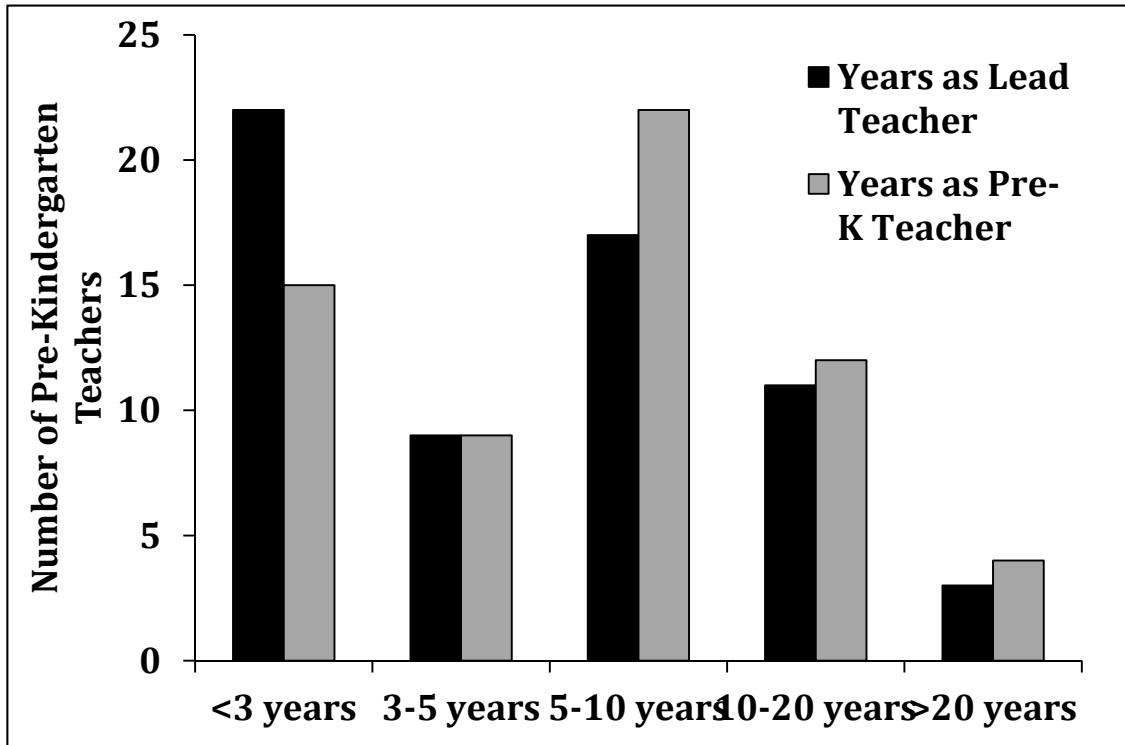


Figure 2: Years of employment as a pre-k teacher and as a lead teacher in a pre-k classroom.

Participants were also questioned on whether they have trained in or attended any of the classes prescribed by the *Florida Department of Children and Families*. Of the 62 participants in the survey, 34 had undergone training in the *Emergent Literacy for VPK Instructors* program. Other professional development courses offered by the state were not well attended by the survey participants such as Florida Voluntary Prekindergarten Education Standards and Preschool Appropriate Practices.

Teachers reported the number of boys and girls enrolled in their classroom. The number of boys across classrooms ranged from 0 to 24, with a mean of 9 boys per

classroom; the number of girls across classrooms ranged from 0 to 34, with a mean of 8 girls per classroom (Figure 3).

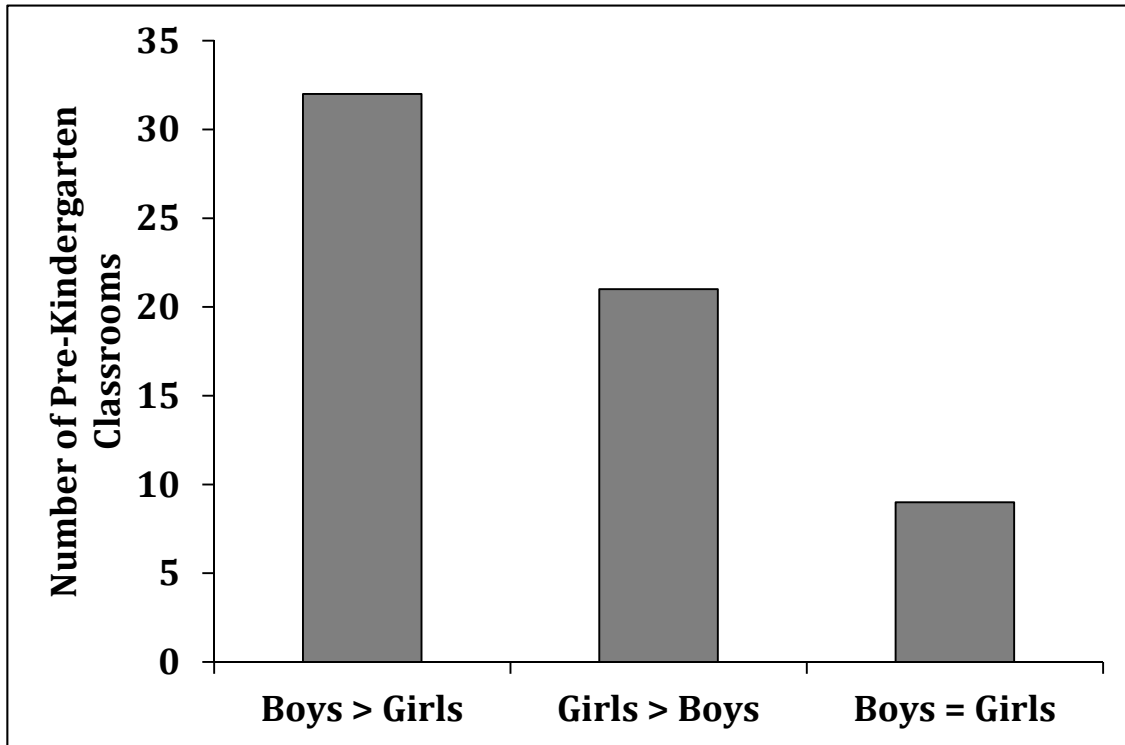


Figure 3: Distribution of boys and girls across pre-k classrooms.

## Materials

For the purpose of the present study we designed *The Pre-Kindergarten Numeracy and Spatial Environment Survey*. Containing 69 total items, the survey asked various questions about family demographics, child demographics, and teacher training/professional development. The survey also asked specifically about whether and how often numeracy and spatial activities and materials were used in the classroom. The survey was designed to be completed online by the lead educator of a preschool

classroom. Qualtrics software was used to administer the survey and to gather the data. Survey completion time ranged from 10 – 45 minutes.

The survey began with posing questions in reference to the relevant demographics and relevant professional development information pertaining to the teacher. Participants were asked how many years they have worked in pre-kindergarten classrooms, and of those years how many were spent working as the lead teacher in a pre-kindergarten classroom. Participants were asked about the highest educational status they achieved (i.e., high school diploma or equivalent, a associate degree or an equivalent 2-year undergraduate degree, a Bachelors degree or an equivalent 4-year undergraduate degree, a Masters degree, a Doctoral degree or equivalent degree and a Professional degree). For college and advanced degrees, participants were asked in which area or field the degree(s) were obtained. Teachers were also asked to report the minimum eligibility requirements to be a lead teacher at the center they were currently employed. Participants were asked about their participation in the last five years in childcare training courses offered and recommended by the *Florida Department of Children and Families* and *Florida Department of Education- Office of Early Learning*. Teachers were asked to indicate which courses of those offered by these two agencies they had completed in the last 5 years. Finally, teachers were asked about the curriculum they used to teach math/numeracy as well as who had selected the curriculum.

Inquiries were made regarding the number of boys and girls enrolled in their classroom at the time of the survey completion. Teachers were also asked to make their best educated guess as to the number of children whose parents make less than \$22,000 a year or were living in poverty. We found a significant inverse correlation between the

teacher reported data regarding the number of children in the classrooms from homes whose total income was less than \$22,000 and the median home income from the US census website.

After responding to items related to family demographics, child characteristics and teacher training/professional development, teachers were asked to report their access to and use of various numeracy and spatial manipulatives and materials in the classroom. Questions were split into blocks containing questions pertaining to different manipulatives: Puzzles, 3D blocks, Charts and Maps, Technological Aids, Computers, and Counting Aids. Participants were provided with examples of each type of resource at the beginning of each block of questions in order to help them identify and answers questions about materials present in their classrooms.

For each manipulative, participants were asked about if and how often they had access to the item in their classroom (i.e., “More than once a day”, “Daily”, “Twice a week”, “Weekly” and “Never”). The “Never” option was provided for those teachers who never had access to the numeracy/spatial manipulative in question. In the event that the participant chose this option, they were directed to the end of that particular block and asked about whether they used other manipulatives or activities as a substitute for the unavailable resource. Participants who had responded with all other options besides “Never” were asked whether the manipulative in question was a shared resource among many classrooms and if so, to describe the shared resources situation. Participants who did have access the manipulative were also asked about the frequency of the use of the manipulative in the classroom (i.e., “More than once a day”, “Daily”, “Twice a week”, and “Weekly”). Participants were also asked to indicate in which subjects these

manipulatives were used (i.e., Geography, Counting and Arithmetic, Science and Nature, Free Play, Language Arts and Writing, Music, Arts and Crafts, Computer and Technology, Construction and building). Teachers were given the option of indicating whether the manipulative in question was used for purposes not listed. Participating teachers were asked to report, using their best estimate, the ratio of the number of children in classroom to the number of manipulatives available. The same blocks of questions were repeated until the teacher had answered questions pertaining to all 6 manipulatives of interest (i.e., Puzzles, 3D blocks, Charts and Maps, Technological Aids, Computers, and Counting aids).

Survey questions were asked in a fixed order. Participants were required to answer every single item on the survey for the survey to be considered as completed and to be included in the final analyses. Teachers were informed during the consent process that they would be required to answer all questions in the survey in order for the survey to be considered as completed. The function of “skip logic” was used in the Qualtrics website to ensure the teachers answered all relevant questions. At the end of the completed survey the teachers were thanked for their participation and informed of the method their gift card would be sent to them. This survey was also translated and provided in Spanish for those teachers who were more comfortable in answering questions in Spanish.

#### Procedure

Private, as well as publicly funded, preschools in Miami Dade County, FL were identified using a combination of information retrieved the Quality Counts website ([teachmorelovethe.org](http://teachmorelovethe.org)) and the Miami-Dade County Public County School (MDCPCS)

website (dadeschools.net). The Quality Counts website allowed us to view the contact information of privately owned preschools that offered and participated in the State of Florida's VPK program. Preschools were divided according to the different zip codes allowing us to target a wide range of preschools servicing families of different SES groups across Miami-Dade County. We strived to recruit evenly from zip codes representing all SES categories and used the US Census obtain average income by zip code. The MDCPCS website was used to identify publicly funded preschool programs participating in VPK. This website provided information about the teachers working in Miami-Dade public preschool (i.e., email address of teacher).

Teachers were either contacted directly via email when we had their email address or were contacted by telephone. When possible, teachers were also made aware of our study and *The Pre-Kindergarten Spatial and Numeracy Survey* through recruitment brochures both in English and Spanish. Recruitment materials contained a link to the FIU-hosted Qualtrics Software where they could complete the survey. No limitations were placed on when the teachers could complete the survey. Upon clicking on the link to the study, participants viewed and were asked to complete the online consent form. The consent form was provided in both English and Spanish. Upon completion of the survey, participants were thanked for their time and were asked to report the address to which they wanted their \$5 gift card sent.

## V. RESULTS

### Validity and Reliability of the Survey

In order to judge the validity of the *Pre-Kindergarten Numeracy and Spatial Environment Survey* we evaluated content validity by inviting a panel of 5 graduate



students and 2 faculty members, all of who were working in the field of early childhood development, to provide feedback regarding the survey content and questions. This panel of researchers was presented with a detailed survey examining the use of a variety of manipulatives and resources used in pre-kindergarten classrooms and asked to rate the effectiveness of each question in the survey, as well as the appropriateness of manipulative selection. This feedback was utilized to narrow and condense the number of manipulatives evaluated in the survey as well as the number of questions asked in the survey. After the first round of expert panel feedback, the following manipulative categories were selected: puzzles, 3D blocks, charts and maps, technological aids and counting aids. Revisions were made to the survey based on expert panel feedback and the final version of the survey was again sent to the expert panel for final review and comments. All expert panel members approved of the final survey format and questions, and concluded that the survey would sufficiently evaluate the availability and frequency of use of numeracy and spatial manipulatives in the classroom setting.

To assess reliability of our survey, we used the Cronbach's Alpha statistic as a measure of internal consistency. The internal consistency of the scale items on the survey relating to the access and the frequency of individual items (i.e., puzzles, 3D blocks, technological aids, charts and maps and counting aids) was high for the items that measured the access to and the frequency of use of the numeracy and spatial resources., Cronbach's  $\alpha = .849$ .

We first examined whether schools serving children from low-, middle-, and high-SES families have access to numeracy/spatial materials and manipulatives in the pre-k classroom. Our working hypothesis was that schools serving low-SES children and

children living in poverty would have access to fewer numeracy/spatial materials and manipulatives in the classroom than those schools serving middle- and high-SES children.

For the purpose of calculating the SES of the location of the preschool we acquired the median home incomes of the individual zip codes attained from the addresses that were supplied to us by the pre-k teachers. We retrieved the median home incomes of each zip code from the US Census website ([Quickfacts.census.gov](http://Quickfacts.census.gov)).

All teachers indicated the zip code of their preschool location and thus we were able to determine the median home income served by each preschool. The mean of the median incomes as per the preschools individual zip code was \$48,487.85 ( $SD = \$17,412.391$ ). The median home income ranged from \$0 to \$94,399. Thus, on average, teachers who completed the survey were teaching children from middle-SES families. For the purpose of analysis the median home income was used as a continuous variable while serving as the independent variable in the analysis regarding hypothesis #1a and hypothesis #1b.

Descriptive analyses revealed that nearly all of the teachers had access to the manipulatives indicated on the survey (see Figure 4). Though most teachers had access to numeracy and spatial manipulatives, there was variation in how often (i.e., frequency) teachers used these numeracy/spatial manipulatives in the early education setting (see Figure 5). Many teachers reported daily use of 3-D blocks, technological aids, and counting aids, with fewer teachers reporting daily use of maps and charts.

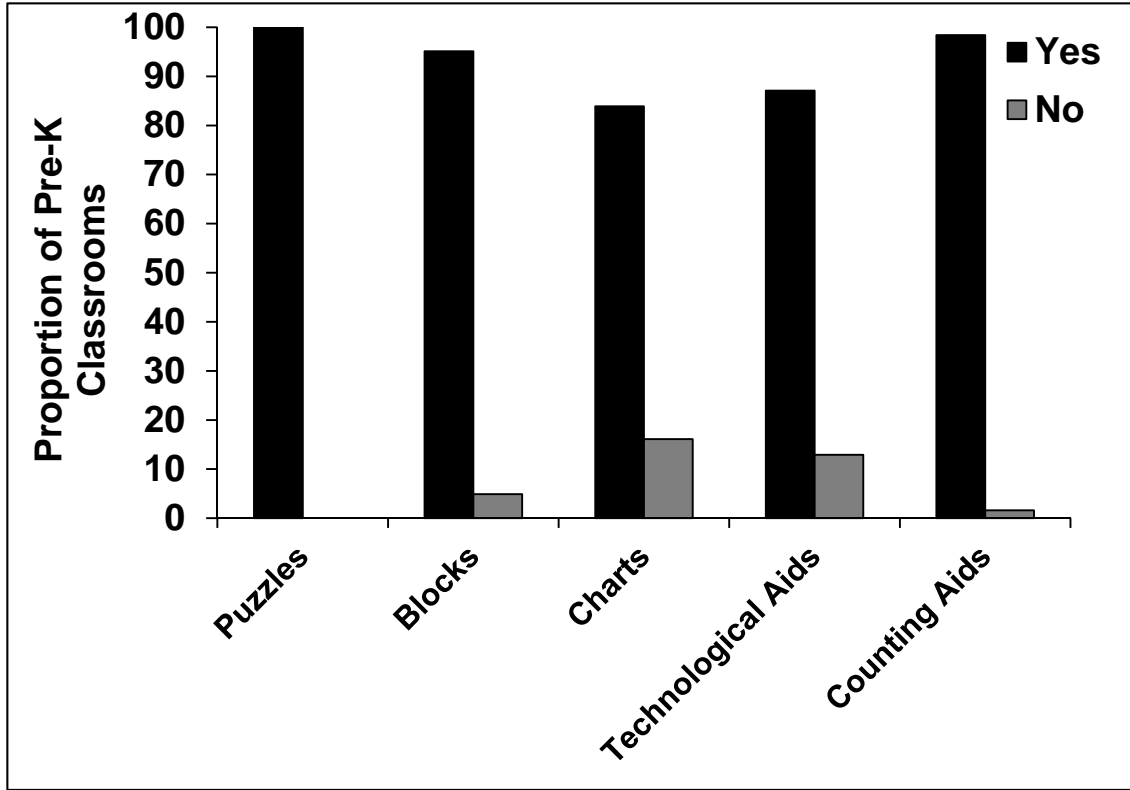


Figure 4: Proportion of teachers who had access to numeracy/spatial manipulatives.

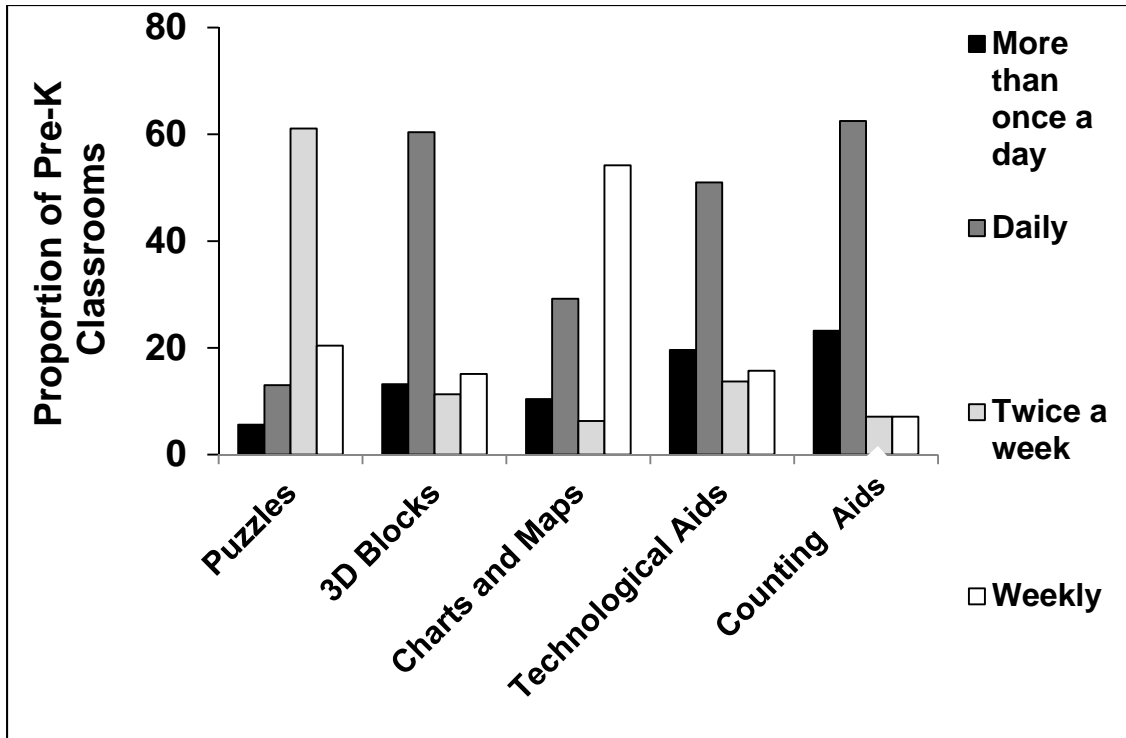


Figure 5: Frequency of use of numeracy/spatial manipulatives across pre-k classrooms.

All 62 teachers indicated that they had access to at least one of the six manipulatives. Here, we used the total number of manipulatives to which teachers reported they had access (possible range = 1 - 6) as our dependent variable (i.e., access to manipulative). We used the family SES variable, as calculated above, as our independent variable. We used a regression analyses to examine the relation between the independent variable (family SES) and dependent variable (access to manipulative). When we assessed family SES as a predictor for the dependent measure of access to manipulatives , we found that family SES was not a significant predictor of access to manipulative,  $R^2 = .009$ ,  $F(1,61) = .474$ ,  $p > .05$ . Family SES accounts for only 0.9% of the variation in our dependent variable, access to manipulative, and the model was not statistically significant.

Next we examine whether schools serving primarily children living in poverty or coming from low-SES families use numeracy/spatial materials and manipulatives as frequently as those schools serving children from middle- to high-SES families? Our hypothesis was that schools serving low-SES children and children living in poverty would use numeracy/spatial materials and manipulatives less often in the classroom than those schools serving middle- and high-SES children. As stated before, teachers were asked to report how often they used each manipulative in the classroom on a 4-point likert scale (i.e., “More than once a week”, “Twice a week”, “Daily” and “Weekly”). “More than once a week” was coded as a 1, “Twice a week” was coded as a 2, “Daily” was coded as a 3 and “Weekly” was coded as a 4. To calculate our dependent variable (frequency of manipulative use), we took the average of the teachers’ responses to this question across all 6 manipulatives (possible range = 1 – 4). We used the family SES variable, as calculated above, as our independent variable. We used a linear regression to examine the relation between our predictor variable, family SES, and dependent variable, frequency of manipulative use. Regression analysis in which we used family SES as the predictor variable and frequency of manipulative use as our dependent variable revealed that family SES was not a significant predictor of frequency of manipulative use,  $R^2 = .002$ ,  $F(1,61) = .728$ ,  $p > .05$ . Family SES accounts for only 0.2% of the variability in our dependent variable.

We also examined whether those classrooms with a greater proportion of boys to girls used numeracy/spatial materials and manipulatives as frequently as those classrooms with equal proportions of boys to girls or those classrooms with a greater proportion of girls to boys. Here, we predicted that classrooms with a greater proportion of boys to girls

will use numeracy/spatial materials and manipulatives more frequently than classrooms with equal proportions of boys to girls or classrooms with a greater proportion of girls to boys. For these analyses we used the proportion of boys to girls as reported by the teacher as our predictor variable (i.e., proportion of boys; range 0 – 100%) and the previously calculated variable, frequency of manipulative use (possible range = 1 – 4) as our dependent variable. A linear regression was used to examine the relation between our predictor variable, proportion of boys, and dependent variable, frequency of manipulative use. A Pearson correlation between frequency of manipulative use and proportion of boys was not statistically significant,  $r = .099$ ,  $p > .05$ . Regression analysis in which we used proportion of boys as the predictor variable and frequency of manipulative use as our dependent variable revealed that proportion of boys was not a significant predictor of frequency of manipulative use,  $R^2 = .011$ ,  $F(2,59) = .325$ ,  $p > .05$ . Proportion of boys to girls in the classroom accounted for only 1% of the variability in our dependent variable, frequency of manipulative use

Finally, we were interested in exploring whether teachers who have more years of experience working as a lead teacher in the early education setting and/or who have completed more teacher professional development courses use numeracy/spatial materials and manipulatives more frequently than those teachers who have fewer years of experience working as a lead teacher and/or who have completed fewer or no teacher professional development courses. Our working hypothesis was that teachers who have more years of experience working as a lead teacher in the early education setting and who have completed more teacher professional development courses will use numeracy/spatial materials and manipulatives more frequently than those teachers who

have fewer years of experience working as a lead teacher and who have completed fewer or no teacher professional development courses. As stated previously, teachers were asked to report how many years they had served as a lead educator and how many professional courses they had completed in the last 5 years from a checklist of all available courses offered by *the Department of Children and Families* and *Florida Department of Education- Office of Early Learning*. These two values were calculated for each teacher and were subsequently used as our predictor variables (i.e., years as lead teacher; number of professional development courses). To again calculate our dependent variable (frequency of manipulative use), we took the average of the teachers' responses to this question across all 6 manipulatives (possible range = 1 – 4). A linear regression was used to examine the relation between our predictor variables, years as lead teacher and number of professional development courses, and dependent variable, frequency of manipulative use. The regression analysis revealed that neither years as lead teacher nor number of professional development courses were significant predictors of frequency of manipulative use,  $R^2 = .009$ ,  $F(2,53) = .796$ ,  $p > .05$ .

## VI. DISCUSSION

With an increasing number of children enrolling in early education programs, like Florida's VPK program, the focus in mathematics and spatial development research has shifted away from the home setting to the early-education setting. Given the shift, it is critical to examine those factors that may influence the availability and use of numeracy and spatial manipulatives within early education classrooms.

Through the current research we sought to delve deeply into the relation that may exist between the socioeconomic status of the location of the preschool center with the

level of availability of manipulatives in the classrooms. In fact, previous research suggests that family SES moderates advantages boys might have over girls, such that boys from higher income backgrounds perform better on spatial tasks than boys from lower income backgrounds (i.e., girls performed poorly regardless of SES level; Levine et al., 2005). For the this purpose, we devised the *Pre-Kindergarten Numeracy and Spatial Environment Survey*, a 69 item questionnaire that sought to examine the availability and frequency of use of numeracy and spatial manipulatives in individual classrooms across Miami-Dade county. For the development of the survey researchers working in the field of early child development were surveyed regarding the validity of the questions posed to teachers and the final version of the survey was designed based on the consensus of the expert panel.

Our regression analysis revealed that family SES did not significantly predict access to numeracy and spatial manipulatives. We had predicted that the SES of the preschool centers location would affect the frequency of use of the numeracy and spatial manipulatives. No significant relation between family SES and educator frequency of use of numeracy and spatial tools was found. Family SES is one of the most robust predictors of child development, and thus, we believe that our measure of family SES in our survey may not be an accurate portrayal of the actual SES of families served by the preschool. That is, the lack of a family SES finding on teacher's use of manipulatives may simply be explained by an internal validity issue; we may not be accurately measuring SES. Any future work with our survey will require that we alter our measure of family SES.

Prior research indicates that boys traditionally exhibit better spatial skills (i.e., mental rotation abilities) compared to girls (Levine, Huttenlocher, Taylor, & Langrock,



1999). This gender difference may potentially be the consequence of preferential exposure of boys to manipulatives with higher numeracy and spatial content. The differential input to early education setting may significantly impact not only spatial abilities but also math ability. Because of previous research we hypothesized that within pre-school classrooms where there were a greater number of boys when compared to girls teachers would employ more numeracy/spatial manipulatives than those classrooms with more girls than boys or equal numbers of boys and girls. Contrary to our prediction, our results did not support the hypothesis. Instead, they indicated that there was no increase in frequency in the use of numeracy and spatial manipulatives with a greater proportion of boys. Given the extensive literature in support of sex differences in children's spatial ability, we were surprised by this finding. However, our sample of classrooms may potentially be an explanation for this null finding. Classrooms were assigned to one of three categories (more boys, more girls or equal numbers of boys and girls) using a proportion of boys to girls. Thus, a classroom with 10 boys and 9 girls (only one more boy than girls) would be assigned to the more boys' category. This approach to calculating our independent variable is potentially a problem in addressing our original research question. It is possible that educators use manipulatives more frequently in classrooms where boys outnumber girls 2:1 or even 3:1. Unfortunately, our sample was limited in exploring this question further as most classrooms had a very narrow differential between boys and girls. Future work will need to address this issue.

Our third hypothesis explored the role of the teacher's years of experience as a lead teacher and any additional training they may have obtained on frequency of manipulative use. We hypothesized the number of years of experience as a lead teacher

and the additional training obtained by teachers would predict the use of manipulatives in the classroom. This hypothesis was also not supported. Should these results hold in future work and with a larger sample size, this would indicate that we need to investigate other possible pathways and factors, beyond family SES, child characteristics, and teacher experience, that may influence the development of mathematical abilities in early childhood.

#### *Limitations of the current study*

The lack of significant findings for each of our hypotheses could be attributed to certain limitations that are associated with the study. One of the more prominent limitations in this study was the narrow distribution of participants across the SES spectrum. The data draw heavily from participants who were employed in centers that served areas that are located in middle socioeconomic status. We defined this category as areas served by the preschool where the parents make anywhere from \$22,000 to \$75,000 a year. We attempted to recruit participants serving a wide range of SES families, however most of the participants who opted to complete the study were not serving families living in poverty or from low SES groups. The exclusion of vital participants probably skewed our data and affected our results because the group was homogeneous with respect to family SES. In future studies we will have to pay close attention to implement recruitment measures to ensure that data will be collected from a wider range of participants.

The study also depends on the self-reports of the participants, asking them to self-report the manipulatives and materials to which they use and have access. With self-report data there is always a cause for concern because of the accuracy of the reports.

This is of concern given that we are asking teachers to recall and report the frequency of use of these materials in the classroom. Going forward we will discuss ways to overcome self-report problems, including experimenter based classroom observations of teacher manipulative use.

Our sample size was also relatively small. Despite focused and sustained efforts regarding recruitment we were only able to gain participation from just 62 teachers.

Finally, a potential limitation was the use of the online format, which may have excluded participants who were uncomfortable or unfamiliar with computers or computer software. We are considering the use of this survey in a paper/pencil format for future data collection. We also believe this will enable us to gather data from a variety of sources, including those teachers who may not have access to computers and possibly, be the very same teachers who are serving low-income families.

## VII. CONCLUSIONS

With an increasing number of children enrolling in the VPK program in Florida the preschool environment is now a pivotal area of early education research. We know from previous work that parental and teacher input is highly influential in the development of math and science skills of preschool-aged children. Yet, we know surprisingly little about those factors in the early education setting that may potentially impact children's math and spatial development. One such factor that has received much attention recently is children's engagement and use of math and spatial manipulatives/toys and activities. In the current study we aimed to identify various factors that might influence the availability and use of such toys and materials in the early education setting. Though no significant relations were reported between family SES,

child characteristics and teacher professional development on children's access to and use of math and spatial manipulatives, we hope that future work will begin to illuminate the potential moderators of children's mathematics and spatial development.

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