

A COMPARISON OF YOUNG CHILDREN'S OUTCOMES IN MATH, COGNITIVE
SELF-COMPETENCE, AND SOCIAL SKILLS BETWEEN THREE DIFFERENT
TEACHING APPROACHES

by

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ABSTRACT

Child outcomes in math, cognitive self-competence, and social skills were analyzed to compare the influence of three different teaching approaches: one with children's free-choice centers and two with small-group teacher-directed academic centers with center time variations. No differences in children's baseline math skills were found after means were adjusted for SES and verbal ability. Some differences were found in girls' increased math skills over boys' increased math skills after participation in the math games. No differences were found in children's cognitive self-competence. Significant differences were found in children's social skills over the three teaching approaches. Teacher beliefs about teaching math were also examined to see whether participation in the math project would positively impact teacher beliefs.

DEDICATION

This thesis is dedicated to every one who helped me and guided me through the research and writing process to complete this thesis. In particular, the participating teachers who supported me and helped me complete the research within their classrooms.

LIST OF ABBREVIATIONS AND SYMBOLS

F	Fisher's F ratios: A ration of two variances
\bar{X}	Mean: The sum of a set of measurements divided by the number of measurements in the set
\bar{X}^1	Mean for teaching approach 1
SD^1	Standard deviation for teaching approach 1 associated with the mean for teaching approach 1
\bar{X}^2	Mean for teaching approach 2
SD^2	Standard deviation for teaching approach 2 associated with the mean for teaching approach 2
\bar{X}^3	Mean for teaching approach 3
SD^3	Standard deviation for teaching approach 3 associated with the mean for teaching approach 3
p	probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
<	Less than
=	Equal to
SES	Socioeconomic status: an indicator of social and economic position

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Introduction

The importance of early mathematics as a content area in today's prekindergarten curricula is widely recognized. Early mathematics development predicts later achievement. For example, Jimerson, Egeland and Teo (1999) found that 1st-grade math achievement scores correlated .64 with 6th-grade math achievement scores. More importantly, Stevenson and Newman (1986) found that prekindergarten math achievement scores correlated .46 with 10th-grade math achievement scores. In 2002, the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics (NCTM) jointly developed a position statement apprising us that mathematics instruction is an important part of the early childhood classroom. The NCTM published Curriculum Focal Points (2006) for prekindergarten describing three areas of emphasis in early mathematics curricula: number and operations, geometry, and measurement. The updated NAEYC Developmentally Appropriate Practice in Early Childhood Programs (Copple & Bredekamp, 2009) includes these same Curriculum Focal Points (2006). In addition, most states have early learning standards for mathematics that include and extend the guidelines from the two national associations (Neuman & Roskos, 2005). There are different pedagogical approaches to providing learning opportunities for math in early childhood classrooms. The focus of this project was to compare young children's learning of basic math concepts, cognitive self-competence, and social skills using three different pedagogical approaches: children's free-choice centers and two small-group teacher-directed academic instructional units with center time variations.

Children's Free-Choice Centers

A center is an area in a classroom that contains hands-on learning materials. Often there are several centers in the classroom (e.g. math center, writing center, music center, science center, home living center, block center) and children can freely choose which center they visit. Many early childhood curriculum approaches support children's free-choice classroom learning centers. Examples include the Creative Curriculum and the High Scope Curriculum, each of which is highly used by Head Start, a federal program to educate and prepare children from economically disadvantaged families so they will enter school ready to learn (Chapter III: Relationship, 2002). Both of these curriculum approaches have children's free-choice centers as a foundational philosophy (High Scope Preschool, 2010; Trister Dodge, Colker, Heroman, 2002). According to NAEYC Developmentally Appropriate Practices, to create these centers, teachers are to furnish the areas with materials including math-related games and manipulatives that engage children in learning activities that are of high interest and developmentally appropriate. Developmentally appropriate means teaching practices and classrooms are age and developmentally appropriate, use a child-centered approach, adapt for uniqueness in individual children, and are responsive to cultural and social contexts (Copple & Bredekamp, 2009).

Small-Group Teacher-Directed Academic Centers

In contrast to children's free-choice centers, many of today's prekindergarten classrooms located in elementary schools use a direct teaching small-group method for center time. This may be because many school-based prekindergarten programs are for at-risk 4-year-old children. A pattern of lower math achievement by children from low-income families is evident from the early grades of elementary school (Denton & West, 2002). The small-group teacher-directed academic centers intend to provide children supervised experiences to 'catch-up' with their

higher SES peers. A research study conducted by Starkey, Klein, & Wakely (2004) investigated math gains in 4-year-old children with teachers supervising and directing small-group activities with concrete materials. There were four comparison groups in the study: low-income and middle-income groups with intervention and low-income and middle-income groups with no intervention. Children in the intervention group scored significantly higher on the posttest than the children in the control group who did not receive the intervention, but most importantly, the children from low-income families reflected a greater increase in the mean score from pretest to posttest than the children from the middle-income families. Thus, young children from low SES family backgrounds appear to benefit from small-group teacher-directed instruction.

Curriculum Concerns

Selection Frequency. One concern with children's free-choice centers is that some children may choose not to select a center. For example, Tudge and Doucet (2004) found that 60% of the children in their study never selected a lesson or activity focusing on mathematics or play with mathematical related objects. Additionally, the study found that these children were unlikely to receive mathematical focused lessons in childcare facilities and were unlikely to play math-related games at home. Although the children's free-choice learning centers had play materials to encourage learning of mathematical concepts, the children did not engage with the materials (Tudge and Doucet, 2004).

Long Term Achievement/Competence. A concern regarding small-group teacher-directed academic centers is the effect of structured activities in prekindergarten which may decrease self-esteem resulting in decreases in the motivation to learn and long-term achievement. The Perry Preschool Project examined the effectiveness of quality preschool using the High Scope Curriculum, which focused on children's intellectual development and social development

(Schweinhart, et al., 1985). Children who participated in children's free-choice centers, which are characteristic of the High Scope Curriculum, had higher initial gains in IQ versus children who were in the control group. Those initial gains in IQ did not remain, they faded out by ages 7 and 8, but the achievement differences in children remained higher for the children who completed the project. In the longitudinal research follow-up at age 27, the children who participated in the Perry Preschool Project had a 44 percent higher high school graduation rate than the children who did not participate. In the follow-up at age 40, the children who participated had a 42 percent higher median monthly income (\$1,856 vs. \$1,308) than the children who did not participate. Put another way, children who participated in the Perry Preschool Project where the curriculum emphasized children's free choice of centers involving active learning and the children engaged in activities that were planned, carried out, and reviewed by the children themselves with support from adults, continued with higher educational achievement which may be tied to social development and motivated learning. The benefits are continuously being researched to try to understand how the Perry Preschool Project may have affected the children's development of motivation, sociability, and the ability to work with others (Schweinhart, et al., 2005).

Lack of Time to Practice Social Skills. Another concern about direct teacher instruction of children is that some teachers believe that a structured environment (i.e. one that is not play based) will allow children less time to practice social skills. Most early childhood teachers recognize their role in planning for play activities that facilitate children's social skill development and that children need ample time to practice newly acquired social skills (Copple & Bredekamp, 2009). The National Research Council and Institute on Medicine supports the practicing of social skills emphasizing "the elements of early intervention programs that enhance

social and emotional development are just as important as the components that enhance linguistic and cognitive competence” (Shonkoff & Phillips, 2000, pp. 398-399). In addition, NAEYC Developmentally Appropriate Practices supports a *caring community of learners* where early childhood settings set the foundation in the classroom that the community is consistent, positive, and provides caring relationships between adults and children, among children, among teachers, and between teachers and families. In a *caring community of learners* children are engaged in cooperative experiences, where teachers provide many opportunities for children to play together (Copple & Bredekamp, 2009).

Teacher Training. A final concern regarding the inclusion of early mathematics content in the prekindergarten curriculum regardless of whether that curriculum is offered as children’s free-choice centers or as small-group teacher-directed academic centers is that teachers are not well prepared to teach early mathematics. Some researchers have suggested math instruction support and training for child-care providers (e.g. McDill & Natriello, 1999). For school-based programs, prekindergarten teachers are certified and usually have a preparatory course in methods of teaching mathematics to young children. As a result of that, teachers may know the procedures that they teach but may have a weak understanding of the conceptual basis for that knowledge (National Research Council, 2001).

Given the importance of exposing young children to early mathematical concepts because it is related to later math achievement, more research is needed to identify the most effective curriculum approach for early math instruction. The principal aim of this study is to compare three methods of teaching early mathematical concepts: children’s free-choice centers and two small-group teacher-directed instructional units with center time variations.

Objectives of the Study

This study assessed the impact of different teaching approaches for 4- and 5-year-old children in learning early math skills. The following questions guided the research.

Research Question 1: Will preschool age children who participate in a free-choice math center have a greater increase in math ability than preschool age children who participate in a small-group teacher-directed academic math center?

Research Question 2: Will preschool age children who participate in a free-choice math center have a greater increase in cognitive self-concept than preschool age children who participate in a small-group teacher-directed academic math center?

Research Question 3: Will preschool age children who participate in a free-choice math center have a greater increase in social skills than preschool age children who participate in a small-group teacher-directed academic math center?

Research Question 4: Will teachers, regardless of whether they facilitated children's participation in free-choice math centers or lead a small-group direct-instruction math center, have a more positive attitude toward teaching mathematics after receiving professional development regarding how to teach early mathematical concepts and implementing math activities from this project?

Methodology

Sample and Participant Selection

The participants in this study were 60 four- and five-year-old children in prekindergarten classrooms in a southern city. The research was implemented in two elementary schools and one university-based model child care center. The sites were selected for participation in the study because of the type of curriculum offered: children's free-choice centers or small-group teacher-directed academic centers with center time variations.

Teaching Approach -1, Rotating Centers. The classrooms in this city school site used the teaching approach of "small-group teacher-directed academic math centers". These classrooms used small-group instruction with rotation to a new activity every 20-to-25 minutes. For example, a group of 4 or 5 children would be at a table supervised by an adult in an activity such as literacy for 20-25 minutes and then a timer would ring and the children would line up in their group to go to the next table. They would wait for a minute for all other children to stand to empty the tables and then upon the teachers direction the children would go to the next table, which may be mathematics, art, or another literacy activity. This would result in moving to four or five tables depending on how many adults were available to supervise with different activities within a 1 to 1.5 hour period. These teachers also had access to and used a math curriculum, the Every Day in Pre-K: Mathematics Curriculum®.

Teaching Approach 2, Whole-group Centers. The classrooms in this city school site used the teaching approach of "small-group teacher-directed academic math centers". The classrooms

used the teaching approach of small-group instruction with all children participating at the same time in the same activity(s) for a comparable length of time as the other city school, 1 to 1.5 hours. The activities at the table usually progressed or built on each other over the time period, but the children were all performing and learning at the same time through the same activities in small-groups supervised by an adult at each table. At times, children would change from small-group to large-group during this time if whole group instruction was needed on the topic. Then the children would go back to their small-group table to begin another activity on the topic. This allowed the children a longer time frame to engage and concentrate on one topic or concept.

Teaching Approach 3, Free-choice Centers. The university-based model childcare center used the teaching approach of “children’s free-choice centers.” The free-choice centers were offered several times daily, for variable lengths of time, some for 1 hour to 1.5 hours. The child-care center used the Creative Curriculum® and was NAEYC accredited.

Child Participants. All of the children participating in the study were advancing to kindergarten. At the beginning of the study the average age of the children was 5 years 0 months, with the youngest child 4 years 6 months and the oldest child 5 years 7 months. The children’s ethnicity were African American (55%), White/Caucasian (38%), Hispanic (3%), and Asian/Other (3%). In the elementary schools, 82% of the participating children were African American and the schools were located in low and moderate income neighborhoods. In the university-based model preschool, 95% of the participating children were White/Caucasian and the program was located in a moderate to higher income neighborhood. There were 24 boys (40%) and 36 girls (60%). See Table 1 for site characteristics.

Table 1

Characteristics of Research Sites

	Site 1/Approach 1	Site 2/Approach 2	Site 3/Approach 3
Location	City school in low income neighborhood (Academic focus)	City school in low to moderate income neighborhood (Academic focus)	University-based model Preschool program Moderate to High income neighborhood (Social, Creative focus) NAEYC Accredited
	Eligible for Free or Reduced Lunch, 94.4% (2008-2009)	Eligible for Free or Reduced Lunch, 53.6% (2008-2009)	
Number of Classrooms	2	2	4
Number of Children	17	23	20
Boys	4	10	10
Girls	13	13	10
Ethnicity of participants			
White		4	19
African American	15	18	
Hispanic	2		
Asian/Pacific			1
Other/mixed		1	
Hollingshead Index of Social Position (number of children within each category)	Cat-1 (upper) 0 Cat-2 (mid-High) 1 Cat-3 (middle) 6 Cat-4 (mid-low) 6 Cat-5 (low) 4	Cat-1 (upper) 0 Cat-2 (mid-High) 2 Cat-3 (middle) 7 Cat-4 (mid-low) 13 Cat-5 (low) 1	Cat-1 (upper) 9 Cat-2 (mid-High) 4 Cat-3 (middle) 4 Cat-4 (mid-low) 3 Cat-5 (low) 0
PPVT-4, Peabody	Min score 72	Min score 82	Min score 92
Picture Vocabulary Test	Max score 124	Max score 128	Max score 131
	Avg score 94.35	Avg score 104.69	Avg score 116.35
	SD 12.34	SD 10.24	SD 11.21
Program Characteristics	Every Day in Pre-K: Math Curriculum		Creative Curriculum
Teaching Approach	Small-group Instruction Teacher-directed learning <i>20 minute small group rotation for 1 hour to 1.5 hours</i>	Small-group Instruction Teacher-directed learning <i>1 hour to 1.5 hours all children doing same activity(s) in small groups, no rotation</i>	Free-choice centers Child-directed learning <i>Free-choice centers offered several times daily, for variable times, some for 1 hour to 1.5 hours</i>
Other Factors			<i>Multi-aged classroom 3 to 5 year olds</i>

Procedures

This study used a pre-test, math game activities, post-test design within three teaching approaches: rotating centers, whole-group centers, and free-choice centers. The children were assessed on their math skills, cognitive self-concept, and social skills before and after the math game activities. The teachers completed a survey and were interviewed before and after they participated in the math games. Teachers received individualized professional development on the math concepts presented as math game activities and how to play the math games.

The data in this study were collected by three trained assessors. The primary investigator, who has a background as a special educator with considerable assessment experience and knowledge, trained two undergraduate research assistants to help with data collection. The primary investigator also collected data, but to decrease investigator bias, the children at each site were randomly assigned to different assessors. Baseline data were collected on children's mathematics skills, cognitive self-competence, and social skills prior to the math games activities. Children's social economic status (SES) and receptive verbal ability were assessed and used as statistical control variables. All child assessments were conducted on an individual basis.

While children were being assessed for baseline data, the principal investigator conducted professional development individually with each teacher. For teachers in the city schools, which used the rotating centers and whole-group centers, the professional development included discussions about appropriate mathematical concepts, how math is presented in the daily routine during morning circle, time spent teaching mathematics, and strategies used during small-group direct-instruction. For teachers in the university-based model program, which used children's free-choice centers, the professional development included discussions about appropriate

mathematical concepts, how math is presented during large group activities such as circle time, how to facilitate child-directed activities which include free-choice centers, and how to deal with issues with free-choice math centers, such as children's miss-use of math manipulatives.

In addition to receiving professional development, all teachers were surveyed and interviewed about their attitudes towards teaching math. All teacher assessments and interviews were conducted on an individual basis. After all children were assessed for baseline data, the teachers continued to implement their curricula approach at their site. The two city school prekindergarten programs implemented the math games using rotating centers and whole-group centers. The university-based model child-care program implemented the math games using the children's free-choice math center.

After the math game activities had been conducted at each site, post-math-games data were collected on children's mathematics skills, cognitive self-competence, and social skills. The teachers at each site were surveyed and interviewed again about their attitudes towards teaching mathematics after participating in the project.

Measures

Test of Early Mathematics Ability, 3rd edition (TEMA-3). The TEMA-3 is a norm-referenced assessment designed to assess young children's math ability (Ginsburg & Baroody, 2003). The TEMA-3 is designed for children ages 3 to 8 and consists of 72 items in both informal and formal mathematics. Within the area of informal mathematics, four areas are assessed primarily through verbal, pictorial, or concrete tasks: 1) counting and enumeration skills, 2) number-comparison facility, 3) calculation skills, and 4) understanding of concepts. In the area of formal mathematics, four areas are assessed using written, verbal, mental calculation and other tasks and include 1) numeral literacy, 2) mastery of number facts, 3) calculation skills,

and 4) understanding of concepts. The TEMA-3 has two parallel forms, Form A and Form B. Cronbach's alphas were computed for six age intervals for both forms using data from the normative sample. The Cronbach's alpha for both forms are high and all equal or exceed .92 indicating that the TEMA-3 is a highly reliable test. In the present study, the Cronbach's alpha was .92 for the pre-math-games (Form A) and was .92 for post-math-games (Form B).

Formative Math Assessment. Formative math assessments (Komara & Herron, 2011) assessed math ability in numeracy, sorting, and patterning. These three mathematical concepts were the focus of the math games activities. To assess numeracy, dot cards and numerical cards were laid out on a table and the child was asked to count dots on cards from 1 to 10 and find the matching number. The child was scored for each correct counting and match. The child could score from 0 to 10 for numeracy. To assess sorting, the child was asked to sort an item, such as pom-poms or sticks by a trait such as color or size. The child was scored a '1' if he/she could sort by a trait or scored a '0' if he/she could not sort. To assess patterning, the child was asked to copy a pattern as demonstrated by the assessor laying down colored cards. Then the child was asked to extend the pattern or repeat the pattern. Five patterns were presented to the child for copying and repeating, AB, ABB, AAB, ABC, and AABB. Finally, the child was asked to create their own pattern. The child was scored a '1' for each pattern copied, repeated or created or scored a '0' if not copied, repeated or created. The child could score from 0 to 5 for copying patterns, from 0 to 5 for repeating patterns, and from 0 to 1 for creating a pattern.

The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (PSPCSAYC). The PSPCSAYC has four parts (Harter & Pike, 1980). For this study two parts were administered: the cognitive competence section and the peer social competence section. There is a picture book for each gender. A child can score 1 to 4, with 1 representing not very

much like me and 4 representing very much like me. For each part, six sets of picture cards are shown to the children. For a cognitive competence example, one picture shows a boy (or girl) saying the alphabet completely and the other picture shows a boy (or girl) saying just A, B, C. The assessor points to each picture and says “This boy is pretty good at saying the alphabet” pointing to next picture “This boy is not very good at saying the alphabet”. Then the assessor asked “Which boy is most like you?” After the child selects which picture is most like him/her, the assessor asks a second question depending on which picture was selected by the child. The assessor asks either “Are you pretty good or really good at saying the alphabet” or “Are you not too good at saying the alphabet or sort of good.” The child points to one of two circles, one larger than the other representing the more positive result. For a social competence example, one picture shows several boys (or girls) on the playground equipment and the other picture shows just two boys on the playground equipment. The assessor points to each picture and says “This boy has lots of friends to play with on the playground” pointing to the next picture “This boy does not have very many friends to play with on the playground”. Then the assessor asked “Which boy is most like you?” After the child selects which picture is most like him/her, the assessor asks a second question depending on which picture was selected. Either “Do you have pretty many or a whole lot of friends” or “Do you have hardly any friends or a few.” The child points to one of two circles, one larger than the other representing the more positive result. As reported by Harter and Pike (1980), Cronbach’s alphas on the preschool cognitive competence subscale has coefficient alpha of .71 and the preschool peer social competence subscale has coefficient alpha of .74. In the present study, pre-math-games Cronbach’s alphas were .54 and .67, cognitive and peer subscales respectively. The post-math-games Cronbach’s alphas were .33 and .81, cognitive and peer subscales respectively.

Social Skills Rating System (SSRS). The SSRS provides a broad assessment of child social behaviors (Gresham & Elliott, 1990). The teacher behavioral forms were used to assess the teacher's perception of the prekindergarten children's social skills in the areas of cooperation, assertion, and self-control. Each subscale has ten items. The *cooperation* subscale includes behaviors such as helping others, sharing materials, and complying with rules and directions. The *assertion* subscale includes initiating behaviors, such as asking others for information, introducing oneself and responding to the actions of others. The *self-control* subscale includes behaviors that emerge in conflict situations, such as responding appropriately to teasing, and in non-conflict situations that require taking turns and compromising. In previous research, the Cronbach's alpha was .90 for cooperation, .90 for assertion, and .91 for self-control on the preschool teacher form (Gresham & Elliot, 1990). In the present study, pre-math-games baseline Cronbach's alpha was .74 for cooperation, .80 for assertion, and .84 for self-control. The post-math-games Cronbach's alpha was .84 for cooperation, .87 for assertion, and .89 for self-control.

Hollingshead Index of Social Position. The two-factor index is composed of an occupational scale and an educational scale (Miller & Salkind, 2002). Each scale is based on a 7-point index with 7 representing the highest score possible. For example, a 7 on the occupational scale represents an occupation classified as a major professional (e.g. medical doctor, lawyer, executive in a major corporation). A 1 on the occupational scale represents an occupation classified as unskilled employees (e.g. cafeteria workers, farm helpers, construction laborers, street cleaners). A 7 on the educational scale represents graduate professional training. A 1 on the educational scale represents less than 7 years of school. The occupational scale scores were multiplied by 7 and educational scale scores were multiplied by 4. The two scale scores

were then summed to create an SES score. The score is then evaluated to fall into one of 5 categories. Category 1 has a range of 11-17 (upper class); Category 2 has a range of 18-27 (upper middle class); Category 3 has a range of 28-43 (middle class); Category 4 has a range of 44-60 (lower middle class); and Category 5 has a range of 61-77 (lower class). The SES score was used to control for differences in children's abilities due to the influence of parents' education and occupation.

Peabody Picture Vocabulary Test, 4th edition (PPVT-4). The PPVT-4 is the leading measure of receptive vocabulary for standard English and also a screening test of verbal ability (Dunn & Dunn, 2007). It is a norm-referenced assessment and contains training items followed by 228 test items. For each item, the child selects a picture that best illustrates the meaning of a stimulus word spoken by the assessor. The 228 items are grouped into 19 sets of 12 items. The sets are arranged in order of increasing difficulty. The PPVT scores were used to control for differences in children's math ability because of verbal ability. Dunn and Dunn (2007) reported Cronbach's alphas of .97 and .96. In the present study, the Cronbach alpha was .96.

Mathematics Teaching Efficacy Beliefs Instrument (MTEBI). The MTEBI is an assessment of mathematics teaching self-efficacy and outcome expectancy (Enochs, et al., 2000). The MTEBI consists of 21 items that have a 5-point Likert-scale response option. Responses range from 1 "strongly disagree" to 5 "strongly agree." The MTEBI contains two subscales: Personal Mathematics Teaching Efficacy Belief (SE) and Mathematics Teaching Outcome Expectancy (OE). The SE subscale includes 13 questions with possible total scores ranging from 13 to 65. A sample SE item includes "I will continually find better ways to teach mathematics." The OE subscale includes eight questions with total scores ranging from 8 to 40. A sample OE

item includes “When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.” From the entire survey, eight of the questions must be reverse scored to produce consistent values between positively and negatively worded items. Enochs, et al., (2000) reported a Cronbach’s alpha of .88 for the SE scale and a Cronbach’s alpha of .77 for the OE scale. In the present study, statistical analysis was not conducted for Cronbach’s alpha, because of the low number of teacher participants (n=8).

Teacher Interviews. Interview questions concerning their opinions of the MTEBI, their teaching beliefs about math, and participation in the research project were asked of each teacher. Some sample questions asked prior to the math games activities included “How do you feel about adding math games and/or supplemental math materials to your classroom?” and “If you could make any changes to your classroom concerning the teaching of mathematics, what would they be?” Some sample questions asked after the math games activities included “How did your students react to the math games and/or supplemental math materials?” and “How often did you teach math or observe children in centers involved in math activities?”

Math Game Activities

The first investigator met with each teacher as part of their professional development to learn of their plans for future thematic units or teaching concepts. These themes or concepts became the basis for developing math activities that focused on demonstrating an understanding of numeracy, sorting, and patterning. The themes or concepts included spring flowers, insects, under the ocean, and weather. All of the teachers participated in the math games based on insects and under the ocean. One student teacher intern at one of the city school classrooms used a zoo animal math game instead of the math game on weather. She used the same process of

having manipulatives for children to count, sort, and pattern. Two additional units were created for the children's free-choice centers using colored popsicle sticks and colored tokens.

Following is a description of one of the math games. The process was used repeatedly for each game. The materials were either objects or laminated picture cards, patterning strips, and index cards with pictures and numbers to use with the adding sheets. For example, the under the ocean game had small laminated picture cards of yellow fish, red coral, green sea weed, and grey shells. Each child was given a bag of picture cards and was asked to sort the cards into one of the following groups: fish, coral, seaweed or shells. Then a patterning strip with pictures of a fish, coral, seaweed, or shell appearing in a repeated pattern was available for each child to copy or extend/repeat the pattern. An example of a patterning strip would be an AB pattern of coral, sea weed, coral, sea weed. Others patterns used were ABB, AAB, and ABC. The children were to sort the used picture cards back into the appropriate pile after completing the pattern. After the children had patterned several different patterning strips, then an adding sheet was available for the children. For under the ocean math games, there was a picture of sea weed dividing the paper into two halves. The two halves were to be used in the counting and adding part of the game. A child selected an index card that had a picture and a number, for example, the number 4 with one picture of a fish. The child would identify the number on the card and tell any peers also playing the game how many fish to put on their adding sheet. The children would count out 4 fish and place them on one side of their paper. Then another child selected an index card with a picture and number. The number was called out so children could count that number of items and place them on the other half of their adding sheets. The children were then asked to add the two sides together to see how many under the oceans items they had altogether. For example, they could have 4 fish and 3 shells to make 7 under the ocean items. Again, the children were to

sort the used picture cards back into the appropriate pile before continuing the adding game. Therefore, the processes of counting, adding, sorting, and patterning were used for each of the math games.

The city school prekindergarten classrooms incorporated the math games into their rotating centers and whole-group centers. The university-based model child care center classrooms incorporated the math games into their children's free-choice centers. When children at the university-based program were selecting their centers, the primary investigator was available at the center table to supervise and guide the children. Children not participating in the study could participate in the math game activities while available in the classroom. The site using rotating centers incorporated the math games once a week over a 4 week period. All but four children participated in the weekly sessions over all 4 weeks. Absence was the reason for the children not participating. The site using whole-group centers incorporated the math games once a week over a 4 week period in one classroom, and over a 3 week period, with one week having two sessions, in the other classroom. All but six children participated in the weekly sessions over all the weeks. Absence was the reason for the children not participating. The site using free-choice centers incorporated the math games once a week over a 4 week period. All but four children participated in the weekly sessions over all 4 weeks. Absence or lack of interest was the reason for children not participating.

Preliminary Analyses

Ten children with disabilities originally participated in the study. Three of these children needed instructional modifications with the math games because of the significance of their intellectual disabilities. These three children were eliminated from the study because of incomplete cognitive self-competence scores (PSPCSAYC). The remaining seven children with

disabilities were compared to the typically developing children on two of the formal assessment measures taken at the beginning of the study, the TEMA-3 and PPVT-4. The results revealed that the seven children with disabilities were significantly different from the sample of typically developing children, in terms of math ability and verbal ability. The baseline mean math score (TEMA-3) for the children with typical development was $\bar{X}=105.65$, $SD=12.76$. The baseline mean math score (TEMA-3) for the children with disabilities was $\bar{X}=77.86$, $SD=8.36$. The mean differences between the means of the two groups in math ability was significant, $F(67,2)=10.79$, $p=.002$. The baseline mean verbal score for the children with typical development was $\bar{X}=94.15$, $SD=14.03$. The baseline mean verbal score for the children with disabilities was $\bar{X}=64.57$, $SD=9.99$. The mean differences between the means of the two groups in verbal ability was significant, $F(67,2)=56.31$, $p<.001$). Because of the significant differences in the means of the two groups of children, only the children with typical development were included in the study sample.

Results

Children's Math Ability: Formal Math Assessments

Pre-math-games Baseline Data Analysis. The first analysis compared the children's pre-math-games means for math ability across the teaching approaches at the three sites. Descriptive data were calculated on math ability scores (TEMA-3) for each teaching approach, $\bar{X}^1=89.59$, $SD^1=14.53$; $\bar{X}^2=92.22$, $SD^2=12.46$; $\bar{X}^3=100.35$, $SD^3=9.33$. The results revealed that the pre-math-games means for children's math ability were statically significant, $F(60,2)=4.075$, $p=.022$. A multiple comparison procedure using Tukey HSD found that children in free-choice centers (A-3) had higher pre-math-games mean math ability scores than children in rotating centers (A-1), $p=.026$. Children's pre-math-games math ability scores differed by site, and therefore teaching approach, and the sites were known to serve children of different SES backgrounds. An additional analysis was conducted to determine if the means in children's pre-math-games math scores differed after controlling for SES and receptive verbal ability.

Pre-math-games Adjusted Means Data Analyses. The second and third analyses used ANCOVA to examine differences by teaching approach in children's pre-math-games means for math ability after controlling for children's receptive verbal ability (PPVT-4) and socioeconomic status (Hollingshead Index) across the three sites, each with a different teaching approach. Results of the first F-test, which controlled for receptive verbal ability, revealed no significant differences in children's pre-math-games math ability scores, $\bar{X}^1=92.63$, $\bar{X}^2=92.47$, $\bar{X}^3=97.47$, $F(60,2)=.82$, $p=.447$. Results of the second F-test, which controlled for SES, found no significant differences in children's pre-math-games math ability scores, $\bar{X}^1=89.69$, $\bar{X}^2=92.28$,

$\bar{X}^3=100.20$, $F(60,2)=2.28$, $p=.111$. Because receptive verbal ability and SES account for differences in children's pre-math-games math ability, further analyses statistically controlled for the influence of these two variables.

Pre- and Post-math-games Data Analysis. The final analysis conducted a 2 (gender) X 3 (Approach) X 2 (Time) repeated measures ANCOVA on children's mean math ability scores. Gender and approach served as between groups factors and time (pre, post) was the repeated, within group, factor. The ANCOVA failed to reveal significant main effects or interactions as seen in Table 2, all $ps>.05$.

Children's Math Ability: Formative Math Assessments, Counting with Number Identification

Pre-math-games Adjusted Means Data Analyses – Counting with Number Identification. An ANCOVA controlling for children's receptive verbal ability (PPVT-4) and Socioeconomic status (Hollingshead Index), examined differences by teaching approach for children's pre-math-games means for counting with number identification. Results of the F-test found no significant differences by teaching approach in the adjusted means for children's pre-math-games counting with number identification scores, $\bar{X}^1=7.82$, $SD^1=3.26$; $\bar{X}^2=7.48$, $SD^2=2.23$; $\bar{X}^3=7.55$, $SD^3= 2.39$; $F(60,2)=.23$, $p=.79$.

Pre- and Post-math-games Data Analysis- Counting with Number Identification. A 2 (gender) X 3 (approach) X 2 (time) repeated measures ANCOVA was conducted on children's counting with number identification. Children's receptive verbal ability and SES served as covariates in this model. The ANCOVA revealed no main effects for time, teaching approach, or gender, all $ps>.05$. However, the interaction for time and gender was significant, $F(60,2)=5.67$,

$p=.02$. The time by teaching approach gender interaction approached significance, $F(60,2)=2.94$, $p=.06$.

Follow-up Analysis on Main Effect and Interactions. Separate one-way repeated measures ANCOVAs were conducted by gender. Both boys and girls were found to be significantly different from pre-math-games counting and number identification to post-math-games counting and number identification, $\bar{X}(\text{pre-boys})=7.29$, $\bar{X}(\text{post-boys})=8.85$, $p=.046$; $\bar{X}(\text{pre-girls})=8.32$, $\bar{X}(\text{post-girls})=8.81$, $p=.032$. For boys, no significant difference was found between teaching approaches, $F(24,2)=.67$, $p=.52$. In contrast for girls, a significant difference emerged for teaching approaches, $F(36,2)=3.85$, $p=.03$. Post-hoc pairwise comparisons found that girls in whole-group centers (A-2) increased in counting with number identification from pre, $\bar{X}=8.094$, to post, $\bar{X}=9.502$, $p=.001$.

Children's Math Ability: Formative Math Assessments, Sorting

Pre-math-games Adjusted Means Data Analyses – Sorting. An ANCOVA controlling for children's receptive verbal ability (PPVT-4) and Socioeconomic status (Hollingshead Index) examined differences by teaching approach for children's pre-math-games means for sorting ability. Results of the F-test found no significant differences by teaching approach in children's pre-math-games sorting ability, $\bar{X}^1=.47$, $SD^1=.51$; $\bar{X}^2=.48$, $SD^2=.51$; $\bar{X}^3=.75$, $SD^3=.44$; $F(60,2)=.53$, $p=.59$.

Pre- and Post-math-games Data Analysis- Sorting. A 2 (gender) X 3 (approach) X 2 (time) repeated measures ANCOVA was conducted on children's mean sorting ability. Children's verbal ability and SES served as covariates in this model. Only a significant main effect of time (pre, post) was found for sorting, $\bar{X}(\text{time1})=.57$, $\bar{X}(\text{time2})=.93$, $F(60,2)=6.32$,

p=.015. The main effect of gender approached significance, \bar{X} (boys)=.68, \bar{X} (girls)=.82,
 $F(60,2)=2.94$, $p=.092$.

Table 2

*Pre and Post Means (and Standard Deviations) for Approaches,
 ANCOVA Repeated Measures F-values for Main Effects and Interactions*

		Approach			Main Effects	Interactions
		1 Rotating Centers	2 Whole-group Centers	3 Free-choice Centers		
Formal Math	Pre Post	89.59(14.53) 93.06(12.24)	92.22(12.46) 94.30(13.56)	100.35(9.33) 101.80(10.73)	B = .82 T = .01 A = .81 G = 2.19	T x A = .08 T x G = 1.58 T x A x G = .15
Count & No. Ident	Pre Post	7.82(3.26) 8.35(2.55)	7.48(2.23) 9.09(1.35)	7.55(2.39) 8.75(1.37)	B= .23 T= 2.74 A= .26 G= 2.64	T x A = 2.06 T x G = 5.67** T x A x G = 2.94*
Sorting	Pre Post	.47(.51) 1.0(.00)	.48(.51) .91(.29)	.75(.44) .90(.31)	B= .59 T= 6.32** A= .96 G= 2.94*	T x A = .03 T x G = 1.31 T x A x G = 1.15
Patterning -copy	Pre Post	3.47(2.03) 4.94(.24)	3.57(2.09) 4.87(.46)	4.90(.31) 5.00(.00)	B= 2.05 T= 2.76 A= 1.69 G= .11	T x A = 1.66 T x G = .004 T x A x G = .09
Patterning -repeat	Pre Post	1.59(1.91) 2.09(2.14)	2.00(1.83) 3.48(1.81)	4.00(1.34) 4.55(1.00)	B= 4.22* T= .13 A= 4.48** G= .11	T x A = 1.44 T x G = .26 T x A x G = .80
Patterning -create	Pre Post	.24(.44) .18(.39)	.43(.51) .48(.51)	.55(.51) .70(.47)	B= 1.35 T= .01 A= 3.17** G= .01	T x A = .37 T x G = .01 T x A x G = .33
Cognitive Self-compt	Pre Post	3.71(.24) 3.72(.35)	3.59(.43) 3.75(.30)	3.61(.33) 3.59(.30)	B= .92 T= .23 A= .13 G= 1.88	T x A = 1.42 T x G = .14 T x A x G = .11
Social Skills	Pre Post	95.82(9.96) 96.18(8.95)	103.57(11.01) 118.78(11.89)	107.95(12.89) 110.60(14.53)	B= 1.01 T= 1.93 A= 5.26** G= 4.52**	T x A = 15.37*** T x G = 1.64 T x A x G = 2.63*

Note: All analysis performed with adjusted means; B=Baseline, T=Time, A=Approach, and G=Gender; * $p<.10$, ** $p<.5$, *** $p<.01$.

Children's Math Ability: Formative Math Assessments, Patterning

Pre-math-games Adjusted Means Data Analyses – Patterning. An ANCOVA controlling for children's receptive verbal ability (PPVT-4) and Socioeconomic status (Hollingshead Index) examined differences by teaching approach for children's pre-math-games means for copying patterns, repeating patterns, and creating own pattern. No pre-math-games significant differences in the adjusted means were found by teaching approach for copying patterns; $\bar{X}^1=3.47$, $SD^1=2.03$; $\bar{X}^2=3.57$, $SD^2=2.09$; $\bar{X}^3=4.90$, $SD^3=.31$; $F(60,2)=2.05$, $p=.138$; or for creating own pattern, $\bar{X}^1=.24$, $SD^1=.44$; $\bar{X}^2=.43$, $SD^2=.51$; $\bar{X}^3=.55$, $SD^3=.51$; $F(60,2)=1.35$, $p=.267$. However, significant pre-math-games differences were found by teaching approach in the adjusted means for children's repeating patterns, $\bar{X}^1=1.59$, $SD^1=1.91$; $\bar{X}^2=2.00$, $SD^2=1.83$; $\bar{X}^3=4.00$, $SD^3=1.34$, $F(60,2)=4.22$, $p=.02$. A post hoc Tukey HSD found that children in free-choice centers (A-3) had a higher pre-math-games mean for repeating patterns than children in whole-group centers (A-2), $p=.018$. In addition, the difference in pre-math-games means between free-choice centers (A-3) and rotating centers (A-1) approached significance, $p=.062$.

Pre- and Post-math-games Data Analysis- Patterning. A 2 (gender) X 3 (approach) X 2 (time) repeated measure ANCOVA was conducted on children's patterning ability. Children's receptive verbal ability and SES served as covariates in this model. A significant main effect of teaching approach was found for repeating patterns, $\bar{X}^1=2.08$, $\bar{X}^2=2.61$, $\bar{X}^3=4.22$, $F(60,2)=4.48$, $p=.02$, and for creating own pattern, $\bar{X}^1=.17$, $\bar{X}^2=.45$, $\bar{X}^3=.66$, $F(60,2)=3.17$, $p=.05$. All other main effects or interactions were not found significant, all $ps>.05$.

Follow-up Analysis on Main Effect and Interactions. Further post hoc review revealed that for repeating patterns free-choice centers (A-3) were significantly different than whole-group centers (A-2) and rotating centers (A-1), $\bar{X}^1=2.08$, $\bar{X}^2=2.61$, $\bar{X}^3=4.22$, $ps=.01$. For creating

own pattern, free-choice centers (A-3) were significantly different than rotating centers (A-1), $\bar{X}^1=.17$, $\bar{X}^2=.45$, $\bar{X}^3=.66$, $p=.02$, and whole-group centers (A-2) were marginally significantly different than rotating centers (A-1), $p=.054$.

Children's Cognitive Self-Concept

Pre-math-games Adjusted Means Data Analyses. An ANCOVA controlling for children's receptive verbal ability (PPVT-4) and Socioeconomic status (Hollingshead SES index) examined differences by teaching approach for children's pre-math-games means for cognitive self-concept scores. No significant differences were found by teaching approach for cognitive self-competence scores, $\bar{X}^1=3.71$, $SD^1=.24$; $\bar{X}^2=3.59$, $SD^2=.43$; $\bar{X}^3=3.61$, $SD^3=.33$; $F(60,2)=.922$, $p=.404$.

Pre- and Post-math-games Data Analysis. A 2 (gender) X 3 (approach) X 2 (time) repeated measures was conducted on children's cognitive self-competence scores. Children's receptive verbal ability and SES served as covariates in this model. No significant main effects or interactions were found, all $ps>.05$.

Children's Social Skills as Rated by the Teachers

Pre-math-games Adjusted Means Data Analysis. An ANCOVA controlling for children's verbal ability (PPVT-4) and Socioeconomic status (Hollingshead Index) examined differences by teaching approach for children's pre-math-games means for social skills (SSRS) as rated by the teachers. Results of the F-test testing for differences in the adjusted means found no significant differences by teaching approach in children's pre-math-games social skills scores, $\bar{X}^1=95.82$, $SD^1=9.96$; $\bar{X}^2=103.57$, $SD^2=11.01$; $\bar{X}^3=107.95$, $SD^3=12.89$; $F(60,2)=1.01$, $p=.37$.

Pre- and Post-math-games Data Analysis. A 2 (gender) X 3 (approach) X 2 (time) repeated measures ANCOVA was conducted on children's social skills. Children's receptive

verbal ability and SES served as covariates in this model. The ANCOVA revealed no main effect for time, $p > .05$. The main effect for teaching approach was significant, $\bar{X}^1=98.87$, $\bar{X}^2=111.79$, $\bar{X}^3=107.66$, $F(60,2)=5.26$, $p=.01$, and the main effect for gender was significant, $F(60,2)=4.52$, $p=.04$. Teaching approach by time interaction was significant, $\bar{X}(\text{boys})=109.24$, $\bar{X}(\text{girls})=102.98$, $\bar{X}^3=4.22$, $F(60,2)=15.37$, $p < .000$, and time by teaching approach by gender interaction approached significance, $F(60,2)=2.63$, $p=.08$.

Follow-up Analysis on Main Effect and Interactions. Follow up examining pairwise comparisons for the main effect for teaching approach found rotating centers (A-1) significantly different from whole-group centers (A-2), $p=.003$. A one-way repeated measures ANCOVA was conducted by gender to analyze the marginally significant trend for the interaction. For boys, significance was found for children's pre-math-games and post-math-games social skills scores by teaching approach, $F(24,2)=12.72$, $p < .001$. Follow up interaction examining pairwise comparisons found all three approaches significant from pre-math-games to post-math-games for boys social skills, $\bar{X}^1_{\text{pre}}=99.22$, $\bar{X}^1_{\text{post}}=88.72$, $p=.041$; $\bar{X}^2_{\text{pre}}=105.23$, $\bar{X}^2_{\text{post}}=114.27$, $p=.001$; $\bar{X}^3_{\text{pre}}=115.98$, $\bar{X}^3_{\text{post}}=124.34$, $p=.025$. For girls, significance was found for children's pre-math-games and post-math-games social skills scores by teaching approach, $F(36,2)=9.16$, $p=.001$. Follow up interaction examining pairwise comparisons found whole-group centers (A-2) significant from pre-math-games to post-math-games for girls social skills, $\bar{X}^2_{\text{pre}}=102.13$, $\bar{X}^2_{\text{post}}=120.74$, $p=.000$.

Teacher's Attitudes About Teaching Math

Descriptive statistics were conducted on the MTEBI survey responses. No additional statistical analysis was conducted on the scores because of the limited amount of teacher participants ($n=8$). The mean score for all teachers for the Personal Mathematics Teaching

Efficacy Belief (SE) subscale was $\bar{X}_{pre}=52.87$, $SD_{pre}=3.72$ and $\bar{X}_{post}=51.38$, $SD_{post}=2.50$.

The mean score for all teachers for the Mathematics Teaching Outcome Expectancy (OE) subscale was $\bar{X}_{pre}=27.5$, $SD_{pre}=4.21$ and $\bar{X}_{post}=28.5$, $SD_{post}=2.00$. There was not much difference in the means from pre-math-games to post-math-games for either subscale.

Discussion

Children's Math Ability

There were no differences in children's general math abilities by teaching approach after accounting for children's SES and verbal ability. Therefore, the children in each site, using a different pedagogical center approach to math, had similar outcomes. It is possible that the teaching approaches at each site were effective because the teachers were effective at implementing their philosophical approach to teaching math and learning math.

Though significance was not found for children's general math ability, several of the children's specific math skills assessed through formative methods did show gains by teaching approach. First, girls had significant gains in counting and number identification in whole-group centers (A-2). Second, children in free-choice centers (A-3) had higher skills for repeating patterns than children in rotating centers (A-1) and whole-group centers (A-2). Third, children in free-choice centers (A-3) and children in whole-group centers (A-2) had higher skills for creating his/her own pattern than children in rotating centers (A-1). These differences in specific math skills show that free-choice center (A-3) and whole-group center (A-2) approaches have greater effects on children's math outcomes than rotating centers (A-1).

Sorting ability increased over time and significant differences were found between the pre-math-games means and the post-math-games means for all children. This increase in sorting ability and the previous math gains by teaching approaches suggest that the math games provided opportunities to improve counting, number identification, and sorting skills.

There may be several reasons besides the math games that could have influenced children's counting, number identification, and sorting abilities. One reason could be maturation. Children naturally mature in skills over time. A second reason could be the classroom curriculum. A teacher, assistant teacher, or classroom volunteer could have concurrently taught sorting skills with one or more of the children in the study.

Children participated in the math games one time per week over four weeks. This short time period, plus low frequency during the time period, was probably not adequate for children to improve greatly in their math skills. The lack of intensity in providing the math games might reflect the lack of improvement in children's patterning skills over time and reflect the lack of improvement for the boys in counting and number identification. Further research should consider the length of time and the frequency of opportunities for children to participate in math games.

Though the teachers did not mention gender differences in math ability during their interviews, there is the possibility of children this age having knowledge of gender stereotype associated with math ability. Lummis and Stevenson (1990) found that children in the first grade believed that boys were better than girls in mathematics. To further compound the issue, young children are less flexible in their understanding of stereotypes and do not generalize as adults do about social groups (Bussey & Bandura, 1999). Future research should explore the math game process and components and find what appealed to young girls' interests or learning styles for counting and number identification.

Children's Cognitive Self-Concept

As a group, the young children in this study had high cognitive self-concept. There were no differences by teaching approach found in how children perceived their cognitive self-

competence. The Cronbach alphas, both pre- and post-math-games, were low for cognitive self-competence (.54 and .33) which suggests that the children in this study either did not understand the questions or understand how to respond to the questions. Fantuzzo et al. (1996) found the measure, PSPCSAYC, inappropriate for African American preschooler-aged children whose families are from economically disadvantaged backgrounds. He stated that children did not have full comprehension of the administration of the assessment and therefore could not respond appropriately. The results of this study indicate that more research needs to be conducted on creating a reliable and sensitive assessment for cognitive self-competence.

Children's Social Skills as Rated by the Teachers

Children in whole-group centers (A-2) had higher social skills mean scores than children in rotated centers (A-1). The marginally significant trend for time by teaching approach by gender showed mixed results for children's social skills. For boys, all three teaching approaches were significant between pre-math-games and post-math-games social skills. The boys in rotated centers (A-1) decreased in social skills. In whole-group centers and free-choice centers (A-3), the boys increased in social skills. For girls, only whole-group centers showed gains for girls in social skills. Both whole-group centers and free-choice centers had positive effects on children's social skills. One consideration is that whole-group centers (A-2) might have created a *caring community of learners* (Copple & Bredekamp, 2009) because the children are participating in the same activities at the same time in small groups. Approach-3 using free-choice centers create a caring community of learners because the center follows NAEYC guidelines. In contrast, rotated centers had negative effects on boy's social skills. One possible explanation for this could be teacher's perception of social skills during transitions. When rotating centers, there were more transitions where children could be disruptive or be perceived as not following directions.

Teacher's Attitudes About Teaching Mathematics

Overall teacher scores in Efficacy Beliefs (SE) remained stable over time. Efficacy beliefs are a teacher's judgment about whether they will be able to demonstrate behaviors or actions that are needed to positively impact student's learning (Enochs et al., 2000). Participation in this study did not show that teachers gained confidence in teaching mathematics skills as was hoped. Henson (2001) suggested teacher participation in research may be a method of professional development that can positively impact teacher efficacy. One reason why there might have not been improvement in efficacy beliefs is because the average scores (52.87 and 51.38) were already high compared to the maximum score of 65. During teacher interviews, all of the teachers were positive about the experience and many were excited about developing and trying out their own math games in the future.

Overall scores in Outcome Expectancy (OE) remained stable over time. Outcome expectancy is when a teacher believes student learning can be influenced by effective teaching given such factors as family background, IQ, and school conditions (Gibson & Dembo, 1984). One reason why there might have not been improvement in outcome expectancy is because the average scores (27.5 and 28.5) were already high compared to the maximum score of 40. During teacher interviews, many of the teachers mentioned how literacy and social skills have been pushed to the forefront and dominate more of the curriculum than math. Teacher expectations of the level of math skills that could be taught were lower than the children's skills and interests that were demonstrated during the math games. The teachers acknowledged that challenging a child's math skills and providing guided math opportunities were possible in their classrooms.

Limitations

This study has several limitations. First, the formative math assessments in this study were based on non-standardized instruments created by the researcher. Though formative and teacher created math assessments are common in prekindergarten classrooms, they are not typically used in research. Additional research is needed with these assessments to validate their reliability and validity.

Second, the sample was small. Future large scale research needs to be completed on best practices in teaching math and social skills in prekindergarten settings.

Third, since the math games were provided over a very short and focused time period, there was no evidence that they would have a long-term effect on children's overall math learning. If the planned math games had been implemented for a longer period of time or with increased frequency, children may have been able to better learn those math skills.

Fourth, lack of a control group lessens the significance of the findings. A control group would have ruled out maturation as a possible cause of children's gains in social skills or math skills.

Conclusion

As a group, children under all three teaching approaches had gains in specific math skills, such as sorting. Because of the study limitations, it is not with certainty that the math games were the cause. Differences were found in social skills in the different sites, with positive and negative results for boys. It was hypothesized that children in free-choice centers (A-3) would have higher social skills. Results are not as expected, because whole-group centers (A-2) also had increases in children's social skills, in both boys and girls.

Overall, results may support that all three teaching approaches have merit. Results may also support that different teaching approaches may be better for certain childhood populations, such as children from disadvantaged homes. For example, Denton and West (2002) found that small-group teacher-directed academic instruction provided gains in skills for disadvantaged children to allow them to lessen the achievement gap with higher SES peers.

Further study is warranted of the math games because girls had more gains in mathematics, such as counting and number identification. Characteristics of the math games need to be studied to establish what kept children's interest, motivated participation, and provided learning. More studies of early mathematics need to be conducted taking a games approach with hands-on manipulatives.

Further study is also warranted for how teaching approaches effect young children's advancement or decline in social skills. Social skills are just as important for kindergarten readiness as academic skills (Lin et al., 2003). Diamond (2010) suggests looking at the whole child for learning ability and to provide engaging and fun activities as part of early childhood curricula. It is also suggested that play be given a prominent role and active, hands-on learning in small groups be provided in early education settings (Diamond & Lee, 2011).

Every approach to teaching has its supporters and researchers. It is possible that the teacher's beliefs in efficacy and belief in their teaching approach may establish that children in their classrooms will learn, despite the teaching approach. The teachers gained significant knowledge about how to teach mathematics and what math concepts to teach young children. The teachers were excited to be able to implement their own math games the following school year.

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