



## **The Effectiveness of Teaching Number Relationships in Preschool**

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Number relationships, which go far beyond counting skills, refer to the ability to represent a quantity in multiple, flexible ways. It is arguably among the most important mathematics concepts in number and quantity. The current study examined the effectiveness of number relationships instruction in preschool classrooms. Participants included 73 children and 4 teachers from a half-day preschool program in a local school district. For the intervention group, two teachers provided number relationships instruction to 37 of the children in their classrooms (four sections total). No treatment occurred for the control group consisting of the remaining 36 children taught by two teachers. Before and after the 12-week treatment period, the TEMA-3 (Test of Early Mathematics Ability-3<sup>rd</sup> Edition) was administered both as a pretest and a posttest to assess children's understanding of number and quantity. Results indicated that children in the intervention group who received mathematics instruction with the emphasis on teaching number relationships scored significantly higher on the posttest than their counterparts in the control group. However, results of the current study did not reveal any advantages by age group for number relationships instruction. Small sample size may have limited this analysis.

**Key Words:** Number Relationships, Early Childhood Mathematics, Preschool Curriculum, Subitizing, Parts-Whole Concept, Preschool, Teaching

### **INTRODUCTION**

Although young children need experiences with mathematical ideas ranging from classification and patterns to shapes and geometry, the most fundamental concepts at this level are number and quantity (Kilpatrick, Swafford, & Findell 2001; Sarama & Clements, 2009). The National Council of Teachers of Mathematics (NCTM, 2000, p.32) also emphasized the importance of early instruction on number and quantity by

noting, “All the mathematics proposed for prekindergarten through grade 12 is strongly grounded in numbers.” Important questions, then, for early childhood teachers include: What specifically should they teach in number and quantity, and on what topics should initial instruction efforts focus? Counting must certainly be a primary instructional focus for teaching number and quantity; however, presenting counting tasks over and over becomes less effective and meaningful when children have acquired all the necessary counting skills and concepts, such as one-to-one correspondence and cardinality (i.e., knowing that the last counting word represents the whole quantity of the objects in a set).

Number relationships are arguably among the most important mathematics concepts in number and quantity, and they must be developed throughout the early years of life (Baroody, 2000; Jung, 2011; Ma, 1999). Number relationships, which go far beyond counting skills, refer to the ability to represent a quantity in multiple, flexible ways, for example, thinking about the number 6 as 1 and 5, as 2 more than 4, as 2 groups of 3, or as 3 groups of 2. Some young children do not see such relations among numbers. For example, Sarnecka and Lee (2009) showed that children ages 2 to 4 view number words as mutually exclusive. A full understanding of number relationships is important because it helps children not only make sense of more advanced mathematics concepts, such as place value and measurement (Baroody, 2004), but it also prepares them to solve mathematics problems with understanding (Fosnot & Dolk, 2001). For example, children with a strong understanding of number relationships might solve single-digit addition problems, such as  $7 + 5$ , in several different ways. They could break 7 into 5 and 2 to make 10 ( $5 + 5$ ) and add 2 more to get 12. Others may break 5 into 3 and 2 to make 10 ( $7 + 3$ ) and add 2 more. Children can use different strategies, such as the “make-ten” strategy in the example, when they are capable of representing and manipulating quantities in flexible ways.

Young children need to develop three features of number relationships to develop the concept of number and quantity: subitizing, parts-whole relationships, and more-and-less relationships. Subitizing refers to the process of instantly seeing a number without counting, and it is a powerful tool to foster children’s understanding of number. For example, people tend to use either counting or estimation to determine the size of a set of objects; however, when they see very small numbers, such as three or four dots on a die, they most likely recognize the numbers of dots without a need to count them explicitly. Subitizing deserves a considerable amount of educational attention because it is an important skill for developing children’s understanding of numbers (Baroody, 1987).

First, subitizing helps children learn the concept of cardinality. Some children may not know how many objects are in a collection even after they verbally counted them in the correct order. For example, children as young as three can accurately count a small number of objects (Fuson, 1988). However, when they are asked a “how many” question, they typically re-count objects as if the question required merely counting rather than determining the total quantity (Clements & Sarama, 2009). To these children, counting can be viewed as just the action of enumeration, not a purposeful

activity (Munn, 1997). In their experimental study, Benoit, Lehalle, & Jouen, (2004) examined the roles of counting and subitizing in terms of young children's acquisition of the cardinal meaning of number words. These researchers asked 3- to 5-year-olds to determine how many dots were present after they were shown collections of red dots (1 to 6) in two different modes. In the first mode, all elements of red dots were presented at the same time (e.g., three red dots on a screen), while each element was shown one after another in the second mode (e.g., one dot three times). The results showed that children performed better when red dots were presented in the first mode, which may indicate that subitizing is a more fundamental tool than counting for learning cardinal value of numbers.

Another benefit is that subitizing promotes children's understanding of parts-whole relationships, the recognition that a whole can be partitioned into two or more parts. Clements (1999) identified two types of subitizing, perceptual and conceptual, and believed that both contribute to developing parts-whole relationships. Perceptual subitizing is closest to the general definition of subitizing. This skill involves no mathematical process because people instantly perceive a quantity (e.g., 2 dots on a die) without any conscious effort (Sarama & Clements, 2009). However, when people quantify dots on a pair of dice (e.g., 2 dots on one die and 4 dots on the other), they rely on perceptual subitizing first to identify a quantity on each die (e.g., 2 and 4) and then to put them together as a "composite of parts and as a whole" (Clements, 1999, p. 401). The cognitive action of seeing the parts and putting together the whole is called conceptual subitizing. In the example of dots on a pair of dice, children see a whole as the composite of two parts (i.e., decomposing), then use perceptual subitizing to recognize 2 and 4, and finally put them together (i.e., recomposing) to identify 6 as a whole. Similarly, children learn different ways to represent the same quantity by looking at different arrangements of parts, such as "1 and 5" and "3 and 3."

Understanding parts-whole relationships, which is the second type of number relationships, is not an easy task for many young children. Although young children begin to recognize that a quantity (a whole) is composed of smaller quantities (parts), they may not explicitly understand the logical relationships (e.g., they may not know that the sum of 2 and 5 must be the same as 5 and 2). Some experts argue that instruction on parts-whole relationships is less meaningful for young children because they are not cognitively ready. For example, the Piaget's inclusion task revealed young children's inability to think of both a whole and parts simultaneously (Piaget, 1965). However, this conclusion has been questioned by subsequent researchers, arguing that unfamiliar language used in the task may have caused the children's poor performance. Researchers discovered that children as young as 4 were successful on the inclusion task when more familiar terms, such as "family," were used; concluding that young children may be able to coordinate parts and the whole earlier than Piaget believed (Fuson, Lyons, Pergament, Hall, & Kwon, 1988; Markman, 1973).

Also, young children's inability to solve missing-addend problems has been targeted as additional evidence that they lack understanding of parts-whole relationships (Kamii, 1985). However, more studies draw different conclusions. According to Sophian and

McCorgray (1994), for example, 5 and 6-year-olds can reason about missing-addend problems although their reasoning did not always transfer to their ability to solve the problem correctly. For example, they understood that a missing starting amount must be less than a final amount in a join problem (e.g., “At the party, Raggedy’s dogs were there. Then Mickey’s three dogs came. After that, there were five dogs. How many dogs were there at first?) and larger than either part in separate problem (e.g., At first, both Mickey’s and Raggedy’s fish were there. Later, Mickey’s two fish went home, and Reggedy’s seven fish were left. How many fish were at the party?).

Sophian and McCorgray’s research findings should not be interpreted as evidence that young children may have developed sufficient understanding of parts-whole relationships to solve missing-addend problems successfully. Rather, these findings may suggest that children’s understanding of parts-whole relationships is developing before primary grades, and appropriate instruction must be considered to build a sound basis for their mathematical learning (Baroody, 2004; Hunting, 2003; Sarama & Clements, 2009). Developing a full understanding of parts-whole relationships in early years is also important because it serves as the foundation for more advanced mathematics concepts, such as place value (e.g., 15 [whole] as one ten [part 1] and five ones [part 2]) and fractions (e.g., equal-size parts of a whole). For example, Fischer (1990) found that kindergarteners who received instruction with an emphasis on parts-whole relationships developed greater understanding of place value than their counterparts in the control group.

Finally, more-and-less relationships also play a critical role in developing children’s number relationships. Given a pair of collections with different quantities, many young children are able to judge which collection has more (Clements 2004). However, determining how many more (or less) one collection has than the other is more difficult than simply identifying which collection has more (or less). As young children learn counting and begin exploring different quantities, they may learn the “larger number principle,” that is, the later a number word is called in the counting sequence, the larger quantity it has (Baroody, 2004, p.192). However, the ability to use the larger number principle does not guarantee that children see relationships between number pairs. For understanding more-and-less relationships, young children must arrive at the important insight that a quantity (the less) must be contained in the other (the more), instead of viewing that both quantities are mutually exclusive (Clements, 2004). This skill also requires children to mentally think of the difference between two quantities as a third quantity, which is the notion of parts-whole relationships (Krajewski & Schneider, 2009).

#### **Purpose of the current study**

Regardless of the importance of teaching number relationships, it is still questionable whether preschool teachers provide appropriate learning experiences that help young children reflect on all key features of number relationships. One possible explanation why number relationships may not be taught relates to the limited research evidence for its effects on preschool children’s understanding of number and quantity. However, a few studies suggested guidelines for teaching number relationships. For example,

Clements and Sarama (2007) studied the effectiveness of their technology-integrated mathematics curriculum on preschool children's mathematics learning; the three features of number relationships are among the mathematics concepts highlighted in the curriculum along with other mathematics concepts. Other researchers studied the effectiveness of subitizing with children in kindergarten and found positive learning outcomes compared to their counterparts in the control group (Tournaki, Bae, & Kerekes, 2008). However, these studies focused on mathematics curricula in general or a particular feature of number relationships.

Therefore, the present study was designed to examine the effectiveness of mathematics instruction in preschool classrooms that emphasized children's developing understanding of number relationships because few studies, if any, have been conducted to determine the effectiveness of number relationships instruction at the preschool level. The study focused on the effectiveness of providing number relationships instruction using the foundational skills of subitizing, parts-whole relationships, and more-and-less relationships with young children. It was hypothesized that increasing these skills in children would also increase their mathematical understanding of number and quantity. Another purpose of study was to investigate the effectiveness of number relationships instruction with different groups of children such as those representing different ages, genders, and learning skills, such as children with developmental delays or those who were at risk for future academic failure.

## **METHOD**

### **Participants**

The study took place in a public preschool program in a suburban school district near Chicago, Illinois, in the midwestern United States. In 2010, the preschool classrooms, which had previously been located at five elementary schools throughout the school district, were relocated to a recently built preschool with a centralized district location. The preschool had 12 teachers who taught blended classrooms which included children with and without disabilities and children from all three registration groups: EC (Early Childhood), PFA (Preschool For All), and COMM (Community). Children in the EC group were those who were in special education with Individualized Educational Programs (IEPs). Preschoolers who were determined to be at-risk for academic failure, based on results of a screening process, were eligible for PFA which was fully funded by the Illinois State Board of Education. At-risk areas varied and could include English Language Learners (ELL), family income, peer interaction, and behavioural concerns. Families of children in the COMM group paid tuition. Children registered in EC or PFA attended the program five days a week Monday through Friday during the morning (9:30-11:00 am) or in the afternoon (12:15-2:45 pm), and children registered in COMM attended the program four days a week Monday through Thursday during the morning or in the afternoon. Each teacher was assigned a group of 15 children in the morning and a different group of 15 children in the afternoon. Each group was composed of children from all three registration groups. Two paraprofessionals were also assigned to each classroom. The daily schedule for each teacher included table activities/fine motor activities, circle time, center time/snack, playground/gross motor

time, story time, and small group time. Each class had music and physical education weekly and art every other week. The curriculum used in the program was *Mathematics: The Creative Curriculum Approach* which is aligned to the state's Early Learning Standards.

For the study, 4 teachers (2 intervention, 2 control) and 74 three- to five-year-old children participated at the beginning of the study; however, one child did not complete the posttest; therefore 73 children (37 intervention, 36 control) participated in all aspects of the study. For the intervention group, two teachers provided number relationships instruction to children in their classrooms, including 37 children (20 males, 17 females) who were tested before and after the intervention. Among the 37 children in the intervention group, six children participated in additional mathematics activities for another research study; however, they were maintained in the intervention group because they engaged in all the same activities during the entire intervention period as their peers. The remaining 36 children (21 males, 15 females) in the control group taught by the remaining two teachers received no treatment. These teachers provided mathematics activities using the mathematics curriculum adopted by their school district. The children in the control group were pretested and post tested during the same time period as those in the intervention group. Table 1 shows the distributional characteristics of the sample; Figure 1 shows the age distribution of children in each group. The mean age was equivalent for children in groups, with  $M_{\text{intervention}} = 4.61$  ( $SD = .46$ ) and  $M_{\text{control}} = 4.61$  ( $SD = .41$ ).

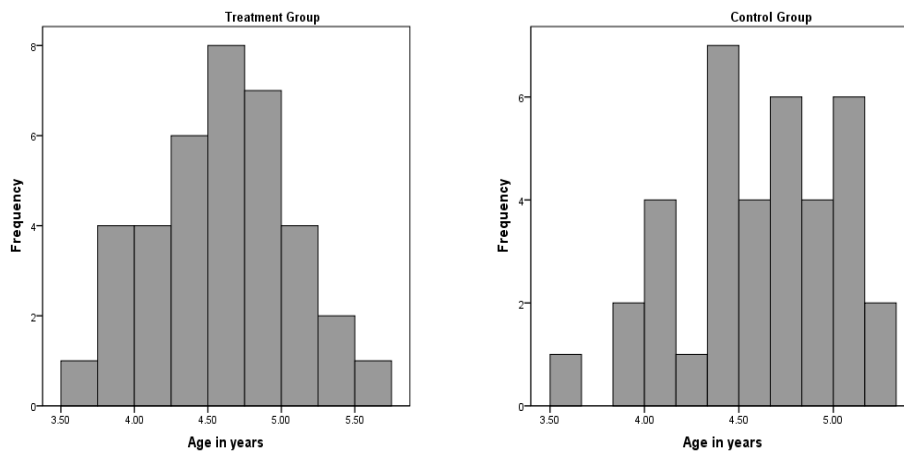


Figure 1: Age distribution of children.

Table 1: Characteristics of sample

	<i>Frequency</i>	<i>Percent</i>
<b>Treatment Group</b>		
Intervention	37	50.7%
Control	36	49.3%
Total	73	100.0%
<b>Registration Group</b>		
EC	23	31.5%
COMM	40	54.8%
PFA	10	13.7%
Total	73	100.0%
<b>Gender</b>		
Female	32	43.8%
Male	41	56.2%
Total	73	100.0%
<b>Classroom</b>		
Teacher A (Intervention)	19	26.0%
Teacher B (Intervention)	18	24.7%
Teacher C (Control)	18	24.7%
Teacher D (Control)	18	24.7%
Total	73	100.0%

### **Instruments**

The TEMA-3 (Ginsburg & Baroody, 2003) is a standardized test to assess mathematical ability in children between the ages of 3 and 8. The assessment contains four categories of items that assess informal mathematics: (a) numbering abilities (e.g., “Count these dots with your fingers and tell me how many there are” “Give me five tokens”), (b) number comparison (e.g., “Can you tell me which side has more dots just by looking?” “Tell me which is more, 4 or 5?”) (c) calculation (e.g., “Joey has 1 token, and he gets 2 more. How many does he have altogether?”), and (d) understanding of concepts, such as cardinality (e.g., “How many stars did you count?”) The TEMA-3 uses an individual interview format, with explicit protocol, coding, and scoring procedures. The total number of the items is 72; however, the assessment must be concluded when a child provides five consecutive incorrect responses.

The TEMA-3 was administered both as a pretest and a posttest, before and after the 12-week treatment period. The TEMA-3 has two parallel forms, Form A and Form B. Only Form A was used for the current study. The test-retest reliability of the TEMA-3 is .82 for Form A. Children’s verbal and nonverbal responses (e.g., written numerals) were collected and recorded on the Form A response form. To assess differences in math achievement between intervention and control groups, as well as to assess the effects of age, gender, and registration group, general linear models were fitted using posttest math ability scores as the outcome variable. Effects in the models were evaluated using an overall alpha level of .05. Effect sizes were computed for statistically significant

effects. Child age (mean-centered) and math ability pretest scores were used as covariates in all analyses.

### **Intervention**

After the first assessment with TEMA-3, two teachers from the intervention group received two training sessions (30 minutes each) to learn specific intervention activities for teaching number relationships. Three activities (rekenrek, Building Block software, ten-frame) were introduced at the training sessions, focusing on how each activity could strengthen young children's understanding of number relationships. Upon teacher requests, we demonstrated each activity in their classrooms but only for the first week. Teachers were then asked to teach each activity in their classrooms from Monday to Thursday for 5 to 10 minutes during their first circle period along with other classroom routines. Instruction with rekenrek was provided twice every week (Monday and Tuesday) while other activities were offered only once a week. We observed each classroom at least twice a week to ensure that all intervention activities were implemented as planned and instructed. The following summarizes each activity and describes teacher implementation.

#### *Using rekenrek.*

For the first two days of each week, teachers used a rekenrek, which contains 20 beads in two 10-bead rows each of five red beads and five white beads. They showed children different arrangements of quantities on the rekenrek (e.g., for showing a quantity of 4: 4 on the top, 3 on the top and 1 on the bottom, 2 on the top and 2 on the bottom) and asked them to recognize the quantities. Counting was allowed, but teachers also encouraged children to identify quantities without counting. Each teacher often invited children to check their answers by counting the number of beads shown on the rekenrek. At the beginning of the study, instruction with the rekenrek emphasized small quantities from 3 to 5, but teachers gradually extended the ranges up to 8 for older children. For the last four weeks of the study, teachers were provided with Microsoft PowerPoint slides that showed images of a rekenrek with different quantities. The "fade-away" animation of each slide allowed teachers to show each image of the rekenrek for about 3 or 4 seconds on their Smart Board. When they used the images, children were allowed to use the actual rekenrek only for checking their observations of quantities on the slides.

#### *Using Building Blocks software.*

Once a week, teachers provided children with computer activities from the *Building Blocks* software (Clements & Sarama, 2008). *Building Blocks* provides computer-based mathematics activities for children between the ages of 3 and 12. For the current study, only two activities, "Snapshots" (Levels 1 and 2) and "Dinosaur Shop" (Level 1), were used because both activities are designed to strengthen children's understanding of number relationships at the preschool level. For the Snapshots activity, children are shown up to 4 dots for 2 seconds, and are then asked to find the same quantity among four choices. For the Dinosaur Shop activity, they are asked to identify a corresponding numeral that represents the total quantity of dinosaurs in a box. The box is a 2 x 5



rectangular array (i.e., ten-frame) in which dinosaurs can be placed. The task encourages children to see a quantity in its relation to 5 or 10. For example, 4 dinosaurs can be recognized as 4 singles, but they can be also considered as 1 less than 5. Therefore, the Dinosaur Shop activity is designed to teach all three features of number relationships: subitizing, parts-whole, and more-and-less relationships.

#### *Using ten-frame.*

Like the Building Block software, teachers presented a “fishing net” activity once a week in which children were asked to find how many fish were caught in the fishing net. We created and printed images of a man fishing from a boat with a net (i.e., 5 x 2 rectangular array). Images of the fisherman and net were attached to a magnetic board where we placed fish stickers on magnetic two-color counters, representing fish. Like the Dinosaur Shop activity, the fishing net is used as a ten-frame, so children were encouraged to discuss their different views of quantity, considering its relation to 5 or 10. Teachers placed the magnetic two-color counters (the fish) in the fishing net each time and asked how many fish were caught. The purpose of using two-color counters was to make each part more visible (e.g., two yellow counters on the top and three red counters on the bottom). Like the other activities, the fishing net activity emphasized small quantities from 3 to 5, but ranges were extended up to 8 by the conclusion of the study.

## RESULTS

Table 2 shows descriptive statistics for math pre-test and post-test scores by treatment group.

Table 2: Descriptive statistics for pre-test and post-test by treatment group

Treatment Group	<i>n</i>	<i>Pre-test</i>		<i>Post-test</i>		
		<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
Intervention	37	98.68	14.79	37	105.14	13.04
Control	36	97.56	15.72	36	100.08	14.83

### Unconditional model (Model 1)

Because children were grouped within existing classes, and the potential for correlated errors among children within classes existed, a null mixed effects model (Model 1) was first fitted, with children serving as the Level 1 variable and classroom (i.e., teacher) serving as the Level 2 variable (see Table 3). The intraclass correlation coefficient indicated that very little variability in scores was attributable to classroom context (ICC = .01). Therefore, classroom was not modeled as a random effect in subsequent linear models.

### Conditional Models (Models 2 and 3)

We next fitted a linear model (Model 2) that included the fixed effect of the intervention on posttest, with age and pretest math skill serving as the covariates (see Table 3). Assuming a moderate effect size in the population, a priori power for detecting a group difference with this design was .95. Results showed a statistically

significant main effect for the intervention ( $F(1, 69) = 6.22, p = .02$ ), but with a small effect size ( $\eta^2 = .02$ ). As expected, the effect for the posttest covariate was statistically significant ( $F(1, 69) = 202.57, p < .01$ ) and large in size ( $\eta^2 = .72$ ); however, the effect for child age was not statistically significant ( $F(1, 69) = 0.45, p = .51$ ). A subsequent linear model (Model 3) that included the interactive effect of Treatment Group  $\times$  Age showed no statistically significant interaction effect ( $F(1, 68) = 0.12, p = .73$ ). That is, the effect of the intervention on posttest scores (controlling for math pretest scores) did not appear to differ by age.

Table 3: Parameter estimates (and standard errors) for effects in models 1-3

Effects	Model 1 (null model)	Model 2	Model 3
Fixed effects			
Intercept	102.64 (1.82)	100.49 (1.18)	100.49 (1.20)
Treatment group	--	4.17 (1.67)*	4.16 (1.68)*
Age	--	-1.31 (1.95)	-0.51 (2.99)
Pretest score	--	0.79 (0.06)**	0.79 (0.06)**
Treatment group $\times$ Age	--	--	-1.40 (3.97)
Random effects			
Intercept (Classrooms)	2.50 (11.05)	--	--
Residual	196.50 (33.46)	--	--

Notes. ICC for null model = .01. \* $p < .05$ , \*\* $p < .01$ .

#### Conditional Models (Models 4 and 5)

Next, we considered the effect of the child's initial registration group (EC, COMM, or PFA) on TEMA-3 scores as well as the effect of gender on these scores. Table 4 shows descriptive statistics for pretest and posttest scores by registration group and gender. A linear model was then fitted (Model 4) that included the effect of registration group, again using pretest scores and children age as covariates (see Table 5). Results indicated no statistically significant main effect for registration group ( $F(2, 65) = 0.04, p = .96$ ). In addition, no significant Treatment  $\times$  Registration Group interaction effect on posttest scores was evident ( $F(2, 66) = 0.44, p = .65$ ). Similarly, when the effect of gender was considered, a linear model (Model 5 in Table 5) showed no statistically significant main effect for gender ( $F(1, 67) = 0.10, p = .76$ ) and no significant Treatment  $\times$  Gender interaction effect ( $F(1, 67) = 0.28, p = .60$ ).

Table 4: Descriptive statistics for pre-test and post-test by registration group and gender

	Pre-test			Post-test		
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
Registration group						
EC	23	90.09	12.82	23	96.00	14.69
COMM	40	104.25	14.07	40	107.63	12.03
PFA	10	92.10	13.81	10	98.00	13.63
Gender						
Female	32	100.09	16.32	32	104.59	14.19
Male	41	96.59	14.21	41	101.12	13.99

Table 5: Parameter estimates (and standard errors) for effects in models 4 and 5

Effects	Model 4	Model 5
Intercept	101.08 (3.75)	101.33 (1.87)
Treatment group	2.84 (4.83)	3.13 (2.56)
Registration group (EC)	0.01 (4.37)	--
Registration group (COMM)	-1.07 (4.15)	--
Registration group (PFA)	--	--
Gender (Male)	--	-1.44 (2.45)
Age	-1.38 (2.08)	
Pretest (centered)	0.79 (.06)**	0.79 (0.06)**
Treatment group × Registration group (EC)	-0.63 (5.79)	--
Treatment group × Registration group (COMM)	2.78 (5.36)	--
Treatment group × Gender	--	1.81 (3.41)

Notes. \* $p < .05$ , \*\* $p < .01$ .

Out of interest, we additionally examined posttest scores for the six children in the intervention group who received additional math instruction. Although, at the sample level, their mean score was higher ( $M = 109.00$ ), their scores did not differ significantly from other children in the intervention or control group,  $F(2,70) = 1.46$ ,  $p = .24$ .

## DISCUSSION AND IMPLICATIONS

The primary purpose of the current study was to examine the effectiveness of teaching number relationships in preschool classrooms. Results indicated that children who received mathematics instruction with an emphasis on teaching number relationships scored significantly higher on the posttest than their counterparts in the control group. This observation has important implications for early childhood mathematics for two reasons. First, results support the inclusion of teaching number relationships in preschool classrooms. In addition, the current study may provide teachers with ideas for implementing specific effective teaching strategies into their teaching practices. Clements and Sarama (2009) noted that early childhood teachers do not provide enough subitizing experiences. Similarly, the concept of parts-whole relationships has not been “explicitly identified” as a major emphasis for early childhood mathematics (Baroody, 2004, p. 205). Baroody argued that current early childhood standards do not explain why teaching parts-whole relationships is important or how teachers can foster this skill in early childhood classrooms. The current study provides examples of how teachers can instruct number relationships in preschool classrooms. For example, the three features of number relationships (i.e., subitizing, parts-whole relationships, more-and-less relationships) are connected to one another and thus can be developed concurrently (Jung, 2011). In the current study, two teachers in the intervention group provided appropriate learning experiences that allowed children to explore all key features of number relationships (e.g., two red and two yellow magnetic counters can be perceptually subitized in the top row of a ten frame, represented in more-and-less relationships (1 less than 5), and viewed as a whole made from sets of 2 and 2).

Due the small sample size, results of the current study did not indicate difference by age for children benefiting from number relationships instruction. We suggest future research consider age in relationships to specific interventions because findings may provide teachers of young children with more precise guidance about appropriate expectations for children at various age levels. Similarly, results of the study indicated no statistically significant effect for registration groups. Therefore, future research must be conducted with a larger sample size to determine how the intervention would affect children considered at risk for future academic failure or those with IEP. Further, future research may consider different at risk areas, such as languages, and peer interactions, separately to study the efficacy of the intervention on a particular group of children. Finally, it is suggested that future research investigate the effectiveness of teaching number relationships over a longer period of time during the school year and also include a sustainability measure.

Finally, the teachers in the present study used a computer software program once a week to teach number relationships while they provided more hands-on activities with the rekenrek, ten-frame, and counters on remaining days. In fact, educators and researchers still argue about whether the use of computers in early childhood classrooms is appropriate; however, there is a growing belief that the scholarly dialogue should shift away from questioning whether or not computers *should* be used toward *how* to use them effectively and appropriately (Clements & Sarama, 2010). One implacable idea from research is to maintain an appropriate balance between on- and off-computer activities, compared to providing one type of activity, to better meet the diverse needs of children. For example, Haugland (1992) found that children made greater gains in mathematics skills, such as problem solving and computation skills, when they experienced both on- and off-computer activities compared to working with computers exclusively. Similarly, future research may examine the effectiveness of using computers to teach number relationships.

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