AN INVESTIGATION OF COUNTING AND THE ROLE IT PLAYS IN PROBLEM SOLVING BY BEGINNING KINDERGARTENERS

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August, 1977
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I would like to express my sincere gratitude to Dr. Edward Labinowich for his help and guidance in this study. He gave generously of his time and expertise. His interest in my efforts were greatly appreciated.

To Dr. VanDyk Buchanan and Professor Elizabeth Brady, I extend deep appreciation for their support and help in this project.

I am most grateful for the cooperation of Lemma Willis and Rose Huling, kindergarten teachers at Superior Street School, and their students who participated in this study.

Finally, I wish to acknowledge the inspiration given me by my own children, Kevin age 5 and Jenny age 3.
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The purpose of this study was to assess beginning kindergartener's ability to solve problems dealing with beginning number concepts, to identify counting behaviors of children during problem solving and to identify factors that influence the success rate of problem solving. Thirty children, ranging in age from four years and eleven months to six years and one month were randomly selected from two kindergarten classes at Superior Street School, a Los Angeles City School.

Each subject was given an individually-administered assessment interview with physical objects. Items were scored on correctness of response, and on physical behaviors during the counting process. The t-test for uncorrelated data was used to test the significance of
difference between groups differentiated by age, sex, and preschool experience. The Pearson product moment correlation coefficient was used to analyze the relationship between rote counting ability and problem solving ability. Frequencies of counting behaviors and strategies were tabulated and analyzed.

Findings showed that there is a statistically significant relationship between both age and rote counting ability and problem solving ability. No significant relationship between either sex or preschool experience and problem solving ability was found. There were several physical behaviors noted during problem solving and counting activities. Most children move objects to be counted one at a time while verbalizing the number names. About half the problems solved were solved by observable counting, while the others were solved by an oral response only.

It was concluded that beginning kindergarteners are able to solve problems involving beginning number concepts and that the main strategy for solving these problems is one-by-one counting.
CHAPTER I
INTRODUCTION

Statement of the Problem

The problem of this study is to assess beginning kindergartener's ability to solve a range of problems dealing with beginning number concepts, to identify counting behaviors of children during problem solving, and to identify categories of children's problem solving strategies.

Research Questions

The research questions asked in this study are:

1. Are beginning kindergarteners able to solve problems involving several different early number concepts?
2. What are the problem solving strategies used by beginning kindergarteners?
3. Are there factors which can be identified that may influence or relate to the success rate of problem solving?

Research Hypotheses

The intent of the study was to test the following null hypotheses:
1. There will be no significant difference in problem solving ability by beginning kindergarteners on selected tasks with physical objects with regard to sex.

2. There will be no significant difference in problem solving ability between children above 5.3 years of age and those below 5.3 years of age.

3. There will be no significant difference in problem solving ability by beginning kindergarteners on selected tasks with physical objects with regard to nursery school attendance.

4. There will be no significant relationship between the ability to rote count and the ability to solve problems on selected tasks with physical objects.

Background and Significance

In a recent yearbook of the National Council of Teachers of Mathematics, *Mathematics Learning in Early Childhood*, Folsom (1975) states,

Since meaningful counting is the main strategy used by children to find the sum in addition and the difference in subtraction, counting should play an important role in the number experiences of primary children (p. 165).

The majority of kindergarten mathematics workbooks emphasize ordinal and cardinal counting activities. There is much drill in numeral recognition, writing of numerals, rote counting and counting of pictures of sets of objects.
The emphasis is on skills for learning mathematics much as learning the alphabet is commonly taught as a prerequisite to learning reading. Problem solving, as opposed to drill and practice is generally left until after the introduction of addition and subtraction in the first grade.

Counting, however, is a powerful problem solving technique in its own right. Further, counting allows the child to use the strategy with which he is most familiar to solve problems with confidence. When a child has had many experiences solving problems using his own methods, he is building a foundation for shortcuts and generalizations teachers call algorithms. Perhaps it is in the rush to assume that generalizations have been made, and to require symbolization of these activities that educators meet with problems. A first grade teacher laments,

> We give them much experience in counting, using number lines and folding perception cards (they look like large dominoes). After constant repetition of certain facts such as $3 + 2 = 5$ or $5 - 3 = 2$, I find that many children still must count each time they meet these facts in their work (O'Hara, 1975, p. 35).

According to Wirtz (1974), "Movement from manipulating objects to manipulating symbols is generally very slow" (p. 37). He summarizes elementary arithmetic as follows:
...arithmetic starts with counting and recording the results of counting.
...arithmetic is especially concerned with four basic experiments: addition, subtraction, multiplication and division.
...arithmetic is a continual search for reliable ways to avoid one-by-one counting (p. 30).

Wirtz contends that preschool children understand the "basic concepts" of the four operations. Observations of preschoolers at play support this contention. They are able to solve problems which require an understanding of equivalence and one-to-one correspondence. What the preschooler still needs to learn are ways to communicate what he knows. Counting seems to be one of the first steps in this process.

Numerous studies have been done to assess the number concepts held by beginning kindergarteners. Perhaps the most valuable result from these studies has been the development of procedures and test instruments which can be used by the classroom teacher with her own children. While there have been many assessment studies done, less than 1 percent of the research reports done in elementary mathematics from 1900 to 1965 have been directly related to counting (Suydam, 1970). A study of counting behavior in itself is of little value to the classroom teacher, however, an understanding of the role counting plays in children's work with numbers can aid the teacher in planning an appropriate curriculum.
When a kindergarten teacher is advised to provide for a great deal of counting activities, it is difficult for her to know just where to go after the children have mastered oral counting and counting objects. This study will provide information related to assessment of number concepts and the uses of counting in problem solving.

Definition of Terms

The following terms are used in this study as defined below:

Rote counting: The ability to verbalize in order the numbers one, two, three...

Rational counting or one-to-one counting: The ability to combine rote counting in a one-to-one correspondence with the partitioning of a set of objects and determine the cardinal number of the set.

One-to-one correspondence: The ability to establish that two sets of objects are equivalent in number.

Invariance: The recognition that the number of a set of objects remains unchanged regardless of the position of the objects. The number is the same unless something is added to or taken away from the set. Invariance is similar to Piaget's conservation of number. For this study the numbers of objects used in the invariance tasks are smaller than the criterion of eight objects set by Piaget.
**Problem solving:** The ability to respond quantitatively to questions posed about physical objects.

**Number naming:** The response to the question, "How many are there?"

**Number reproduction:** The response to the question, "Give me five blocks".

**Subitize:** The ability to see at a glance how many objects are in a set. This is possible, generally, only up to sets of 6 objects.

**Grouping:** Counting by physically or mentally grouping items as opposed to counting one at a time.

**Counting on:** Counting on from a known set or given number.

**Visual correspondence:** Two or more sets of objects are placed such that equivalence is obvious and no counting is necessary to establish equivalence.
CHAPTER II
A Review of Literature

Studies assessing the number knowledge of young children before they have had instruction in school are limited. Many of these studies were carried out prior to the time of the many developments which have expanded the experiences of today's children. Earlier studies such as Buckingham and MacLatchy (1930), Mott (1945), Bjonerud (1960), and McDowell (1962), which dealt with number concepts are quite different by definition than the more recent studies, including Seigel (1971, 1974), O'Brien (1971) and Gelman (1967, 1972), which are dominated by the ideas of Piaget.

During the period around 1928, the teaching of arithmetic before the third grade was largely incidental, with no plan or sequence. Most educators thought the reading was of utmost importance, and for that reason, postponed number work until the second or third grade. However, some studies were undertaken to gather information about the amount of number knowledge a child had acquired prior to entering first grade.
Buckingham and MacLatchy (1930) sought information about the child upon entering school. They reasoned that if he had a grasp of small numbers and could communicate with others on the basis of a common knowledge of small quantities, then this child was ready for number work and that to delay the teaching of number was to retard his growth. The study was done in Ohio and involved 1290 children entering first grade, between the ages of 6.0 and 6.6 years. The assessment was individually administered by the child's regular teacher. The test items consisted of rote and rational counting, number reproduction, number naming and simple addition.

An earlier study by Beckmann (1923) differentiated the components of number consciousness. Ordered from least to most difficult, they were as follows: (1) reproduction-"Give me five marbles" (2) differentiation-"Is this four or five marbles?" (3) finding-"Find the one with the same number of dots as this one" (4) naming-"How many are here?" Buckingham and MacLatchy included only the least and most difficult of Beckmann's components of number consciousness in their assessment.

The test items for addition in the Buckingham and MacLatchy study consisted of oral story problems and invisible addition. In the invisible test, the child was shown two buttons in the examiner's hand. Then the
examiner closed his hand and showed two buttons in the other hand. That hand was also closed and the child was asked, "How many are two buttons and two buttons?" If the child failed to respond correctly, the examiner opened his hands and allowed the child to try again, with the buttons in view.

In general, the results of the study showed that over 50 percent of the children were able to do simple sums in their heads, count rote to twenty, count rationally to fifteen, and reproduce and name numbers to ten. More specifically, the results supported Beckmann's contention that naming numbers was more difficult than reproducing numbers. The results of applying chi square to the Buckingham and MacLatchy data are shown in Table I. It seems that, generally, the increasing differences in difficulty between reproducing and naming numbers is related to the size of the number, eight being a notable exception.
Table I

A COMPARISON OF THE RELATIVE DIFFICULTY OF NUMBER NAMING AND NUMBER REPRODUCING ACTIVITIES IN THE BUCKINGHAM AND MACLATCHY STUDY

<table>
<thead>
<tr>
<th>Number of Items</th>
<th>Number Naming &quot;How many?&quot;</th>
<th>Number Reproducing &quot;Give me ___.&quot;</th>
<th>Chi square</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct*</td>
<td>Incorrect</td>
<td>Correct*</td>
</tr>
<tr>
<td>5</td>
<td>848</td>
<td>508</td>
<td>873</td>
</tr>
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<td>8</td>
<td>611</td>
<td>661</td>
<td>745</td>
</tr>
<tr>
<td>10</td>
<td>571</td>
<td>785</td>
<td>680</td>
</tr>
</tbody>
</table>

*Correct responses on 3 out of 3 trials

Chi square value of 3.84 needed for significance at .05

In the invisible addition test items, the median number of correct responses out of ten combinations was 5.0. Over 50 percent of the children who were unable to do the invisible test were able to respond correctly on the visible test. Buckingham and MacLatchy noted the significance of the results of the visible test. It was seen as an indication of the ability of first-grade children to help themselves when faced with difficulty.

Aside from including the ability to count as an item in the assessment procedure, the Buckingham and MacLatchy study did not focus on the use of counting as a problem-solving strategy. The authors did, however,
offer some general comments about the counting behaviors of subjects in the study. They considered counting as an important basis for number concepts. Through the knowledge of, and practice in rote counting, children become vaguely aware of numbers being less than or more than other numbers. Furthermore, counting gives drill in the naming of numbers and conceptual activity is powerfully supported by the language which names the concept. The authors noted that counting can be used to combine number before a child knows about addition.

We strive hard in school to suppress the counting habit. We do well to do this, but not until after counting has served its purpose. ...Let the child find out how many pennies he will have if he already has 6 and his father gives him 2. This way of finding out things is the appropriate way at this time. There comes a time, however, when these less effective ways should be replaced by more effective ways. Probably at no time in the period of school life, should a normal child be encouraged or even allowed to get his number facts by counting. Such a method, once indispensible, is, by that time infantile (p. 490).

Mott (1945) studied four-, five-, and six-year-olds upon entering kindergarten. In an individually administered test she found that 90 percent of the children could reproduce the first ten ordinals. When presented with concrete addition and subtraction problems, about half the children responded correctly without any noticeable counting behaviors. These results show a
considerable gain over the children in the Buckingham and MacLatchy study, who were a year older.

Mott noted the methods which children used to perform the tasks in her study. When asked to select a certain number of blocks from a pile 86 percent of the children did so one by one. Most children also counted aloud as they were doing so. Only 25 percent of the children selected blocks silently. Age seems to be a factor in the counting behavior exhibited. Seventy-five percent of the six-year-olds, 60 percent of the five-year-olds and 40 percent of the four-year-olds selected blocks silently. Other factors reported as contributing to differences in counting behaviors were the difficulty of the task and fatigue.

The studies by Bjonerud (1960) and by McDowell (1962) gave similar results. The studies involved four- and five-year-old children. In these individual interviews, it was found that children generally counted things one at a time. Bjonerud found that 93 percent of the children could subitize, or see at a glance, two objects. However, when four items were shown, the percentage dropped drastically. Related but different data found by McDowell showed that while 83 percent of the five-year-olds, and 71 percent of the four-year-olds could
count five things, only 73 percent of the five-year-olds and, still 71 percent of the four-year-olds could count six things. This data suggests that while most children are comfortable with numbers less than six, moving to higher numbers greatly reduces the ability of the child to operate efficiently. It also suggests that the ability to deal with small numbers occurs most often during the fourth year of age rather than the fifth year of age as found by investigators a generation or so ago.

The Bjonerud and McDowell studies were mainly concerned with finding out what children know when entering school. Dutton (1963) sought information about the implications that the children's knowledge had on their learning experiences. He used the number section of the Metropolitan Readiness Test to determine the readiness of beginning kindergarteners for first-grade work. He found that one-third of the children were ready for first-grade work. On a post-test, it was found that the children who exhibited readiness at the beginning of the year made few gains in arithmetic. Dutton concluded that the inconsistency was due to the lack of a formal program to build on the foundation with which they had come to school. Buckingham and
MacLatchy's basic concerns about appropriate curriculum and readiness are still evident, thirty-five years later.

Rea and Reys (1970) in their investigation of mathematical competencies of kindergarteners, sought to explore the wide variability in mathematics achievement noted by most other studies of pre-school children. Their individually administered assessment instrument included items covering a broad range of mathematical functions such as money, measurement, vocabulary, as well as number. The data were analyzed by various subgroups including sex, age, socio-economic factors, previous education, parents education, and sibling relationships. The findings showed that the wide variability in achievement is influenced by all of these things, save sibling relationships.

Counting behaviors of children during assessment procedures were treated formally in few of the aforementioned studies. Potter (1968) described the necessary behaviors needed to count a set of things: (1) To know the names of the numbers in order (2) To take each member of the set only once (3) To do the above skills in a one-to-one correspondence. She investigated the ability of two-and-a-half-to-four-year-old children to merely touch stickers arranged on
paper. From three-to-nine stickers were used in different arrangements; a single row, rows and columns or randomly placed. Errors which were identified included redundancy or omission. Younger children approached the task randomly, usually starting at the sticker nearest their hand. Older children did better with orderly arrangements.

Beckwith and Restle (1966) and Wang et al (1971) noted similarly that younger children approached counting tasks randomly and had the most success when counting randomly arranged sets. Wang also reported the the ability of kindergarteners to count zero-to-five objects was well established before success in the six-to-ten range began to appear.

Wohlwill (1960) studied the process by which four-to seven-year-olds arrive at an abstract concept of number. The procedure consisted of "matching-from-sample" tests of varying difficulty. It was found that items requiring the matching of two-to-five objects were easier than those with six-to-eight objects. He attributed the difficulty of higher number concepts to the fact that direct perceptual support breaks down, necessitating symbolic counting.

O'Brien and Richard (1971) suggest that any assessment procedure that is concerned with only the
child's thinking does not aid the teacher in deciding whether or not the child has indeed mastered the concept, or, how to help if he hasn't. When teachers analyze children's strategies in solving addition and subtraction exercises, the authors reason that teachers can better prescribe activities which move the learner to more sophisticated techniques. For example, the teacher places five chips on the table and asks, "How many?" Three more chips are placed on the table and the child is again asked "How many?" Then, "How many in all?" A child may respond with "Eight". Mastery of five plus three is indicated. However, while one strategy may be the recall of a basic number fact, another may be counting on from the known set of five. Some children need to begin again and count all of the chips. Some will count aloud and move each chip as it is counted. Others count silently as they scan each chip with their eyes. Each of these strategies indicate a different level of understanding of five plus three.

Had we not observed this behavior, we would have been tempted to dismiss some of the children's approaches—touching, counting aloud, and so on—as immature reactions to a number situation which should be discouraged. We feel, however, that touching, counting aloud, using fingers and mouthing words are necessary for some children to perform the classification done overtly at the most primitive level (p. 324).
Indeed, studies with older children show that counting is still a major strategy in computation. In Grouws (1974) work with individual third-graders, counting was the third most frequently used strategy to solve open sentences in addition and subtraction. In Lankford's (1974) work with individual seventh-graders, the children were presented with computational exercises. They were to work the exercises and verbalize their thinking. In the addition exercises, counting was the most frequently used strategy. It was even used in some way by over one-third of the students when doing multiplication. It seems, then, that while some adult educators may have considered counting as "infantile" or "immature" or, at best, inefficient behavior in doing number work, reality indicates that children fall back to this strategy when more abstract methods fail them. Whether this failure is due to fatigue, faulty memory, a problem that is too difficult, or lack of knowing any other way to proceed, counting does serve to complete the task.

Jean Piaget, with his observations of young children's concept of number, has influenced much recent research. Glennon and Callahan (1968) in their summary of early research generated by Piaget's work, indicate a general
agreement that children move through the stages described by Piaget. They also note a variability in the age and the rate at which these stages are reached, affected by several factors and variables among tasks and across cultural lines.

Many experimenters have attempted to induce conservation earlier than predicted by Piaget's work. These attempts have not met with a great deal of success. Gelman (1972) attempted to train three-to-six-year-olds to conserve by using small numbers, controlling the vocabulary, and reducing irrelevant cues. Many children still failed to conserve even with only three objects. Others, including Lavatelli (1973) and Lawson (1974) also indicate that many transitional children can conserve with small numbers. In his 1960 study, Wohlwill found that immediate accurate discrimination breaks down at five or six objects, thus necessitating counting. Judgements on small numbers are perceptual rather than logical. Conservation on small numbers does not meet the criteria of seven or eight objects described by Piaget. Piaget's criteria of seven or eight objects for the conservation of number tasks insures that the child's judgements are logical rather than perceptual.

The reasoning behind the attempts to induce
conservation at younger ages lies in the implications this ability has on selecting appropriate curriculum. Piaget has stated that "...conservation is a necessary condition for all rational activities" (p. 3). However, all investigators have not agreed that conservation is a prerequisite to achievement in number work.

Brace and Nelson (1965), Van Engen and Steffe (1966) and Williams (1971) caution against introducing addition and subtraction to children who are non-conservers. Because the concept of number held by five-and-six-year-old children is incomplete, these investigators reason that formal number work is not appropriate.

A study by Mpiangu et. al. (1975), in which the ability of both conservers and non-conservers to learn new arithmetic concepts was investigated, found evidence to the contrary. The results suggest that conservation should not be considered as a crucial concept necessary for success in arithmetic. According to their studies, it would be more profitable to consider arithmetic and conservation of number as concepts that develop simultaneously.

...the effort should be directed toward a genuine evaluation of what arithmetic concepts the child knows and how well he knows them before he starts formal instruction in arithmetic" (p. 191).
Overholt (1965) found that understanding of conservation of substance seems to be related to intelligence and understanding of arithmetic. After adjusting for differences in intelligence, he found no significant difference in mean arithmetic achievement as measured on the Iowa Tests of Basic Skills, between conservers and non-conservers. He concludes that performance on conservation tasks is no better a predictor of arithmetic ability than performance on IQ tests.

SUMMARY

Most children of five or six years have acquired a noticeable amount of number knowledge. They can count verbally, count objects, recognize equivalent sets and use quantitative vocabulary. They have at least one strategy to solve simple problems, counting. These abilities are variable between children and are affected by a variety of influences.

Many of the investigators of children's number concepts agree that a correct response to a specific problem indicates that the child has a functional understanding for that particular problem in that particular way. This in no way indicates mastery of a number.

The results of several studies suggest that number concepts from "one" to "five" develop quite thoroughly
before the higher numbers do. These smaller quantities are dealt with by perceptual means rather than logical means. This implies that work with larger numbers may be inappropriate for young children until their logical capacity allows them to make generalizations about quantity.
CHAPTER III

METHOD

Sample Selection

The thirty subjects for this study were randomly selected from two kindergarten classes at Superior Street Elementary School, a Los Angeles City public school located in Chatsworth, a suburb of Los Angeles. The kindergartners ranged in age from four years and eleven months to six years and one month. Twenty-three of the children had attended some form of pre-school activity away from home on a regular basis at least one day per week. One child was repeating kindergarten. The fifteen boys and fifteen girls studied included Caucasians, Orientals and Mexican-Americans. Minorities made up 17 percent of the sample population studied. Most of the subjects' families were of middle-income socio-economic status.

Research Instrument Development

The test instrument (appendix) was developed by the investigator. The interview items were selected to reflect
beginning number concepts. Two pilot studies were run to determine the appropriateness of the test items and to refine interviewing techniques. The subjects interviewed in the pilot studies ranged from four years and four months to six years and five months in age. Twenty-five children were included in the pilot studies.

Description of the Instrument

The assessment instrument consists of twelve items. Items one and two establish the subject's ability to rote count and count rationally. Items three through ten assess the beginning number concepts of invariance, one-to-one correspondence, equivalence, addition and subtraction. Each concept is represented by a minimum of two situations involving different materials or story lines. Item eleven presents a situation in one-to-one correspondence in which the child is to predict the outcome without utilizing one-by-one counting. Item twelve tests the ability to count hidden objects and partition sets of objects.

Data Collection

The assessment instrument was administered individually to each child by the investigator. The interview took approximately twenty minutes to complete. The interviews were administered during the fifth week of school, thus insuring that the subjects had been exposed to a minimum of arithmetic instruction.
The ability to count six objects rationally is necessary for participation in the interview. All subjects were able to meet this criteria and completed the interview. Items three through ten were scored on three criteria: (1) Physical behavior during counting, e.g. pointing, touching, counting aloud or silently. (2) Correctness of numerical response; (3) Type of counting technique, e.g. one-by-one counting, grouping or subitizing. In the absence of any observable counting behavior, the examiner asked for a justification for the response. Item eleven was scored by noting the number of cars parked when the subject responded. For item twelve, the response for each partition was recorded.

Statistical Analysis

The t test for uncorrelated data was used to test the statistical significance of difference between groups differentiated by age, sex and preschool experience (Hypotheses One through Three). Hypothesis Four was tested using a Pearson product moment correlation. Frequencies of physical counting behaviors and counting strategies were tabulated and analyzed to identify existing patterns of behavior. Selected comparisons were made using chi square analysis. For all hypotheses, the level of significance necessary to reject the null hypotheses was set at the .05 level.
Limitations of the Study

The findings and conclusions reached in this study are limited by the small population sampled and the middle-income socio-economic class of the children. Any findings noted regarding the effect of preschool experiences on problem solving abilities must be used with caution due to the great discrepancy in the size of these subgroups in the sample population. This study can be generalized only to schools with similar populations.
CHAPTER IV
ANALYSIS AND DISCUSSION OF THE DATA
Problem Solving Ability

The t test for uncorrelated data was applied to test hypotheses one through three. The summary data for each of these hypotheses are found in Tables II, III, and IV. Hypothesis One stated that there would be no significant difference in problem solving ability by beginning kindergarteners on selected tasks with physical objects with regard to sex. There was not a significant difference between males and females. Therefore the null hypothesis is not rejected. It is interesting to note, however, that the variances were unequal. The female subjects exhibited a far greater variability as a group than did the male subjects.

TABLE II
SUMMARY TABLE BY SEX OF BEGINNING KINDERGARTENERS' RAW SCORE TOTALS ON ASSESSMENT ITEMS 3-10

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Variance</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>15</td>
<td>13.13</td>
<td>5.41</td>
<td>14</td>
<td>.441</td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
<td>12.67</td>
<td>11.38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Needed for significance at 0.05 t = 2.150
Hypothesis Two stated that there would be no significant difference in problem solving ability between children above 5.3 years of age and those below 5.3 years of age. The \( t \) test indicates a significant difference at the .05 level in favor of the older children as indicated in Table II. Therefore the null hypothesis was rejected.

**TABLE III**

SUMMARY TABLE BY AGE OF BEGINNING KINDERGARTENERS' RAW SCORE TOTALS ON ASSESSMENT ITEMS 3-10

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Variance</th>
<th>df</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 5.3 years of age</td>
<td>12</td>
<td>11.33</td>
<td>8.61</td>
<td>28</td>
<td>-2.7067</td>
</tr>
<tr>
<td>Above 5.3 years of age</td>
<td>18</td>
<td>13.94</td>
<td>5.47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Needed for significance at 0.05 \( t = 2.045 \)

Hypothesis Three stated that there would be no significant difference in problem solving ability by beginning kindergarteners on selected tasks employing physical objects with regard to preschool attendance. There was not sufficient evidence to reject the null hypothesis.
TABLE IV

SUMMARY TABLE BY PRESCHOOL EXPERIENCE OF BEGINNING KINDERGARTENERS' RAW SCORE TOTALS ON ASSESSMENT ITEMS 3-10

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Variance</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preschool</td>
<td>23</td>
<td>12.91</td>
<td>9.45</td>
<td>28</td>
<td>.0445</td>
</tr>
<tr>
<td>No Preschool</td>
<td>7</td>
<td>12.86</td>
<td>.83</td>
<td>.</td>
<td>.</td>
</tr>
</tbody>
</table>

Needed for significance at 0.05 $t=2.050$

Hypothesis Four stated that there would be no significant relationship between the ability to rote count and the ability to solve problems on selected tasks with physical objects. The Pearson-r was .628, significant at the .05 level, and the null hypothesis was rejected.

In an attempt to identify any combinations of the variables of sex, age, and preschool experience, the means of raw score totals for combinations of identified subgroups were computed. Table V indicates the mean raw scores attained by combinations of subgroups. Due to the small numbers of subjects in some of the subgroups, caution must be taken in reaching any conclusions for those groups.

Counting Behaviors During Problem Solving

For each of the assessment items four through ten, there was a problem to be solved. After counting the blocks given, the subject was asked a question for which the response required a change in the number of blocks.
TABLE V
MEANS OF RAW SCORE TOTALS BY SURGROUPS OF BEGINNING KINDERGARTENERS (ITEMS 3-10 OF ASSESSMENT)

<table>
<thead>
<tr>
<th>Variables Taken One or Two at a Time</th>
<th>Male</th>
<th>Female</th>
<th>Age &lt;5.3</th>
<th>Age &gt;5.3</th>
<th>Preschool</th>
<th>No preschool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>13.1 (15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>---</td>
<td>12.7 (15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age &lt;5.3</td>
<td>12.0 (6)</td>
<td>10.6 (6)</td>
<td>11.3 (12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age &gt;5.3</td>
<td>13.9 (9)</td>
<td>14 (9)</td>
<td>--</td>
<td>13.9 (18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preschool</td>
<td>13.5 (11)</td>
<td>12.4 (12)</td>
<td>11.5 (10)</td>
<td>14 (13)</td>
<td>12.3 (23)</td>
<td></td>
</tr>
<tr>
<td>No Preschool</td>
<td>12.3 (14)</td>
<td>13.7 (3)</td>
<td>10.5 (2)</td>
<td>13.8 (5)</td>
<td>--</td>
<td>12.8 (7)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables Taken Three at a Time</th>
<th>Preschool</th>
<th>No Preschool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males &gt;5.3</td>
<td>12.2 (5)</td>
<td>11 (1)</td>
</tr>
<tr>
<td>Males &gt;5.3</td>
<td>14.5 (6)</td>
<td>12.7 (3)</td>
</tr>
<tr>
<td>Females &lt;5.3</td>
<td>10.8 (5)</td>
<td>10 (1)</td>
</tr>
<tr>
<td>Females &gt;5.3</td>
<td>13.6 (7)</td>
<td>15.5 (2)</td>
</tr>
</tbody>
</table>

( ) indicates number of subjects in each group

Mean of raw score totals for all subjects - 12.9

Maximum score possible - 17
Behaviors exhibited by the subjects while solving the problems were classified as counting or not counting. For example, from a given set of five blocks, the subject was asked how many blocks she/he would have if she/he was given one more block. If the child responded immediately with "six", this was judged as not counting. If the child re-counted the five blocks and then said "six", this was judged as counting. Table VI summarizes the frequency of each type of behavior. A chi square analysis was used to determine the significance of difference in success rates between those subjects who counted and those that didn't count during the problem solving activities. The result of the analysis revealed no significant difference. From this we might surmise that children intuitively select the appropriate strategy commensurate with their abilities.

**TABLE VI**

**SUMMARY TABLE OF COUNTING BEHAVIORS DURING PROBLEM SOLVING BY BEGINNING KINDERGARTENERS**

<table>
<thead>
<tr>
<th></th>
<th>Correct Response</th>
<th>Incorrect Response</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>122</td>
<td>23</td>
<td>145</td>
</tr>
<tr>
<td>No Count</td>
<td>119</td>
<td>36</td>
<td>155</td>
</tr>
<tr>
<td>Totals</td>
<td>241</td>
<td>59</td>
<td>300 events</td>
</tr>
</tbody>
</table>

When the subject responded to a problem without
counting, she/he was asked by the examiner, "How do you know that?" Most children who were able to give a rational explanation for their answer, used a basic arithmetic fact for a justification. Another common justification was to count the objects and say "and six"; after solving the problem without counting, the child counted to prove to the examiner that she/he was correct. About half the children who were asked for a justification responded in a manner that suggested they were unable to verbalize their thinking processes. These responses included: "It's easy", "My mom told me", "I'm smart", "I don't know". One child kept looking at the clock after each question was asked. After several repeats of this behavior, the investigator asked her why she was looking at the clock. Her response indicated that she was using the numbers on the face of the clock as a number line and read her responses from the clock.

An item analysis of the assessment interview yielded the following.

1. All subjects could establish one-to-one correspondence
2. All subjects could determine whether two lines of blocks were equal or unequal in number
3. All subjects could count rationally at least six objects
4. Ninety percent or more of the subjects could select four or five blocks from a larger group.

5. At least 60 percent of the subjects could do simple addition and subtraction in various situations.

6. Invariance problems were done correctly by less than half the subjects.

The present study dealt mainly in problem solving with numbers in the one-to-six range. The findings of several investigators, Bjonerud, McDowell and Wohlwill, support the contention that number concepts in the one-to-five range are developed quite thoroughly before higher number concepts are. A similar pattern was observed in this study by analyzing children's success in problem solving with numbers of increasing size. Table VII summarizes this data. While these trends were not statistically significant for this group, they merit further investigation.

Two items of the assessment were analyzed separately. In item eleven (appendix) the subjects were asked to predict the outcome of a situation without counting. Responses were scored by the number of cars parked when the subject responded. Fifty-seven percent of the subjects parked all of the cars before saying that there weren't enough garages. Thirteen percent responded
### TABLE VII
THE EFFECT ON SUCCESS RATES OF INCREASINGLY LARGER NUMBERS OF OBJECTS TO BE CONSIDERED IN PROBLEM SOLVING

<table>
<thead>
<tr>
<th>Concept</th>
<th>Item No.*</th>
<th>Assessment Items</th>
<th>Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number Reproducing</td>
<td>6</td>
<td>Select 4 blocks from a set of 5 (1st trial)</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Select 4 blocks from a set of 6 (2nd trial)</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Select 6 blocks from a set of 15 (1st trial)</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Select 5 blocks from a set of 15 (2nd trial)</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Select 6 blocks from a set of 15 (3rd trial)</td>
<td>80</td>
</tr>
<tr>
<td>Addition</td>
<td>7</td>
<td>Set of 5 given-&quot;If I give you one more...&quot;</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Set of 4 given-&quot;If I give you two more...&quot;</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Set of 5 given-3 more given-&quot;How many...&quot;</td>
<td>57</td>
</tr>
<tr>
<td>Subtraction</td>
<td>9</td>
<td>Set of 6 given-&quot;If I take one away...&quot;</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Set of 5 given-&quot;If I take one away...&quot;</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparison of two lines of blocks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;How many more?&quot; (difference of 1)</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;How many more?&quot; (difference of 2)</td>
<td>57</td>
</tr>
</tbody>
</table>

* See Appendix
correctly when all but two cars were parked, as well as when all but three cars were parked. Seventeen percent responded when only three cars had been parked.

Item twelve (appendix) was also scored independently. Table VIII summarizes the results. The most difficult partition of "four" was when only one tile was visible. To mentally maintain the picture of four tiles, see only one, and compute the number of tiles hidden seemed the most difficult. The partition of four visible tiles with none hidden would seem to be simple, but perhaps the children reasoned that there must be something hidden, for in each case the incorrect response was "one". The partition of two tiles visible was the first sample given, which could account for the relatively large number of errors. The partition of zero tiles visible also seems simple. One child responded that all were hidden, but he could not say how many were hidden. The scores on this task for the individuals giving an incorrect response for the zero-four partition were 3,3,2,1. These lower scores suggest that perhaps the mental structures to perform this task were not developed in these individuals.
### TABLE VIII

**SUMMARY TABLES FOR THE HIDDEN TILES TASK**

**Frequencies of Individual Totals**

<table>
<thead>
<tr>
<th>Number Correct</th>
<th>Number of Subjects</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>8</td>
<td>26.7</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>23.3</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>36.7</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>3.3</td>
</tr>
</tbody>
</table>

**Frequencies of Incorrect Responses**

for the Hidden Tiles Task

<table>
<thead>
<tr>
<th>Number of Incorrect Responses</th>
<th>Partitions of 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Visible</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
</tr>
</tbody>
</table>
Counting Behaviors During Number Naming and Reproducing

For each of the assessment items four through ten, the subjects were first asked to count or select a given number of objects. Physical behaviors during this process were noted by the examiner. Table IX summarizes the observed frequencies of various behaviors. Most children made physical contact with the objects, either moving them or pointing "on" the blocks. Those who subitized were distinguished by a complete lack of any physical behavior. Those subjects who counted one-by-one with no physical contact with the blocks used eye contact, usually accompanied by head bobbing or finger waving. When reproducing, or selecting a given number of blocks, moving the blocks was the exclusive method used. This is understandable since in order to separate the correct number of blocks, it was necessary to move them away from the larger pile.

While most children verbalize the number names while counting, it is interesting to note that counting aloud is found more frequently when naming numbers than when reproducing them. Perhaps this can be explained by the following reasoning: When naming numbers, the last object counted tells the total number of objects counted. In naming numbers, the child is responding to the question "How many?" When reproducing numbers, the child is told
TABLE IX
SUMMARY TABLES OF COUNTING BEHAVIORS WHILE NAMING AND REPRODUCING NUMBERS BY BEGINNING KINDERGARTENERS

**Physical Behaviors**

<table>
<thead>
<tr>
<th>Move Blocks</th>
<th>Point</th>
<th>Subitize</th>
<th>Physical Movement</th>
<th>Total Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Naming</td>
<td>140</td>
<td>58</td>
<td>60 25</td>
<td>22 9*</td>
</tr>
<tr>
<td>Reproducing</td>
<td>90</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>230</td>
<td>70</td>
<td>60 18</td>
<td>22 9</td>
</tr>
</tbody>
</table>

**Audibility**

<table>
<thead>
<tr>
<th>Aloud</th>
<th>Silent</th>
<th>Total Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Naming</td>
<td>165</td>
<td>69</td>
</tr>
<tr>
<td>Reproducing</td>
<td>41</td>
<td>46</td>
</tr>
<tr>
<td>Totals</td>
<td>206</td>
<td>63</td>
</tr>
</tbody>
</table>

**Counting Strategies**

<table>
<thead>
<tr>
<th>One-by-one</th>
<th>Subitzing</th>
<th>Grouping</th>
<th>Total Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Naming</td>
<td>210</td>
<td>87.5</td>
<td>22 9</td>
</tr>
<tr>
<td>Reproducing</td>
<td>90</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>300</td>
<td>91</td>
<td>22 7</td>
</tr>
</tbody>
</table>
to select so many blocks. No oral response is necessary.
She/he just selects the blocks.

Counting strategies differ from physical behaviors in
that children who move the blocks to be counted can move
more than one block at a time. However, the greatest
percentage of children select the blocks to be counted
one at a time.
CHAPTER V
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to (1) assess the problem-solving ability of beginning kindergartners (2) identify factors which influence problem solving ability (3) investigate the role counting plays in problem solving. The subjects were thirty randomly-selected children from two kindergarten classes in one elementary school. Each subject was given an individual interview to assess their ability to deal with beginning number concepts. Items were scored on correctness of response, and physical counting behaviors noted during the problem solving activities. Means of raw scores for subgroups were tabulated. The t test for uncorrelated data was applied to subgroups identified by sex, age and preschool experience. There was no significant difference in problem-solving ability with regard to sex or preschool experience. There was a significant difference in problem-solving ability with regard to age. Subjects above five years and three months of age scored significantly better than those below. The
Pearson product moment correlation showed a significant relationship between the ability to rote count and the ability to solve problems as measured by the assessment interview.

Counting behaviors during the problem solving activities were tabulated. These behaviors included physical movement, oral behaviors and counting strategies. In response to the question, "How many?", most subjects moved the objects individually while verbalizing the number names. When asked questions requiring a change in the number of objects, about half the subjects could respond without counting.

Conclusions

Beginning kindergarteners come to school with a measurable amount of number knowledge. This knowledge is variable among subjects and seems to be most effected by age, with the younger children scoring significantly lower on the assessment interview. The importance of this finding is, perhaps, more significant at the kindergarten level than any other level. With the age span in a typical classroom being one year from the youngest to the oldest child, care must be taken to accommodate the differences in abilities related to age. Of equal importance in choosing appropriate curriculum is the great
developmental growth that is characteristic of children moving from kindergarten to first-grade.

While one-by-one counting was found to be the major strategy used to solve simple number problems, many children exhibited no direct evidence of counting when responding. The results of this study indicate that children seem able to select an appropriate method to solve the problems given. In the light of these findings, it would seem advantageous for the classroom teacher to provide experiences and activities which allow the students to make choices about the methods used to complete the task.

To the extent that the results of this study are generalizable to a broader population of kindergarteners, the use of a brief, informal assessment interview, with physical objects, seems a valid method of identifying the number abilities of children. This information should aid the teacher considerably in planning an appropriate curriculum.

Recommendations

1. This study should be replicated with a larger sample size which includes a broader socio-economic range.

2. The present study could be amended to include an assessment item designed to determine if rational counting
is a better indicator of success in problem solving than rote counting. In the present study data on rational counting could not be used to determine if such a relationship exists. This was because the item concerning rational counting had a ceiling of fifteen objects to be counted.

3. During pilot studies with older children, it was noted that in the transition from oral, one-by-one counting of objects to more sophisticated techniques such as grouping, subitizing and silent counting with the eyes, the error rate increased. A longitudinal study could be designed to identify the effects of this transition on accuracy, and the resulting implications on classroom practices.

4. Counting has been identified as a major problem-solving strategy. The success of counting as a strategy with numbers in the one-to-six range of numbers is evident in this study. A study investigating the efficacy of counting in solving problems involving numbers above six would provide a broader description of the role counting plays.

5. Current curriculum practices in kindergarten and first grade move children through a rather narrow conceptual framework in a wide range of numbers. The trends noted in Table VII suggest that a broader range of concepts
with a smaller range of numbers might be more appropriate for beginning learners. A study could be designed to determine if there is an appropriate number range for beginning learners, considering the skills they have at their command.
APPENDIX
Interview Items

1. E-Count as far as you can.
   (If a child reaches 50, he is stopped.)
2. (Fifteen blocks are randomly placed by the handful on the table. They are purposely not lined or grouped in any way.)
   E-How many blocks do we have here?
3. (Five tea cups are placed separately on the table. A stack of 5 saucers is placed next to them. E will determine what the child calls these items and use the child's words to identify the items.)
   E-We are going to have a tea party. You are to set the table. Do you think you have enough cups and saucers so that each cup has a plate?
4. (Seven blocks are placed on the table.)
   E-How many blocks are there?
   (Upon response, E uses his hands to slightly re-arrange and compact the blocks from whatever position the child has left them.)
   E-How many blocks are there?
5. (Two rows of 4 blocks are placed on the table so
E-Count the top row of blocks. How many blocks are in the bottom row?

6. (Five blocks are placed on the table.)
E-How many blocks are here? Show me 4 blocks.
(Six blocks are placed on the table.)
E-How many blocks are here? Show me 4 blocks.

7. (Five blocks are placed on the table.)
E-How many blocks are here? If I give you one more block, how many would you have?
(Four blocks are placed on the table.)
E-How many blocks are here? If I give you 2 more blocks, how many would you have?

8. (Five blocks are placed on the table.)
E-How many blocks are here? Here are some more blocks.
(Three more blocks are placed on the table.)
E-How many blocks do you have now?

9. (Fifteen blocks are placed on the table.)
E-Would you take 6 blocks from this pile?
(The leftover blocks are removed from sight.)
E-If I take one block back, how many will you have then?
(Fifteen blocks are placed on the table.)
E-This time, take 5 blocks from the pile.
(The leftover blocks are removed from sight.)

E-If I take 2 blocks away, how many will you have then?

10. E-Will you choose 6 blocks and line them up?
(E selects 5 blocks and places them in visual correspondence with child's blocks.)

E-Who has more blocks to play with? How many more blocks do I need so that I will have just as many blocks as you have?
(E adds 3 more blocks to his own line.)

E-Now do we have the same number of blocks to play with? Who has more? How many more blocks do you need so that you have just as many blocks as I have?

11. (A box of 7 toy cars is placed on the table. Six cardboard garages are lined up 1 inch apart.)

E-You are working in a parking lot. Your job is to park the cars in the garages. Every car must be in a garage. Do you think there are enough garages for the cars? (Do not allow the child to count.) Why don't you start parking the cars and you tell me as soon as you know for sure if there are enough garages.

12. (Four 1 square inch ceramic tiles are shown.)
E-How many tiles are there?
(E-puts tiles under his hand and moves hand about
on the table. E allows 2 tiles to slide out in sight
while the other two tiles remain hidden under his
hand.)
E-How many tiles are under my hand?
(This process is repeated for all partitions of 4.)
BIBLIOGRAPHY


