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DISSERTATION
Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By
Rhoda Elizabeth McShane Becher, B.S., M.A.

* * * * *
The Ohio State University
1974

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Acknowledgements</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vita</td>
<td>iii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>vi</td>
</tr>
<tr>
<td>List of Graphs</td>
<td>ix</td>
</tr>
</tbody>
</table>

## Chapter

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Introduction, Background, and Statement of the Problem</td>
<td>1</td>
</tr>
<tr>
<td>Introduction, Background, and Importance of the Study</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>12</td>
</tr>
<tr>
<td>Design of the Study</td>
<td>15</td>
</tr>
<tr>
<td>Definitions of Terms</td>
<td>17</td>
</tr>
<tr>
<td>Limitations of the Study</td>
<td>20</td>
</tr>
<tr>
<td>II. Review of the Literature</td>
<td>21</td>
</tr>
<tr>
<td>Introduction</td>
<td>21</td>
</tr>
<tr>
<td>Piaget's Theory of Cognitive Development</td>
<td>21</td>
</tr>
<tr>
<td>Training Studies for Conservation of Number</td>
<td>30</td>
</tr>
<tr>
<td>Methodological Considerations</td>
<td>58</td>
</tr>
<tr>
<td>III. Procedures and Statistical Model</td>
<td>86</td>
</tr>
<tr>
<td>Population and Sample</td>
<td>86</td>
</tr>
<tr>
<td>Design of the Study</td>
<td>87</td>
</tr>
<tr>
<td>Testing Procedures</td>
<td>88</td>
</tr>
<tr>
<td>Assignment Procedures</td>
<td>95</td>
</tr>
<tr>
<td>Instructional Procedures</td>
<td>99</td>
</tr>
<tr>
<td>Pilot Study—Description and Procedures</td>
<td>102</td>
</tr>
<tr>
<td>Statistical Model</td>
<td>105</td>
</tr>
</tbody>
</table>
Table of Contents (continued)

<table>
<thead>
<tr>
<th>IV. ANALYSIS AND INTERPRETATION OF THE DATA AND DISCUSSION OF THE RESULTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Final Sample.</td>
<td>110</td>
</tr>
<tr>
<td>Analysis and Interpretation of the Data</td>
<td>112</td>
</tr>
<tr>
<td>Summary and Further Discussion</td>
<td>164</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V. SUMMARY, DISCUSSION, CONCLUSIONS, AND IMPLICATIONS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary</td>
<td>170</td>
</tr>
<tr>
<td>Discussion and Conclusions</td>
<td>180</td>
</tr>
<tr>
<td>Implications</td>
<td>195</td>
</tr>
</tbody>
</table>

APPENDIX

| A. CONSERVATION OF NUMBER PRETEST-POSTTEST                               | 201  |
| B. ANSWER SHEET FOR CONSERVATION OF NUMBER PRETEST-POSTTEST             | 206  |
| C. INSTRUCTIONAL ACTIVITIES                                              | 209  |
| D. RAW DATA                                                              | 233  |
| E. TABLES 29 AND 30                                                      | 238  |

BIBLIOGRAPHY.                                                              | 243  |
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Key Variables and Major Findings of Training Studies for Conservation of Number.</td>
<td>34</td>
</tr>
<tr>
<td>2.</td>
<td>The Percentages of Children of Various Ages at Each of the Conservation of Number Stages of Development as Reported in a Number of Studies</td>
<td>62</td>
</tr>
<tr>
<td>3.</td>
<td>Pretest Performance Score-Developmental Status-Sex Distribution</td>
<td>96</td>
</tr>
<tr>
<td>4.</td>
<td>Data Matrix for Three Between Groups-One Within Subjects Design.</td>
<td>97</td>
</tr>
<tr>
<td>5.</td>
<td>Conditions--Instructor--Group Distribution: The Number of Instructors Employing Given Experimental Conditions With Given Numbers of Groups</td>
<td>99</td>
</tr>
<tr>
<td>6.</td>
<td>Data Distribution for Treatment Conditions, Stages of Development and Sex</td>
<td>111</td>
</tr>
<tr>
<td>7.</td>
<td>Data Distribution for Treatment Conditions, Stages of Development and Age</td>
<td>112</td>
</tr>
<tr>
<td>8.</td>
<td>Conservers and Nonconservers on the Intermediate and Posttest as a Result of Treatment Conditions.</td>
<td>114</td>
</tr>
<tr>
<td>10.</td>
<td>Conservers and Nonconservers on the Intermediate and Posttest as a Function of Sex and Treatment Conditions</td>
<td>115</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>12. A Three Between Groups-One Within Subjects Analysis of Variance of the Effects of Treatment Conditions, Stages of Development, and/or Sex on Performance Scores as Functions of Repeated Measures Using the Method of Unweighted Means.</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>13. A Three Between Groups-One Within Subjects Analysis of Variance of the Effects of Treatment Conditions, Stages of Development, and/or Sex on Stage Classifications as Functions of Repeated Measures Using the Method of Unweighted Means.</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>14. Performance Score Unweighted Mean Comparison Matrix for Dunn's Test.</td>
<td>126</td>
<td></td>
</tr>
<tr>
<td>15. Stage Classification Unweighted Mean Comparison Matrix for Dunn's Test.</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>16. A Three Between Groups-One Within Subjects Analysis of Variance of the Effects of Treatment Conditions, Stage of Development, and Age on Performance Scores as Functions of Repeated Measures Using the Method of Unweighted Means.</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>17. A Three Between Groups-One Within Subjects Analysis of Variance of the Effects of Treatment Conditions, Stage of Development, and Age on Stage Classifications as Functions of Repeated Measures Using the Method of Unweighted Means.</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>18. One Way Analysis of Variance of Individual Instructors Interactive Strategy Index Means.</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>19. Instructor Interactive Strategy Index Mean Comparison Matrix for Scheffe's Test.</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>20. Fisher's t Test for Significant Differences Between the Uncorrelated Interactive Strategy Index Means of Treatment Conditions EI and EII</td>
<td>145</td>
<td></td>
</tr>
<tr>
<td>21. A One Between Groups-One Within Subject's Analysis of Variance of the Effects of Instructors and Repeated Measures on Performance Scores of 4- and 5-Year-Old Lower Socio-economic Status Children.</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>22.</td>
<td>A One Between Groups-One Within Subjects Analysis of Variance of the Effects of Instructors and Repeated Measures on the Stage Classifications of 4- and 5-Year-Old Lower Socioeconomic Status Children</td>
<td>147</td>
</tr>
<tr>
<td>23.</td>
<td>The Number of Adequate and Inadequate Response Rationales for Each Treatment Condition on the Pretest, Intermediate Test, and Posttest.</td>
<td>148</td>
</tr>
<tr>
<td>24.</td>
<td>Chi Square Analysis for Significant Differences in the Number of Positive Changes in Response Rationales from Pre- to Intermediate and Pre- to Posttests as a Result of Treatment Conditions</td>
<td>149</td>
</tr>
<tr>
<td>25.</td>
<td>A Three Way Analysis of Variance of the Effects of Repeated Testing (Treatment Conditions III and IV), Stage of Development, and Sex on Performance Scores of 4- and 5-Year-Old Lower Socioeconomic Status Children Using the Method of Unweighted Means.</td>
<td>151</td>
</tr>
<tr>
<td>26.</td>
<td>Performance Score Unweighted Mean Comparison Matrix for Dunn's Test.</td>
<td>155</td>
</tr>
<tr>
<td>27.</td>
<td>A Three Way Analysis of Variance of the Effects of Repeated Testing (Treatment Conditions III and IV), Stage of Development, and Sex on Stage Classifications of 4- and 5-Year-Old Lower Socioeconomic Status Children Using the Method of Unweighted Means.</td>
<td>157</td>
</tr>
<tr>
<td>28.</td>
<td>Stage Classification Unweighted Mean Comparison Matrix for Dunn's Test.</td>
<td>163</td>
</tr>
<tr>
<td>29.</td>
<td>The Number of Children from Each Pretest Performance Score Category Achieving Given-Intermediate or Posttest Scores, the Total Number of Each Type of Change (+, -, 0), and the Total Number of Points Gained (+) or Lost (-), on both the Intermediate and Posttest.</td>
<td>239</td>
</tr>
<tr>
<td>30.</td>
<td>The Number of Children from Each Pretest Stage Classification Achieving Given Intermediate or Posttest Stage Classifications and the Total Number of Each Type of Change (+, -, 0)</td>
<td>241</td>
</tr>
</tbody>
</table>
LIST OF GRAPHS

<table>
<thead>
<tr>
<th>Graph</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>The Unweighted Mean Performance Scores for Each Treatment Condition as a Function of Repeated Measures</td>
<td>124</td>
</tr>
<tr>
<td>II.</td>
<td>The Unweighted Mean Stage Classifications for Each Treatment Condition as a Function of Repeated Measures</td>
<td>125</td>
</tr>
<tr>
<td>III.</td>
<td>The Pattern of Performance for Each Treatment Condition from Pretest to Posttest as Shown by the Unweighted Performance Score Means as a Function of Repeated Measures</td>
<td>130</td>
</tr>
<tr>
<td>IV.</td>
<td>The Pattern of Stage Classifications for Each Treatment Condition from Pretest to Posttest as Shown by the Unweighted Stage Classification Means as a Function of Repeated Measures</td>
<td>131</td>
</tr>
<tr>
<td>V.</td>
<td>The Mean Interactive Strategy Indices for Individual Instructors and Each Treatment Condition</td>
<td>141</td>
</tr>
<tr>
<td>VI.</td>
<td>The Posttest Unweighted Mean Performance Scores of Each Treatment Condition as a Function of Stages of Development</td>
<td>153</td>
</tr>
<tr>
<td>VII.</td>
<td>The Posttest Unweighted Mean Performance Scores of Each Treatment Condition as a Function of Sex</td>
<td>154</td>
</tr>
<tr>
<td>VIII.</td>
<td>Posttest Unweighted Mean Stage Classifications of Each Treatment Condition and Each Stage of Development as a Function of Sex</td>
<td>159</td>
</tr>
<tr>
<td>IX.</td>
<td>Posttest Unweighted Mean Stage Classifications of Each Treatment Condition and Each Sex as a Function of Stages of Development</td>
<td>160</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION, BACKGROUND, AND STATEMENT OF THE PROBLEM

Introduction and Background

The enlightening and provocative theoretical and empirical work of Jean Piaget, describing the ontogenesis of logical thought, has stimulated a resurgent interest in and an increasing concentration of experimental investigations devoted towards delineating more explicitly the patterns and processes of cognitive growth. Piaget has provided a comprehensive, stage-dependent, conceptual framework, emphasizing both the processes and products of cognitive development. Replications, validations, applications, extensions, elaborations, revisions, and challenges, have followed his encompassing and specific expositions.

According to Piaget, the acquisition of knowledge and the development of logical thought evolve through a series of identifiable stages which follow an invariant sequence. The characteristic behaviors exhibited at each stage are the result of specific psychological structures which set limits on intellectual functioning. How one
organizes and adapts to his environment is dependent upon the particular structures he possesses at a given stage of development. The creation of new structures resulting in a more mature form of functioning is stimulated by the forces of maturation, experience, social interaction, cultural and/or educational transmission, and equilibration.

Piaget has identified and described four main stages in the development of logical thought:

1. The sensori-motor period, which occurs from approximately ages 0 to 2, and is characterized by behavior that results from a schema of action or a generalized motoric response to the environment. Major accomplishments which occur during this period are the construction of the concept of a permanent object together with the development of an elementary notion of causality;

2. The pre-operational period, which occurs from approximately ages 2 to 6, and is characterized by thought that is perceptually bound, centered, and egocentric in nature. The child is unable to conserve quantities or reverse actions in thought. The key achievement of the period is the acquisition of the symbolic function or the development or emergence of the ability to form internalized representations via language;
3. The **concrete operational period**, which occurs from approximately ages 6 to 12, and is the stage during which the child begins to reason logically about concrete situations. He decenters his thought and is no longer perceptually bound. He attains reversibility of operations and consequently the ability to conserve; and

4. The **formal operational period**, which is achieved at about age 12 and is viewed as an extension and expansion of the reasoning abilities attained during the previous period. In the concrete operational stage the child is able to reason logically, but only about concrete problems. In the formal operational period the child is able to reason logically about all types of problems including such things as hypothetical problems, complex verbal propositions, and combinatorial thought. This period is the culmination in the development of cognitive structures (Piaget, 1950).

The most studied phenomenon in Piaget's elaborate theoretical system is the concept of conservation, or the understanding that a quantity remains constant despite transformations of its physical appearance. Conservation depends upon the logical multiplication of all the factors involved in a given situation; it is a reasoning process coordinating all dimensions rather than a mere perceptual assessment. The mental operations which allow one to
maintain the invariant quantity of matter despite misleading perceptual cues include reversibility, compensation, and substantive and/or operational identity (Elkind, 1970). Several factors appear responsible for the extensive attention directed toward investigating this concept. Early interest was stimulated by the totally unexpected responses of preoperational children to conservation problems. Disbelief and intrigue prompted efforts to replicate and validate Piaget's unique findings. Results of these studies produced overwhelming evidence consistent with that reported by Piaget. The existence of a series of behaviors characterizing the development of conservation has been confirmed.

More recent interest has been directed towards isolating the probable antecedents of conservation, identifying the specific processes involved in the transition from one stage to another, and devising training procedures which will result in early acquisition. Theoretical and practical concern for these factors can be attributed to the fact that conservation is a central theme in Piaget's theory of cognitive development and its presence serves as an indicator that a child's cognitive processes are operational and he is capable of logical thought.

The first quantity to be conserved, around age 6, is number. Conservation of number refers to the fact that
the numerical or quantitative property of a set remains constant despite perceptual changes or rearrangements of the elements in the set (Piaget, 1952a). The appearance of conservation of number serves as an indication of the transition from the stage of pre-operational (egocentric and perceptually bound) thought to the stage of concrete operations. In addition, an understanding of the constancy of number is viewed as a necessary prerequisite for mathematical instruction involving operations on number (Van Engen, 1971). In view of the importance associated with the ability to conserve, it is understandable that intensive investigations have been concerned with tracing the development of number, and attempting to define the mechanisms and specify the conditions that stimulate this development. This information is then utilized in attempts to facilitate the early achievement of conservation.

Three stages, or substages, in the development of conservation of number have been identified (Piaget, 1952a). They are:

Stage I "Global Comparisons" or the period during which the child is 1) perceptually bound, 2) focuses on one dimension, and 3) is unable to establish equivalent sets;

Stage II "Intuitive Thought" in which the child is still perceptually bound but beginning to coordinate dimensions; he is able to establish equivalent sets, but is
unable to maintain the equivalence once the perceptual correspondence is destroyed; and

Stage III "Operational Thought" in which the child is able to "conserve" number or maintain the invariance of number despite perceptual transformations.

In between each of these stages or substages there are transition periods (Transition I and Transition II) which are characterized by inconsistencies or instabilities in behavioral performance and/or verbal responses. For example, at Transition I the child may exhibit the ability to establish one-to-one correspondence on one item but not on two and/or he may give verbal responses inconsistent with his previously exhibited behavioral response. At Transition II the child may give correct responses on one item indicating conservation and then give an incorrect response on a subsequent item.

At least two different problems are involved as the child develops from stage I to stage III of conservation of number. For the child to move from stage I to stage II he must develop the concept of numerical equivalence, or one-to-one correspondence. The child at stage II has developed an understanding of equivalence, but must learn to attend to and maintain the relevant numerical dimension during perceptual transformations in order to move to stage III of development.
Three major orientations—Piaget's equilibration theory, a learning theory or behavioristic model, and a language or symantical explanation—have provided theoretical accounts of the processes and factors involved in this development. Subsequent studies evolving from each of these positions have attempted to substantiate these explanations by demonstrating the extent of their influence in accelerating the acquisition of conservation. In all of these studies, whether using cognitive conflict training, reversibility training and/or training in one-to-one correspondence, cue discrimination and reinforcement, social learning, verbal pretraining, or verbal rule instruction, the emphasis has been on provoking the recognition of numerical invariance during perceptual changes. Although exceptions exist, efforts to accelerate the achievement of conserving behaviors, by a variety of training approaches, have generally proven successful. Interestingly, however, in many of the studies, the subjects have tended to be of middle socioeconomic status and to have possessed some aspects of conservation (i.e., the ability to establish equivalent sets through one-to-one correspondence—stage II of development) or to have entered into transition period II prior to their inclusion in the study. Whether or not the "successful" training procedures would also be "successful" with lower socioeconomic status children and/or with
children who do not possess elements of conservation had not been determined. Thus one of the purposes of this study was to assess the effectiveness of conservation of number training procedures emphasizing the component conservation concepts (one-to-one correspondence and the invariant aspect of number during perceptual transformations) in accelerating the acquisition of 1) conservation of number or 2) conservation related skills by 4- and 5-year-old lower socioeconomic status children at each of the preconservation stages.

Most modern mathematics programs (e.g., Harbrace Mathematics, Harcourt, Brace and Jovanovich, Inc., 1972; Modern Mathematics Through Discovery, Silver Burdet and Co., 1970; Modern School Mathematics: Structure and Use, Houghton Mifflin Co., 1972; and New Dimensions in Mathematics, Harper and Row, 1970) and consequently most readiness and introductory work in mathematics use a set theory approach in developing an understanding of numbers. The set theory approach emphasizes the concepts of equivalent sets, comparing sets, assigning a cardinal number to sets, and the variance of number brought about by operations (addition, subtraction . . .) on sets.

Although an understanding of numerical operations is presumed to depend upon a prior understanding of numerical constancies (Van Engen, 1971) no experiences with
perceptually transformed equivalent sets are provided in most of the readiness programs. Whether experiencing a change in number (quantity) through an operation (addition, subtraction . . .) on a set is sufficient to induce the related conclusion that "no operation" means "no change in number (quantity)" had not been established. The need for such an assessment appeared critical, however, in view of the fact that the set theory approach is the most widely accepted approach to the development of numerical understandings. Therefore, a second purpose of this study was to determine the extent to which experiences with sets and operations on sets could accelerate the acquisition of 1) conservation of number or 2) conservation related skills by 4- and 5-year-old lower socioeconomic status children.

A third major purpose of this study was to 1) compare the effectiveness of training procedures emphasizing component concepts of conservation and training procedures using a set theory approach in facilitating the development of an understanding of number; and 2) to attempt to determine stage appropriate activities by comparing the relative effectiveness of these two training procedures at each of the conservation of number substages (I, TI, and II) of development. From a curriculum planning standpoint, when choices must be made from a variety of alternatives, such a comparison would provide an empirical means of
choosing and justifying the inclusion in the curriculum of specific activities to facilitate the attainment of logical thought and numerical understanding. In addition to the problem of selecting the most effective experiences for attaining a given objective, there is the question of sequencing or organizing the experiences so that they are consistent with the child's level of development and occur at a time when they may have optimum effect. To expect that different activities or experiences would have differential effects at different stages of development is reasonable. Yet there had been no specific experimental attempts to identify activities or procedures that would be more appropriate at a given stage or substage of development and therefore facilitate the transition to the next higher level. Such an identification appeared critical for both theoretical and practical reasons.

An additional purpose was to determine the efficiency of each of these approaches in facilitating number development by administering an intermediary test midway through the training sessions (after 6 lessons) as well as a final posttest (after 12 lessons). The amount of time or number of instructional sessions needed for each of these approaches to result in the successful acquisition of conservation of number or conservation related skills had not been determined. Also it had not been determined at what point, in
terms of substages of development, instruction should begin. Consequently, the efficiency of each of these approaches was compared at each of the substages of development.

An additional variable that was examined was the effect of sex on performance and in interaction with the other variables. Although a number of studies (Almy, Chittenden, and Miller, 1966; Shantz and Sigel, 1967; Pattison and Fielder, 1969; Rothenberg, 1969; Rothenberg and Courtney, 1969; Rothenberg and Orost, 1969; Peters, 1970; Roll, 1970; Figurelli and Keller, 1972; and Hamel, Van der Veer, and Westerhof, 1972) have indicated no significant sex differences in the development of conservation, there have been two recent studies (Baker and Sullivan, 1970; and Wasik and Wasik, 1971) which suggest that in the lower socioeconomic status populations, sex differences are evident in favor of males. Although this information was rather tentative, it appeared prudent to include sex as a variable since the population of this study was comprised of lower socioeconomic status children.

The decision to use lower socioeconomic status children as the population to be studied was made for two reasons. First, most conservation studies have employed children of middle socioeconomic status families and it appeared important to determine the effectiveness of the various approaches with a different population. Secondly,
lower socioeconomic status children tend to exhibit a lag in conservation development and in the development of basic numerical skills (Almy, Chittenden, and Miller, 1966; Rothenberg, 1969; Rothenberg and Orost, 1969; Baker and Sullivan, 1970; Wasik and Wasik, 1971; Gaudia, 1972; and Figurelli and Keller, 1972). Consequently it was felt that, depending on the effectiveness of the training approaches in facilitating the acquisition of conservation of number or conservation related skills, the study could make an important contribution to the educational development of these children and other similar children to whom the results could be generalized.

Statement of the Problem

There were two major purposes for this study. The first was to investigate the effectiveness and efficiency of two types of experiences in facilitating the development of conservation of number and/or conservation related skills in nonconserving 4- and 5-year-old lower socioeconomic status children. The second purpose was to determine if the effectiveness and/or efficiency was affected by the subjects' developmental status and/or sex.

Questions

The study was directed by five major questions:

1. How effective are training procedures based on component concepts of conservation in facilitating the
acquisition of 1) conservation of number or 2) conservation related skills in lower socioeconomic status children, and what is the effect of these experiences for children at each of the conservation of number substages of development?

2. How effective are training procedures based on a set theory approach to numerical understanding in facilitating the acquisition of 1) conservation of number or 2) conservation related skills in lower socioeconomic status children, and what is the effect of these experiences for children at each of the conservation of number substages of development?

3. Are there any significant differences in the effectiveness of experiences emphasizing the component concepts of conservation and the effectiveness of experiences based on a set theory approach to number in facilitating the acquisition of 1) conservation of number or 2) conservation related skills, or in the effectiveness of each of these experimental conditions at each of the conservation of number substages?

4. Are there any significant differences in the efficiency of each of the approaches in facilitating the acquisition of 1) conservation of number or 2) conservation related skills, or for each of the substages of development?
5. Are there any significant sex differences in the effectiveness and/or efficiency of each of these approaches in facilitating the acquisition of 1) conservation of number or 2) conservation related skills, or in interaction with each of the substages of development?

**Hypotheses**

The hypotheses of the study were:

1. There will be a significant difference ($\alpha \leq .05$) in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills

by 4- and 5-year-old lower socioeconomic status children, as shown by performance scores and stage classifications, on the conservation of number intermediate test and/or posttest, as a result of treatment conditions.

2. There will be a significant difference ($\alpha \leq .05$) in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills

by 4- and 5-year-old lower socioeconomic status children, as shown by performance scores and stage classifications, on the conservation of number intermediate test and/or posttest, as a function of their stage of development in interaction with treatment conditions.
3. There will be a significant difference ($\alpha \leq .05$) in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills
by 4- and 5-year-old lower socioeconomic status children, as shown by performance scores and stage classifications, on the conservation of number intermediate test and/or posttest, as a result of the sex of the subjects in interaction with treatment conditions.

4. There will be a significant difference ($\alpha \leq .05$) in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills
by 4- and 5-year-old lower socioeconomic status children, as shown by performance scores and stage classifications on the conservation of number intermediate test and/or posttest, as a function of their stage of development and sex in interaction with treatment conditions.

Design of the Study

The study was conducted over a 7 week period extending from January 20 to March 8, 1974 and involved three experimental conditions using a pretest-intermediate test-posttest model:

1. Experimental group I (EI): Conservation Approach
twelve 10-15 minute instructional sessions emphasizing the component concepts of conservation and the invariant aspects of number;
2. Experimental group II (EII): Set Theory Approach
twelve 10-15 minute instructional sessions
emphasizing the concepts of sets and the variant
aspects of number; and

3. Experimental group III (EIII): Control I
no treatment.

The intermediate test, given after 6 lessons, and the post-
test, given at the end of the 12 lessons, were exactly the
same as the pretest which was a modified version of the
standard Piagetian conservation of number paradigm.

The 4- and 5-year-old lower socioeconomic status
children in the study were drawn from Head Start centers,
Title I pre-kindergarten programs, and social welfare
supported preschool and day care centers in Franklin County,
Ohio. The testers and instructors were junior and senior
elementary education majors at The Ohio State University.

The main analysis concerned 1) the effectiveness
and efficiency of two types of instructional experiences in
facilitating the development of conservation of number
and/or conservation related skills by 4- and 5-year-old
lower socioeconomic status children, and 2) the differen-
tial effectiveness and efficiency of training conditions
with children classified according to their developmental
status and/or sex. The effectiveness and efficiency of
training conditions in facilitating the acquisition of
conservation was determined through an analysis of the
number of children in each condition exhibiting the con-
servation response on the intermediate test and posttest. Analysis of variance was used to determine if significant differences existed on the intermediate test and/or posttest in the performance scores and stage classifications of children under each treatment condition, thus indicating the effectiveness and efficiency of instruction in facilitating the acquisition of conservation related skills.

Prior to the major study a pilot study was conducted for the following purposes:

1. to provide training for the testers and instructors; and

2. to pre-test the instructional activities and testing instrument.

No major changes were made in the basic design and procedures, activities, or instrument as a result of the pilot study although minor alterations were made in wording and instructional directions.

**Definition of Terms**

Component Concepts of Conservation. Includes the conservation of number related skills as well as the ability to attend to the relevant numerical dimensions during perceptual transformations.
**Conservation Approach.** A series of instructional activities or experiences using sets and verbal training in order to develop an understanding of one-to-one correspondence and its use in determining "more," "same," and "less" in reference to numbers, as well as the invariance of number during perceptual transformations.

**Conservation of Number Related Skills.** Refers to the ability to set up one-to-one correspondence and to indicate an understanding of "same" and "more" in reference to number.

**Developmental Status/Stage Classification.** A descriptive term used to indicate the possession of specific skills, concepts, or behaviors characteristic of a given level of development.

**Effectiveness.** A significant difference in 1) the number of children acquiring conservation, or 2) the acquisition of conservation related skills as shown by performance scores and stage classifications, on the intermediate test and/or posttest as a function of treatment conditions.

**Efficiency.** The amount of time or number of instructional sessions needed by each approach to effectively facilitate the acquisition of conservation of number or conservation related skills.
Instructional Activity/Instructional Lesson. A planned experience emphasizing the experimental objectives.

Instructional Session. A 10-15 minute period of time in which one of the instructional activities (lessons) is presented to a group of four children.

Intermediate Test. A test that is exactly the same as the pretest and posttest except that it is given midway through the series of instructional sessions.

Lower Socioeconomic Status Children. Children enrolled in Head Start centers, Title I pre-kindergarten programs, or social welfare supported preschools and day care centers.

Performance Score. The number of points obtained on the conservation of number test.

Set Theory Approach. A series of instructional activities or experiences using sets and verbal training in order to develop an understanding of one-to-one correspondence and its use in determining "more," "same," and "less" in reference to numbers, as well as the effects of operations on number.

Stage/Substage. A period within a developmental sequence in which specific characteristic behaviors are exhibited.

Testing Session. A ten minute period of time in which the testing instrument is administered individually to each child.
Limitations

1. The study was directed towards all lower socio-economic status children, however, the sample was predominately black (88%).

2. The study was limited to 4- and 5-year-old non-conserving lower socioeconomic children.

3. All of the testers and instructors were white and unfamiliar to the children.

4. The possible effect of conserving peer instruction was eliminated through the exclusion of children who possessed conservation behavior.

5. Due to the fact that instruction had to take place within participating centers, children were assigned by "groups of 4" to treatment conditions rather than independently.

6. There were no delayed posttests or tests for generalizability.

7. Testing and instruction took place at a specified time outside the regular classroom and thus was "imposed upon" the children rather than evolving from the ongoing daily activities. Consequently, the "readiness" of each child to participate was assumed.
CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The literature related to the problem under investigation has been organized and summarized into three major sections. The first section is concerned with the basic concepts of Piaget's theory of cognitive development. The second section provides an extensive review of the training studies for conservation of number, while the third section deals with methodological considerations.

Piaget's Theory of Cognitive Development

View of Intelligence

Jean Piaget is a Swiss psychologist and genetic epistemologist who has provided an enlightening, elaborate, and comprehensive description of the ontogenesis of logical thought, with an emphasis on both the processes and products of cognitive growth. His theoretical view of intelligence--its development, structure, and functions--reflects his extensive interest and training in biology.

Piaget views human intelligence as one type of biological adaptation, an adaptation which permits or
allows an individual to interact effectively with the environment at a psychological level (Piaget, 1952b). Consequently, the development of knowledge is seen as an active process, which occurs as the individual discovers or constructs "reality" through his activities, rather than a passive acquisition through imposition or transmission.

A basic premise of Piaget's theory is that the human organism inherits two basic tendencies or "invariant functions," adaptation and organization, which are interdependent, and also interrelated with the structures of intelligence. Piaget postulates that, just as there is the tendency, at the physiological level, for all living things to organize and integrate their structures into a composite, higher order system, so too there exists, at the psychological level, the tendency to form coherent systems of thought by organizing and integrating experiences gained through interactions with the environment. The acquisition of experiences occurs through the process of adaptation which involves the interaction of assimilation and accommodation. Assimilation is a cognitive process which allows an individual to incorporate new information or experiences into his existing intellectual structures. It operates whenever the organism sees something new in terms of something familiar, behaves in a new situation as it
has behaved in other previous situations, or invests anything with familiarity (recognition), importance, or value. Accommodation, which is a complimentary process to assimilation, occurs whenever variations in the environment or environmental circumstances are sufficiently different to prevent direct assimilation, and consequently require the modification or alteration of existing structures or perhaps even the creation of a new schema in order to cope. Thus the individual changes his concepts (accommodates) in order to assimilate the new experiences.

Piaget further proposes that the reason these processes exist and operate is that there is a psychological (just as there is a physiological) tendency towards equilibrium with the environment. When environmental circumstances cause cognitive conflict, and consequently disrupt the equilibrium, the individual goes into disequilibrium. The tendency for equilibrium propels the individual to either assimilate or accommodate—to adapt—in order to restore balance. The motivation for learning and development is inherent. As each adaptation occurs, new psychological structures are formed, which in turn influence the way the individual will organize and adapt to his environment in the future (Ginsburg and Opper, 1969).
The Development of Psychological Structures—Stages of Development

The emergence of psychological structures, which are characteristically different at different ages and which consequently set limits on the nature of an individual's behavior at each stage of development, follow an invariant sequence. At the first stage of development, the Sensori-Motor period, which exists from birth to about age two, the child is unable to think. He interacts, and consequently copes, with the environment through sensori-motor or overt actions. Through repeated experiences, the infant forms "habits," or organized patterns of behavior which Piaget calls schemata. Through differentiation, elaboration, and integration, new schemata are formed which in turn give rise to new psychological structures and consequently the development of intelligence.

Around age two the child develops the ability to represent objects and events internally (to think) and thus becomes less dependent upon direct sensori-motor activities in order to give direction to his behavior. The ability to form internal representations marks the entrance into the Pre-operational period. This stage in the development of logical thought is characterized by the fact that while the child is no longer restricted to only sensori-motor responses his thought is still perceptually bound. Although he is able to internalize actions via
symbols, his thought is dependent upon concrete situations and his perceptions dominate or control his thinking. The thought of the child at this stage of development can be described as centered, that is he tends to focus on only one perceptual aspect or dimension of a situation at a time. He can not coordinate all the perceptual information and cognitively evaluate it. This inability to decenter perceptions is also reflected in the child's personality and behavior which can be described as egocentric. The child is unable to take another person's point of view or to even consider that any thoughts exist other than his own. Consequently he never reflects on his own thinking and therefore is unable to consider evidence which differs from his own thought. Another characteristic of his thinking at this stage of development is his inability to reverse his thoughts; he is unable to evaluate a given perceptual situation by reasoning back to the point of origin. A fourth characteristic of this period is his inability to attend to transformations. Rather than being able to see the "process" by which changes are brought about, the child focuses on the various "states" of the event. Consequently, he is unable to compare states or evaluate relationships among states.

The next stage in the development of logical thought is the period of Concrete Operations which begins
when the child is able to decenter his thinking, around age 6 or 7. Although he is now capable of logical operations or reasoning, his thinking is limited to concrete situations and events. He is still incapable of solving abstract, hypothetical or verbal problems. A key accomplishment of the Concrete Operational period, and consequently an extensively studied phenomenon, is the attainment of the ability to conserve. Conservation, within Piaget's theoretical framework, refers to the ability to maintain the invariance of quantity despite perceptual transformations. In order for conservation to occur, the child has had to decenter his thought and thus become capable of attending to transformations as well as mentally reversing actions. He is able to make cognitive evaluations of perceptual situations.

The acquisition of the ability to apply conservation principles to various types of problems follows an invariant developmental sequence. The first quantity to be conserved, around age 6, is number. The acquisition of conservation of number marks the entrance into the period of Concrete Operations and thus is of great theoretical, as well as practical, interest. The last quantity to be conserved is volume, and its attainment, at about age 11 or 12, usually indicates that the child is about to enter into the last and final stage of development, the Formal Operational period.
The Formal Operational period is characterized by the ability to apply logical operations in the solutions of all classes of problems. The child is no longer confined to thinking only about concrete situations and events. He is now able to think abstractly, to entertain hypothetical situations, and to engage in complex thinking requiring combinatorial thought and verbal propositions. This period is the culmination in the development of logical structures (Wadsworth, 1971; Ginsburg and Opper, 1969).

**Mechanisms of Transition**

Piaget has identified four factors, or mechanisms of transition, which he believes are responsible for stimulating the development from one stage to another. These factors are maturation, physical or concrete experience, social transmission and interaction, and equilibration.

Piaget views the role of maturation in intellectual development in terms of the possibilities and impossibilities presented by the physical system at each stage of development. Realization of the child's potential, however, is dependent upon his social, cultural, and educational environment (Inhelder and Piaget, 1958).

A second factor in cognitive growth is experience with physical phenomena. Piaget believes that the roots of conceptual intelligence are found in sensori-motor acts. Schemata (or the structures which determine how an
individual organizes and adapts to his environment) arise out of the child's internalization of his own actions on objects. Thus the provision of opportunities for the child to act on, rather than react to, concrete objects is a necessary provision for intellectual development.

Social transmission and interaction is another factor which stimulates cognitive development. Through interactions with other individuals the child comes in contact with a variety of opposing ideas and points of view which create cognitive conflict. The inherent need for equilibrium demands that this conflict must be resolved, thus forcing the child to either assimilate or accommodate in order to adapt. In addition it is a means of developing concepts which are socially or arbitrarily defined (concepts which have no physical referents such as sharing).

The fourth factor influencing cognitive growth is equilibration. Equilibration is a self-regulatory mechanism that integrates the internal and external forces and thus moves the individual from one state of equilibrium to another state of even greater equilibrium. As the individual develops, this movement from states of equilibrium to higher level states of even greater equilibrium results in greater and greater degrees of understanding and knowing.
Research Methodology

The empirical data upon which Piaget has based many of his conclusions regarding the development of logical thought have been gathered through a clinical rather than an experimental methodology. In order to more clearly understand and describe the ontogenesis of intelligence and the qualitative, rather than quantitative, changes that occur as the child develops, Piaget felt that an approach which permitted the explorations of thoughts and ideas would be most appropriate. Consequently, he developed his "clinical method" which allowed him to "discover" the contents of children's thoughts at various stages of development (Ginsburg and Opper, 1969).

Basically the "clinical method" can be described as a series of open-ended questions which probe and follow the child's thinking without suggestion, evaluation, or the imposition of adult views. Although it is possible to set up a general framework of questions (Ginsburg and Opper, 1969), the clinical method is a highly flexible approach and thus can not be "standardized." In his earlier work Piaget tended to rely totally on language to establish the situation or event to which his questions applied. Later he modified his procedures so that his questions pertained to problems involving concrete material which was present and available to the child to manipulate.
The flexibility of the Piagetian approach has caused a number of critics to question the validity and reliability of Piaget's research. Consequently there is a burgeoning literature of experimental investigations devoted towards replicating, validating, challenging, revising, extending, elaborating, and applying his enlightening and provocative findings. Although his theoretical interpretations remain open to question, the existence of a series of identifiable stages in the development of logical thought has generally been confirmed (Elkind, 1970).

Training Studies

Introduction

Piaget's theoretical accounts of the ontogenesis of logical thought provide detailed descriptions of the characteristic behaviors exhibited at each stage of development. However, only a very general description is given of the factors responsible for influencing growth. Consequently, a number of training studies have been conducted for the purposes of identifying the specific processes involved in transition as well as determining the extent to which development can be accelerated.

The literature on conservation is extensive. Therefore, the review presented here is limited primarily to training studies for conservation of number. Occasional reference to other areas is made, particularly where the
training procedures utilized appear relevant to the conservation of number literature.

As discussed previously, Piaget describes three stages in the development of conservation of number. At (sub) Stage I, the child is unable to establish one-to-one correspondence or the equivalence of sets, but instead makes a global comparison focusing on only one perceptual dimension of the problem. At (sub) Stage II, the child is able to establish the equivalence of sets through one-to-one correspondence but is unable to maintain the equivalence if the arrangement of one of the sets is transformed so that the visual cues of correspondence are destroyed. Conservation of number (Stage III) occurs when the child asserts the invariance of number (and the equivalence of sets) despite changes in the physical appearance of the sets (Piaget, 1952a).

At least two different problems are involved as the child develops from Stage I to Stage III of conservation of number. For the child to move from Stage I to Stage II he must develop the concept of numerical equivalence, or one-to-one correspondence. The child at Stage II has the notion of equivalence but must learn to attend to and maintain the relevant numerical dimension during perceptual transformations in order to move to Stage III of development.
Basically three major orientations have attempted to offer explanations for this development, to define the mechanisms and identify the specific factors and conditions that mediate the transitions, and to accelerate the acquisition of conservation. The three positions are: 1) Piaget's equilibration model; 2) a learning theory or behavioristic model; and 3) a language or symantical explanation. A description of each of these positions, followed by a review of the related training studies, is presented in the following paragraphs. In cases where the efficacy of procedures drawn from two or more of these positions is compared, the study is classified under the position to which the theoretical rationale suggested greatest emphasis and/or to which the results lend greatest support.

The key variables and major findings of all the training studies reviewed are summarized and presented in Table 1. The meaning of the abbreviations and symbols used in Table 1 is as follows:

1. SEC: Socioeconomic class or status
2. Ind.: individual
3. S: successful
4. U: unsuccessful
5. A/S: Addition/Subtraction
6. *: used to indicate whether "successful" or "unsuccessful"
7. CC: cognitive conflict
8. L: lower SEC
9. M: middle SEC
10. K: kindergarten
11. X: mean
12. CA: chronological age
13. 1st: first grade
14. n: number
15. cons.: conservers
16. nc: non-conservers
17. E's: Experimental groups
18. hetero: heterogeneous
19. 1-1: one-to-one correspondence
20. H: upper SEC
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Type of Training</th>
<th>Training Sessions</th>
<th>Results</th>
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</thead>
<tbody>
<tr>
<td>Smedslund 1959,1961</td>
<td>72 L9 M9 K; X Stage II</td>
<td>Cognitive Conflict (A/S deformations plus counting) v.s. learning through reinforced practice; knowledge of results (counting before and after transformations) v.s. dissociation of perceptual cues v.s. control</td>
<td>2 trials per day 2 successive days Ind.</td>
<td>* No significant effects, CC greatest gains; control better than other two.</td>
</tr>
<tr>
<td>Wohlwill 1959</td>
<td></td>
<td>Cognitive conflict (A/S deformations) v.s. direct external reinforcement</td>
<td></td>
<td>*6 Not significant but favored CC1.</td>
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<tr>
<td>Author/Year</td>
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<tr>
<td>Gruen 1965</td>
<td>90</td>
<td>Pre-K to K; CA 4-6 to 6-4 X CA 5-1 Understanding of addition/subtraction before training.</td>
<td>Cognitive Conflict (A/S) v.s. learning through reinforced practice knowledge of results 1/2 of each group received verbal pre-training</td>
<td>2 16 trials per day 5 successes-Ind.</td>
</tr>
<tr>
<td>Murray 1972</td>
<td>43 M</td>
<td>K-1st 13</td>
<td>Cognitive Conflict (Social interaction) v.s. control</td>
<td>1 Group (n=17, 2 controls 1 no control)</td>
</tr>
<tr>
<td>Wallach &amp; Sprott 1964</td>
<td>66 M</td>
<td>1st.; X CA 6-11</td>
<td>Reversibility v.s. control</td>
<td>1 8 trials 1 day Ind.</td>
</tr>
</tbody>
</table>
| Wallach, Wall & Anderson 1967 | 56 M | 1st.; X CA 6-11 Stage II or above | Reversibility alone v.s. Addition/Subtraction | 1 Repeat trials until 4 correct predictions. | Ind. * Reversibility resulted in significant increases; A/S did not.
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<tr>
<td>Author/Year</td>
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<td>SEC</td>
<td>Age/Grade/Status</td>
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<tr>
<td>Roll 1970</td>
<td>44</td>
<td>M</td>
<td>K; X CA 6-11 Stage II or above</td>
</tr>
<tr>
<td>Feigenbaum 1971</td>
<td>103</td>
<td>heter</td>
<td>18 years X CA 54 months</td>
</tr>
<tr>
<td>Curcio, Robbins &amp; Ela 1971</td>
<td>48</td>
<td>X CA 4-6</td>
<td>Conservation of body parts (fingers) exhibited</td>
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</table>

* $*$ No difference on post-test but significant difference on delayed post-test in favor of body parts.
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<tr>
<td>Shantz &amp; Sigel 1967</td>
<td>36 M K; CA 5-4 to 5-10 all understand &quot;same&quot; &quot;more&quot; &quot;less&quot;</td>
<td>Multiple Concepts Multiple labeling and classification v.s. discrimination/memory learning</td>
<td>9 20-30 minutes</td>
<td>1 a day for 3 weeks Group (n=6)</td>
</tr>
<tr>
<td>Harper &amp; Steffe 1968</td>
<td>K-1st</td>
<td>Multiple concepts--1-1; 19 perceptual rearrangements: &quot;as many as&quot;; &quot;more than&quot;; &quot;fewer than&quot;; addition/subtraction</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Pace 1968</td>
<td>94 M X-1st; Stage I (n=10) Stage II (n=84)</td>
<td>Multi-concept</td>
<td>25 10-20 minutes</td>
<td>5 weeks Group (n=12-23)</td>
</tr>
<tr>
<td>Rothenberg &amp; Orost 1969</td>
<td>130 L M</td>
<td>Multiple concepts--cognitive conflict and reversibility</td>
<td>4 15-20 minutes</td>
<td>1 week Ind.</td>
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<tr>
<td><strong>Feigenbaum &amp; Sulkin 1967</strong> (discontinuous quantity)</td>
<td>47 hetero</td>
<td>K; X CA 5-10</td>
<td>Discrimination/Reinforcement</td>
<td>1</td>
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<tr>
<td>Winer 1968</td>
<td>42 L M</td>
<td>X</td>
<td>Response sets to either add/sub or to length induced through practice</td>
<td>2</td>
</tr>
<tr>
<td>Gelman 1969</td>
<td>60</td>
<td>K; X CA 5-5</td>
<td>Discrimination learning set with feedback v.s. Oddity condition with feedback v.s. Stimulus change learning set without feedback.</td>
<td>2</td>
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<tr>
<td>Scott 1969</td>
<td>29 Pre-K CA 4-0 to to 5-6</td>
<td>Describing and classifying sets, compare on basis of length and number</td>
<td></td>
<td>11</td>
</tr>
<tr>
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<tr>
<td>Blum 1969</td>
<td>32</td>
<td>CA 4-2 to 8-11, understand &quot;more&quot;, &quot;less&quot;, &quot;same&quot;</td>
<td>Discrimination counting</td>
<td>2 days *</td>
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<td></td>
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<td></td>
<td>Training successful with both social classes and all ages.</td>
</tr>
<tr>
<td>Blum &amp; Adcock 1969</td>
<td>43</td>
<td>1st and 2nd; CA 5-7 to 8-3</td>
<td>Transformations—predict, count, match, rule control v.s.</td>
<td>*</td>
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<td></td>
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<td></td>
<td></td>
<td>Significant increases by experimental group but not by control.</td>
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<tr>
<td>Hatan &amp; Suga 1969</td>
<td></td>
<td></td>
<td>Practice and reinforcement</td>
<td>*</td>
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<td></td>
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<td></td>
<td></td>
<td>Only slight increases and then only with subjects who showed responses early in training.</td>
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<tr>
<td>Peters 1970</td>
<td>131 L</td>
<td>X; X CA 5-7</td>
<td>Verbal mediators and cue discriminations 1. noncued discovery 2. perceptual guided discovery 3. verbal didactic instruction 4. control</td>
<td>2 trials 2 days Ind.</td>
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<td></td>
<td></td>
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<td></td>
<td>Training conditions significantly higher than control with verbal rule instruction group significantly higher than the others.</td>
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<tr>
<td>Author/Year</td>
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<td>Training Sessions</td>
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<tr>
<td>Halford &amp; Fullerton 1970</td>
<td>24 L M</td>
<td>Discrimination task--match the standard--choose between number and arrangement</td>
<td>5 trials per day</td>
<td>8/12 achieve conservation in experimental group; 1/12 in control; significant.</td>
</tr>
<tr>
<td>Sullivan 1969</td>
<td>42 M 1st</td>
<td>Observational learning Modeling (via film) with verbal principle v.s. modeling without principle</td>
<td>1</td>
<td>Verbal principle significantly higher than no principle group.</td>
</tr>
<tr>
<td></td>
<td>170 M 1st</td>
<td>Modeling-verbal principle v.s. modeling-no principle v.s. control</td>
<td>1</td>
<td>No significance between groups.</td>
</tr>
<tr>
<td></td>
<td>17 M 1st</td>
<td>Non-conservation modeling--no explanation--no feedback</td>
<td>1</td>
<td>Significant decreases in conservation responses and explanations.</td>
</tr>
<tr>
<td>Author/Year</td>
<td>Sample</td>
<td>Type of Training</td>
<td>Training Sessions</td>
<td>Results</td>
</tr>
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<td>-------------</td>
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<tr>
<td></td>
<td>13 M Pre-K; CA 4-2 to 4-9</td>
<td>Modeling—no rule—no feedback</td>
<td>1</td>
<td>* Significant increases in judgments but not explanations.</td>
</tr>
<tr>
<td><strong>Language Based Training Studies</strong></td>
<td><strong>Beilin 1955</strong></td>
<td>170 M K</td>
<td>Verbal Mediators 1. Nonverbal reinforcement 2. Verbal orientation 3. Verbal rule instruction 4. Equilibration 5. Control</td>
<td>4 36 trials 40 minutes Ind.</td>
</tr>
<tr>
<td></td>
<td><strong>Figureelli &amp; Keller 1972</strong></td>
<td>48 L 1st; CA 6-0 to 8-0</td>
<td>Verbal rule with corrective feedback vs. control</td>
<td>1 5 trials 25-40 min. 1 day Ind.</td>
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TABLE 1 continued

<table>
<thead>
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<th>Training Sessions</th>
<th>Results</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td># Length</td>
<td>Time Covered</td>
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<tr>
<td>Frank</td>
<td>1964</td>
<td>4-0 to 7-0</td>
<td></td>
<td>2 days</td>
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<tr>
<td>Hamel</td>
<td>1972</td>
<td>80 M 6 year olds</td>
<td>1</td>
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<tr>
<td>Fletcher</td>
<td>1970</td>
<td>200 1st; X CA 7-0</td>
<td>1</td>
<td>Ind.</td>
</tr>
<tr>
<td>Owens</td>
<td>1972</td>
<td>47 L K-1st; 5- and 6-year-olds</td>
<td>26</td>
<td>20-30 min.</td>
</tr>
<tr>
<td>Set Theory Based Training Studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzing</td>
<td>1970</td>
<td>40 L K; X CA 5-3</td>
<td>12</td>
<td>30 min.</td>
</tr>
</tbody>
</table>
Equilibration Based Training Studies

According to Piaget's equilibration theory all organisms possess an inherent mechanism which integrates internal and external forces and thus functions to promote cognitive development while maintaining a state of equilibrium. The acquisition of conservation depends upon the ability to decenter perceptions, attend to transformations and relevant quantitative properties, and to reverse actions mentally. Thus for conservation to occur, overt actions on the environment must be internalized, organized, and coordinated, giving rise to new cognitive structures and a coherent system of thought. From his cognitive evaluations, rather than a superficial perceptual assessment, the individual becomes capable of maintaining the invariance of a quantity after physical transformations (conserving) by inferring that: 1) a change in one dimension is compensated by a change in another interrelated dimension (compensation); 2) an inverse operation will return the quantity to its original condition (reversibility); or 3) nothing has been added or taken away (operational identity) and/or the quantity is the same as it was before the transformation (substantive identity) (Ginsburg and Opper, 1969).

A number of training studies have attempted to move the child from perception to inference by providing experiences which will provoke recognition of the principles
which imply invariance (conservation). Within the equilibration theory framework there have been three basic approaches to this problem: 1) cognitive conflict training; 2) reversibility training; and 3) a multiple concepts and methods technique.

Cognitive Conflict Training Studies

Cognitive conflict refers to the inability to incorporate new schemata into existing ones, thus creating a state of disequilibrium, and consequently forcing a change in cognitive structures. The change in structures allows the conflict to be resolved resulting in a return to an equilibrated state.

Believing that cognitive conflict is provoked, and conservation acquired, by experiencing repeated exposures to conflict situations, Smedslund (1959, 1961) developed an organism-object conflict situation training technique in which the child experiences either the addition or subtraction of the stimulus material together with a physical transformation. Results of his study with substance and weight were equivocal. Succeeding studies with number (Wohlwill, 1959; Wohlwill and Lowe, 1962; and Gruen, 1965) revealed trends in favor of this technique although they were not significant. Mermelstein and Meyers (1969) found no significant differences or trends when using the cognitive conflict approach. The use of organism-object
conflict situations for stimulating cognitive growth appears to have only very limited effect. In fact Smedslund himself, in a 1966 report, indicated that it lacked the power to provoke modification of intellectual structures. In its place he suggested the use of organism-organism conflict situations, or the confrontation of ideas and points of view among peers, as a means of bringing about decentralization and consequently intellectual growth. Murray (1972) utilized this approach and found significant shifts (.01) from nonconservation to conservation status. Although his results are convincing, since no other studies have directly explored this concept, the findings, while suggestive, cannot be viewed as conclusive.

Reversibility Training

A second approach to conservation training, which is derived from Piaget's equilibration theory, places emphasis on one of the key elements of operational thought—reversibility. Reversibility refers to a maintenance aspect or capacity of a system in which an inverse operation negates or compensates for a previously performed operation. Reversibility guarantees stability or equilibrated states and consequently provides a means of maintaining the invariant quantitative dimensions of a situation despite perceptual changes. Following from this theoretical premise, researchers have hypothesized that successful
training in the reversibility of operations will result in the establishment of an equilibrated state, and the corresponding formation of logical structures, which will eventually lead to the acquisition of conservation.

Wallach and Sprott (1964) were the first to utilize reversibility as a training procedure for conservation of number. In discussing the role of reversibility in facilitating the acquisition of conservation they point out that numerical equality is recognized as the result of one-to-one correspondence. The perceptual aspect of correspondence, or "fitting together," is destroyed during transformation, thus removing the defining attribute of equality. The knowledge that the defining attribute can be returned through an inverse operation or action is assumed to be the major criteria by which continuation of equality is maintained. Learning to expect this equality when transformations are returned to their original positions is the main factor in reversibility training. The results of their study as well as those of Wallach, Wall, and Anderson (1967), Roll (1970) and Feigenbaum (1971), revealed significant increases in conservation responses as a result of reversibility training. Equivocal results were found by Curcio, Robbins, and Ela (1971). As the results of these studies indicate, reversibility training does appear to be a fairly successful approach for facilitating the acquisition of conservation.
Multiple Concepts and Methods Approach

The third type of approach following from Piaget's theoretical system employs multiple concepts and methods in training, which have been derived from an analysis of the prerequisite operations and component concepts of the conservation response. Rather than attempting to isolate a single specific type of experience that induces conservation, the purpose of these studies has been to identify as many related component concepts and prerequisite operations of conservation as possible and to organize and incorporate them into an instructional sequence. Concepts and techniques which have been used are: 1) multiple labeling, multiple classification, and reversibility training together with an emphasis on cue discrimination (Shantz and Sigel, 1967); 2) one-to-one correspondence, more, less, same, addition, subtraction, and perceptual rearrangements (Harper and Steffe, 1968); 3) one-to-one correspondence, matching, and perceptual rearrangements (Pace, 1968); and 4) rote counting, enumeration, one-to-one correspondence, "same number," "more" with respect to number and length, addition, subtraction, and reversibility together with the use of conserving peers as "assistant teachers" to serve as models of the conservation response (Rothenberg and Orost, 1969).

All of the studies which have utilized the multi-concept, multi-method approach have been successful in
accelerating the achievement of conservation. As Beilin (1971) points out, however, their theoretical value is limited because it is not possible to assess the extent of influence contributed by each of the various concepts and methods.

One can not assume, as these studies imply, that all the elements in the mixture contribute to changes in subject performance. It is quite likely that some elements inhibit acquisition or neutralize the effects of other procedures (Beilin, 1971, p. 97).

Summary

Thus of the three approaches to conservation training drawn from Piaget's equilibration theory, only the reversibility and multi-concept, multi-method approaches can be considered to be clearly successful in bringing about the conservation response. None of the cognitive conflict studies involving organism-object conflict situations have obtained significant results. Although significant results were reported from the one study which employed organism-organism confrontation, since no other attempts have been made to directly explore this concept, the results, while suggestive, can not be viewed as conclusive.

Learning Theory Based Training Studies

Training studies evolving from a learning theory point of view or behavioristic base attempt to explain and foster the acquisition of conservation through the develop-
ment of response sets via practice, the application of reinforcement principles, or through observational learning or modeling. Within this frame of reference, the conservation problem is seen as a discrimination and differentiation task. In order to conserve, the child must learn to ignore the misleading perceptual cues and/or to attend to the relevant invariant dimension.

Young children tend to define quantity multi-dimensionally and consequently all cues in a situation are potentially relevant to his definition of amount (Zimiles, 1966; Gelman, 1969). When initially presented with the standard conservation task paradigm, the child has no means by which he can determine to which of the available cues he should attend. The subsequent transformations which take place tend to focus his attention on the irrelevant attribute being manipulated thus enhancing the likelihood that this dimension will be used in determining amount.

Directing the child's attention to the appropriate conceptual property, and consequently heightening the probability that a consistent response (response set) to that dimension will occur thus inducing conservation, can be brought about by: 1) providing practice in making correct discriminations; 2) reinforcing correct responses through verbal feedback, knowledge of results, or external rewards; and/or 3) providing opportunities to observe modeling of the conservation response.
Providing practice in making appropriate discriminations has been found to be a successful technique by Shantz and Sigel (1967), Winer (1968), Halford and Fullerton (1970), and Peters (1970), all of whom reported significant results, and by Scott (1969) who found a trend in the predicted direction.

The use of reinforcement principles (verbal feedback, knowledge of results, and external rewards) to bring about the achievement of conservation has resulted in successes (Blum, 1969; and Blum and Adcock, 1969) and failures (Wohlwill, 1959; and Gruen, 1965). Contradictory evidence is also reported from studies which have combined and/or compared approaches. Feigenbaum and Sulkin (1964) found significant differences in favor of practice alone as opposed to the use of reinforcement, whereas Hatano and Suga (1969) reported no significant results from either approach. Wohlwill and Lowe (1962) compared the effects of reinforcement through knowledge of results with the use of external rewards and found both to result in significant differences with no differences in the effectiveness of either approach. Gelman (1969) compared the effects of practice plus verbal reinforcement plus external rewards with the use of verbal reinforcement alone and practice alone. Significant effects were found for the combined approach.
Evidence from studies employing observational learning or modeling as a technique for inducing the acquisition of conservation is rather scarce and somewhat contradictory. Sullivan (1969) conducted two studies comparing the effects of modeling with and without verbal explanations and found contradictory results. In the first study, modeling with explanations was found to result in significant increases in the conservation responses whereas in the second study it did not. Rosenthal and Zimmerman (1972) reported modeling alone (without explanations) to be sufficient to result in significant increases in conservation acquisition.

Summary

Of the three approaches to conservation of number training which have been derived from a learning theory or behavioristic model, the use of practice in making appropriate discriminations is the most consistently successful method. Although some successes have also been reported from studies employing modeling or reinforcement techniques, the unsuccessful attempts suggest the existence of interfering factors which as yet are unidentified and therefore unable to be controlled, thus limiting the usefulness of these approaches.
Language Based Training Studies

The third explanatory position regarding the acquisition of conservation is one in which the role of language is examined as the critical factor. Basically three different points of view regarding the effects of language can be identified.

Language as a Verbal Mediator--Verbal Rule Instruction

A number of studies have questioned the extent to which language serves as a verbal mediator in the solution of the conservation tasks. The hypothesis is that children possess the necessary cognitive structures to give the conservation response but they are still rather diffuse. Language, as a verbal mediator, tends to focus the child's attention on the critical aspects of the conservation task and on the specific instances where conservation responses are applicable, and therefore facilitates their application in achieving conservation. In order to test this hypothesis, training methods were devised in which the children were given corrective feedback in the form of a rule which explains the invariance (verbal rule instruction). Results of these studies have indicated that this technique is generally successful with significant increases reported by Beilin (1965), Peters (1970), Figurelli and Keller (1972), Rosenthal and Zimmerman (1972), and Murray (1972).
Equivocal results were reported by Sullivan (1969) with Mermelstein and Meyer (1969) indicating no significant changes.

Language as an Information Processing and Organizing System

A second view of the role of language in cognitive development is that it is an information processing and organizing system. Through language, or verbal formulations, experiences can be represented and transformed symbolically, thus permitting a greater flexibility and range of thought. According to this position, proposed by Bruner (1964), the activation of language structures, which are already possessed by the child, permits the misleading perceptual aspects of conservation transformations to be subordinated to the intrinsically logical features. As a result, acquisition of conservation is facilitated. Language activation can be brought about through the use of questions prior to or in the absence of actual transformations.

Bruner's position, which purports that the formation of mental structures occurs as a result of the language activated, differs drastically from Piagetian theory. Piaget's contention is that the formation of mental structures precedes language development and consequently he does not believe that language activation can accelerate the acquisition of conservation.
Support for Bruner's position is gained from the successful results of a study by Frank (cited by Bruner, 1964) and one by Hamel, Van der Veer, and Westerhof (1972). Mermelstein and Meyer (1969) found no significant effects from language activation training.

Symantical Explanation

The third position regarding the effect of language on conservation performance can be described as a symantical explanation. According to this view, failures on conservation tasks occur because young children do not understand the terminology used in the questioning format. Consequently, a number of studies have investigated the effects of providing verbal pretraining experiences for key relational terms (more, less, and same) used in the standard conservation paradigm. Significant results have occurred from the use of verbal pretraining to insure an understanding of relational terminology as indicated by the findings of Gruen (1965) and Rothenberg and Orrost (1969) with Fletcher (1970) reporting a trend in the predicted direction. Nonsignificant results were found by Owens (1972).

Summary

In summarizing the results of studies which have utilized some form of language training to stimulate conservation acquisition, it is evident that both successes
and failures have occurred as a result of all three positions. Consequently, no conclusions can be drawn regarding the role language plays in the attainment of conservation.

Set Theory Based Training Studies

Most modern mathematics programs (e.g., Harbrace Mathematics, Harcourt, Brace and Jovanovich, Inc., 1972; Modern Mathematics Through Discovery, Silver Burdet and Co., 1970; Modern School Mathematics: Structure and Use, Houghton Mifflin Co., 1972; and New Dimensions in Mathematics, Harper and Row, 1970) and consequently most readiness and introductory work in mathematics use a set theory approach in developing an understanding of numbers. Number is considered to be an abstract quantitative property of a concrete set. Thus work with sets can be used to develop an understanding of the principles and operations associated with number. Basic concepts which are emphasized include: 1) an understanding of equivalent sets; 2) set comparisons; 3) the cardinal number of sets; and 4) the variance in number brought about by operations (addition, subtraction, multiplication, and division) on sets.

Although an understanding of numerical operations is presumed to depend upon a prior understanding of numerical constancies (Van Engen, 1971), no experiences with perceptually transformed equivalent sets are provided in most of the readiness programs. In view of the fact that the
set theory approach is the most widely accepted approach to the development of numerical understanding, it is both critical and imperative to determine if experiencing a change in number (quantity) through an operation (addition, subtraction . . .) on a set is sufficient to induce the related conclusion that "no operation" means "no change in number (quantity)." Only one empirical study (Benzinger, 1970) of the effects of this approach on conservation acquisition has occurred with no significant differences reported.

Summary and Conclusions

In summary, training studies for conservation of number have been conducted for the purposes of identifying the specific processes involved in cognitive growth as well as determining the extent to which development can be accelerated. Basically three major orientations have attempted to offer explanations for development, to define the mechanisms and identify the specific factors that mediate transitions, and to accelerate the acquisition of conservation. The three positions are: 1) Piaget's equilibration theory; 2) a learning theory or behavioristic model; and 3) a language or symantical explanation.

Of the three approaches to conservation training drawn from Piaget's equilibration theory, only the reversibility and multi-concept, multi-method approaches can be
considered to be clearly successful in bringing about the conservation response. None of the cognitive conflict studies involving organism-object conflict situations have obtained significant results. Although significant results were reported from one study which employed organism-organism confrontation, since no other attempts have been made to directly explore this concept, the results, while suggestive, cannot be viewed as conclusive.

Of the three approaches to conservation of number training which have been derived from a learning theory or behavioristic model, the use of practice in making appropriate discriminations is the most consistently successful method. Although some successes have also been reported from studies employing modeling, and reinforcement techniques, the unsuccessful attempts suggest the existence of interfering factors which as yet are unidentified. As a result, these factors are unable to be controlled, and therefore limit the usefulness of these approaches.

In summarizing the results of studies which have utilized some form of language training to stimulate conservation acquisition, it is evident that successes and failures have occurred as a result of all three positions. Consequently, no conclusions can be drawn regarding the role language plays in the attainment of conservation.
Despite the limitations of post hoc comparisons, insufficient reporting of information, variations in experimental designs, controls, training approaches, and populations studied, a number of conclusions appear evident from the previously reviewed training studies for conservation of number. Several theoretical explanations have been shown to account for the attainment of conservation of number and a number of specific factors have been identified that appear to mediate cognitive transitions. Yet there is no definite evidence which indicates the superiority of one position or set of factors over the others. Considerable evidence does exist, however, which establishes the fact that the acquisition of conservation of number can be accelerated through a variety of training procedures. Thus while the theoretical issues remain basically unresolved, practical applications, in terms of the acceleration of cognitive development, are possible.

Methodological Considerations

Introduction

The studies previously reviewed were attempts to identify the specific experiential factors and transition mechanisms involved in the development of conservation. In addition, a number of subject or demographic, task, and procedural variables have been shown to have influential effects on conservation behavior. Together these variables
comprise a host of methodological considerations to which attention must be given when evaluating the effectiveness of training studies or designing research to assess the efficacy of different procedures.

Subject or Demographic Variables

The subject or demographic variables which have been examined to determine their extent of relationship and possible influence on conservation behavior include: 1) chronological age; 2) mental age—IQ.; 3) cultural or socioeconomic background; 4) sex; and 5) personality characteristics. Knowledge of the inter-individual variations that exist as a function of these factors is necessary before adequate generalizations can be made about the effects of training studies on the growth of conservation behavior in children. In addition, an understanding of the effects of these variables can provide a source of explanations for individual differences that may exist within sampled populations.

Chronological Age

Extensive investigations have been directed towards determining the degree of relationship between the age of the subject and his level of cognitive development, or conservation substage status. Theoretical interest in this relationship centers upon Piaget's contention that develop-
ment occurs in an invariant sequence only generally associated with age. While emphasizing that the age of the subject was not the critical factor in this development, the reports of his research (Piaget, 1952a) indicate that specific types of behaviors tend to be exhibited within a rather limited age range. Validation of this proposition would tend to provide information regarding patterns of growth, the inter-dependence of maturation and environment, and consequently offer general guidelines for the timing and nature of instructional intervention.

Replication studies (Dodwell, 1960, 1961; Wohlwill, 1960; Elkind, 1961; Hood, 1962; and Almy, Chittenden, and Miller, 1966) have confirmed the developmental progression described by Piaget, and established a range of ages generally associated with each. With regard to the development of an understanding of number, it has been strongly indicated that conservation is not commonly present until at least age 6. Some contrary evidence has been presented, however, which suggests that much younger children naturally conserve. Braine (1964) and Bruner, Oliver, and Greenfield (1966) report studies in which children as young as 4 and 5 were shown to be conservers, while Mehler and Bever (1967) have indicated that children ages 2;6 to 3;2 exhibit conservation behaviors which are lost and do not reappear until the child is about age 4;6.
Both theoretical considerations and empirical replications have attempted to resolve this discrepancy in age-stage relationship. In discussing Braine's and Bruner's results, Gruen (1966) has suggested that the early identification of conservers may have occurred because of the criteria used to define conservation. The criteria generally used by Smedslund (1961, 1963, 1965) and others is to require an adequate explanation in addition to a conserving judgment whereas Braine and Bruner only required the judgment. Rothenberg (1969) tested this hypothesis and found that even when only a conservation judgment is required, conservation behavior is rarely found among 4- and 5-year-olds. As for the Mehler and Bever findings, studies by Beilin (1968), Rothenberg and Courtney (1969) and Higgins-Trenk and Looft (1971) have failed to replicate their results.

Further information regarding the age-substage relationship in the development of conservation of number can be gained from examining Table 2 which summarizes and presents a number of the studies which have reported the percentages of children of various ages found at each substage. The meaning of the abbreviations used in Table 2 is as follows:

1. SEC: Socioeconomic class or status
2. M: middle SEC
3. CA: chronological age
4. n: number of subjects
5. hetero: heterogeneous
6. K: kindergarten
7. \( \bar{X} \): mean
8. lst.: first grade
9. L: lower SEC
### TABLE 2

The Percentages of Children of Various Ages at Each of the Conservation of Number Stages of Development as Reported in a Number of Studies

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Sample</th>
<th>Age and/or Grade</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stage I</td>
<td>Stage II</td>
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<tr>
<td></td>
<td>#</td>
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<td></td>
</tr>
<tr>
<td>Hood 1962</td>
<td>M² 23</td>
<td>CA³ 4-9 to 5-0</td>
<td>72% (n=7)</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>5-1 to 6-0</td>
<td>40% (n=13)</td>
</tr>
<tr>
<td>Feigenbaum &amp; Sulkin 1964</td>
<td>hetero 50</td>
<td>K; 6 7 CA 5-10</td>
<td>94% (n=47)</td>
</tr>
<tr>
<td>Pace 1968</td>
<td>M 53</td>
<td>K; CA 4-10 to 5-9</td>
<td>17% (n=9)</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>1st, 8 CA 5-10 to 6-9</td>
<td>2% (n=1)</td>
</tr>
<tr>
<td>Rothenberg &amp; Courtney 1969</td>
<td>hetero 117</td>
<td>CA 2-5 to 4-4</td>
<td>62% (n=72)</td>
</tr>
<tr>
<td>Rothenberg 1969</td>
<td>hetero 210</td>
<td>CA 4-3 to 6-0</td>
<td>20% (n=42)</td>
</tr>
<tr>
<td>Pattison &amp; Fielder 1969</td>
<td>L 4 55</td>
<td>K; CA 5-0 to 6-5</td>
<td>38.2% (n=21)</td>
</tr>
<tr>
<td></td>
<td>M 59</td>
<td></td>
<td>37.2% (n=22)</td>
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<td></td>
<td>[68.2% (n=32)]</td>
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<td></td>
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<td>[67.7% (n=34)]</td>
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Transitions
<table>
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<th>Author/Year</th>
<th>Sample</th>
<th>Age and/or Grade</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># SEC</td>
<td></td>
<td>Stage I</td>
</tr>
<tr>
<td>Gelman</td>
<td>100 K</td>
<td></td>
<td>70% (n=70)</td>
</tr>
<tr>
<td>1969</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sigel &amp; Goldstein</td>
<td>21 M</td>
<td>CA 2-7 to 4-0</td>
<td>81% (n=17)</td>
</tr>
<tr>
<td>1969</td>
<td>21</td>
<td>CA 4-1 to 5-0</td>
<td>43% (n=9)</td>
</tr>
<tr>
<td>1969</td>
<td>24</td>
<td>CA 5-1 to 6-1</td>
<td>25% (n=6)</td>
</tr>
<tr>
<td>Curcio</td>
<td>167</td>
<td>CA 3-6 to 5-4</td>
<td>27% (n=45)</td>
</tr>
<tr>
<td>1971</td>
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</table>
As is revealed in Table 2 there is a gradual increase in the occurrence of conservation behavior corresponding to an increase in chronological age. A positive relationship in terms of age is evident, with older subjects exhibiting the ability to conserve more frequently than younger ones. In spite of the high correlation which exists between age and cognitive functioning, the lack of perfect correspondence suggests that individual differences within age groups must be taken into consideration when attempting to account for variance.

Mental Age

The effect of mental age or intellectual ability on performance on Piagetian tasks is another factor which has been investigated. Dodwell (1961) found a .34 correlation between a Piagetian classification test and I.Q. Elkind (1961) reported a correlation of .43 between conservation tasks and I.Q. A study by Hood (1962) revealed a definite relationship between mental age and conservation acquisition. Children with M.A.'s less than 5 rarely showed conservation whereas children with M.A.'s of 8 almost always did. Similar results were reported by Goldshmid (1967). Existing evidence indicates that mental age, or intellectual ability, does exert some limited influence on conservation achievement but it is not extensive.
Cultural or Socioeconomic Background

Considerably more attention has been directed towards determining the effects of cultural and/or social class (socioeconomic) background on the conservation ability of children. Extensive interest in this area reflects the belief that an individual's cognitive style, thought patterns, and modes of thinking are determined at least partly by two factors. These are 1) the nature of intellectual functioning and cognitive expectations required by a culture and 2) the types of experiences and opportunities provided.

More cross cultural data are provided for conservation tasks than probably any other phenomenon (Reese and Lipsitt, 1971). The occurrence of conserving behaviors and the existence of developmental trends are universal, although variations in the rates of acquisition are evident (Hyde, 1959; Price-Williams, 1961, 1962; Goodnow, 1962; Vernon, 1965; Greenfield, 1966; De Lemos, 1969; Tuddenham, 1969; Fogelman, 1970; and Gaudia, 1972).

With respect to the American based comparative studies, the effect of social class or socioeconomic status on the conservation responses and rate of acquisition has been the most extensively studied cultural variable. With few exceptions (Estes, 1956; and Mermelstein and Meyer, 1969), the results (Almy, Chittenden, and Miller, 1966;
Rothenberg, 1969; Rothenberg and Orost, 1969; Baker and Sullivan, 1970; Wasik and Wasik, 1971; Kaufman, 1971; Gaudia, 1972; Figurelli and Keller, 1972) have consistently indicated that significant differences exist between middle socioeconomic status and lower socioeconomic status children in terms of their developmental rate and conservation responses. Middle socioeconomic status children tend to score significantly higher than lower socioeconomic status children. Also, the definite developmental lag that lower socioeconomic status children exhibit tends to increase with age.

Sex

Efforts to determine the influence of an individual's sex on the development of conservation behavior have also been numerous. Generally, however, the effects of this variable have been assessed in conjunction with a variety of other factors.

The majority of studies (Almy, Chittenden, and Miller, 1966; Shantz and Sigel, 1967; Pattison, 1969; Rothenberg, 1969; Rothenberg and Courtney, 1969; Rothenberg and Orost, 1969; Peters, 1970; Roll, 1970; Figurelli and Keller, 1972; and Hamel, Van der Veer, and Westerhof, 1972) have not indicated any significant differences between males and females in their natural performance, or performance as the result of training, on conservation tasks.
However, some interesting exceptions have been discovered. While certainly not conclusive, there is slight evidence (Goldschmid, 1967; Fogelman, 1970a and b; Baker and Sullivan, 1970; Wasik and Wasik, 1971) to suggest the possibility that sex differences in conservation development may exist under certain conditions. Males were found to perform significantly better than females on conservation tasks in which they were "actively" involved in making the transformations, whereas females were shown to be superior on tasks in which they were passive observers. In addition, although there do not appear to be any sex differences in the conservation of number performance of middle socioeconomic status children, lower socioeconomic status males up to the age of 6 to 6-1/2 show conservation achievements significantly greater than their female counterparts. In attempting to explain this finding, Baker and Sullivan (1970) state that

The ability to reason arithmetically, and facility with number are known to be more common among boys (Terman and Tyler, 1954) and may be linked to the males sex role. Since lower-class children are earlier aware of appropriate sex roles and have them more narrowly delineated (Ausebel, 1958) it is possible that for males there would exist in both social class milieux, the experiences necessary for the development of number conservation. For females, however, such experiences might only be available in the middle class environment (p. 28).

Further investigation of this phenomenon is necessary, however, before any specific conclusions may be drawn about sex differences in conservation development.
Personality Characteristics

Another very important subject variable which has received only limited attention in assessing its influence on, or relationship to, individual differences in conservation acquisition and performance is the personality of the individual. Personality primarily refers to the ways in which individuals interact with and react to others and situations within their environment. Personality characteristics or dimensions which have been shown to exert influential effects on information processing, organization, and problem solving include: attention/distract-ability; impulsivity/reflectivity; flexibility/rigidity; persistence/giving up; independence/dependence; sociability/shyness; competence/incompetence (Sigel, 1968; Peters, 1967).

Peters (1967) and Sigel (1968) have presented theoretical discussions in which they examined the conservation task in terms of the particular problems involved and hypothesized the personality traits that they would expect to be characteristics of early conservers. In order to conserve, the child must be able to attend to the relevant cues and disregard the irrelevant features of the transformational situation. Consequently, it would seem that a child who was able to resist distraction, to persist in his attention, to refrain from immediately responding, to reflect upon the directions and the actions of the
experimenter, as well as to assert and maintain a response in view of perceptually contradictory evidence, would be more likely to conserve earlier than a child who could not do these things. In addition, because of Piaget's contention that cognitive growth is stimulated by repeated social interactions with peers, it would seem that the more sociable children would be more likely to exhibit conservation before the less sociable ones.

Empirical investigations of the extent to which conservers and non-conservers differ on these personality traits have not been extensive although those that have occurred have produced interesting results.

Peters (1967) reports the results of a Head Start evaluation in which children who completely failed the conservation tasks and children who exhibited conservation ability through all manipulations were compared. In summarizing the results of his study, the author indicated that

the child who achieves conservation of numerical correspondence before his agemates possesses greater attentiveness, impulse control, persistence, resistance to distraction, independence in task oriented situations, and friendly assertiveness (p. 305).

In a second study, Peters (1970) investigated the hypothesis that an individual's cognitive style, or mode of attacking a problem, is likely to interact with the types of conservation training a subject receives. Children with
high analytic abilities and low verbal scores made the most progress under the verbal treatment condition. Children with low analytic abilities and high verbal scores progressed best under the perceptual discrimination condition.

Although only limited attention has been given to the effects of personality characteristics on conservation behavior, what evidence exists indicates that it is a potentially influential factor which needs further investigation.

**Task Variables**

In addition to the variance in development that is shown to occur as the result of demographic or subject variables, differences in responses can also be attributed somewhat to factors directly related to the conservation task paradigm. Specific conditions that have been examined are: 1) the questioning procedure—the type of questions asked, the terminology used, and the complexity of the questioning format; 2) the criteria required for a conservation response; and 3) the stimulus material employed—the size of the aggregate presented, the nature or significance of the materials used, the number and nature of transformations made, and whether the subject should be a passive observer or active participant in the testing situation.
Questioning Procedures

With regard to the questioning procedures employed, there are several aspects to this issue. The first concerns the decision as to whether to use standardized questions or the more flexible Piagetian method of questioning (Rothenberg, 1969). The standard format has the advantage of providing more comparable situations but also has the major deficiency of not allowing the examiner to explore the possible reasons for incorrect responses. As Rothenberg (1969), Shantz and Sigel (1967) and Wallach (1966) have indicated, when a standard format is utilized, it is impossible to determine if a subject's failure to conserve is because he has not understood the language of the question, the concept of conservation, or both.

Some attempts have been made to determine the extent to which the terminology used in the questions is understood and therefore its potential effect or influence on the conservation responses. Results (Beilin, 1965; Prattoomraj and Johnson, 1966; Griffiths, Shantz and Sigel, 1967; and Siegel and Goldstein, 1969) indicate that while young children (ages 4 to 7) seem to understand the relational terms "more" and "less," the majority of them do not understand the meaning of "same." These findings suggest that a lack of understanding of the terminology used may account, at least in part, for failures to conserve.
Rothenberg (1969), while recognizing and acknowledging the potential influence of terminology on conservation responses, suggests that fairly accurate interpretations of failures to conserve can be made if prior assessment of the subjects' comprehension of key words has occurred followed by verbal pretraining for unknown words. Her concern lies more with the structure of the questions used during assessment. The format of the most commonly used questions (Wallach and Sprott, 1964; Zimiles, 1966; et al.) contains several parts: "Does this row (or side) have more, or does this row have more or do they both have the same number (amount, etc.)?" (pp. 384-85). These long questions are difficult for children to remember, they rarely (if ever) require the same response to all parts, and as Siegel and Goldstein (1969) have shown, children tend to respond only to the last part they hear. Thus the order in which the questions are asked may well affect the degree to which children are considered conservers. Similar problems occur in the two part question: "Do these two rows have the same number or does one have more?" (p. 385), which has also been used extensively (Fleischmann, Gilmore, and Ginsburg, 1966; Wheatley, 1968, et al.). In addition, a number of studies (Dodwell, 1960; Elkind, 1961; Wohlwill and Lowe, 1962; and Wallach, Wall, and Anderson, 1967) use a type of question which deals with a single event, "Are
there the same number of eggs and egg cups?," "Which row has more pieces in it now?" (p. 385). Because of the emphasis in the question on "same" or "more," this type of question tends to favor either a conserving or non-conserving response respectively.

Following a suggestion by Hood (1962), Rothenberg presented two consecutive single event questions after each transformation in order to more reliably estimate the subjects' comprehension of each problem. One question asked if the two groups had the "same" amount, the other asked if one had "more." The results of the study with 4- and 5-year-old lower and middle socioeconomic status preschool and kindergarten children indicated that a much greater percentage of children (almost double) would be considered conservers if only one of the two questions were asked than if both were. This is particularly true if a "Yes" response is required to equivalence questions. Lower socioeconomic status children gave significantly more inconsistent non-conserving responses to the two questions ("yes"--"yes") than did middle socioeconomic status children. Such a difference may reflect a deficiency in their basic understanding of the language. The higher frequency of "yes"--"yes" responses among lower socioeconomic status subjects offered a greater chance of responding correctly to one or the other of the questions than for middle socioeconomic status subjects.
An additional finding of the study was that there was a higher percentage of correct responses to questions of "same" on equality items and to "more" on inequality items, suggesting that there is a tendency for young children to "agree" rather than disagree with the experimenter. This was particularly evident for young lower socioeconomic status children with low verbal ability. When the conservation question requires an agreement response, i.e., "Are they the same?"—"Yes," there is a high incidence of "false positives." Splitting the question to require agreement/disagreement will significantly reduce this occurrence and lead to a more accurate assessment. Thus it appears as if a questioning format using more than one question about each transformation is essential for obtaining an accurate picture of each child's conservation status.

Criteria of Conservation

Closely related to this discussion on questioning format is the issue of what should constitute the criteria of a conservation response. The critical question is whether justification of conserving responses is a necessary criteria for defining achievement of conservation.

Gruen (1966), by reanalyzing the data from previous experiments, has shown that when subjects are not required to justify their "same--different" responses to questions of equivalence following transformations, more (and younger)
subjects are judged to be "conservers." Rothenberg (1969) also reports the inflationary effect brought about by not requiring a justification of responses. She, however, goes on to indicate that when explanations are required, many low verbal children (particularly lower socioeconomic status children) tend to be classified inaccurately as non-conservers. Dimitrovsky and Almy (1972) conducted a longitudinal study of the emergence of explanations of conservation responses in comparison with the onset of the ability to make consistent judgments indicative of conservation. Four hundred and thirty-two subjects were tested at the beginning of kindergarten, first, and second grades. Results of the study indicated that kindergarten children who responded correctly to conservation questions were significantly less likely to give adequate explanations than children who began to give correct conservation responses in first and second grade. In their discussion, the authors offer two interesting propositions as explanations. The first is that just as it is possible to have a language associated with a concept without real understanding of the concept, it may also be possible that children can truly understand conservation without having the necessary language to explain it. The second suggestion is that the increased exposure to language, as well as instruction in science and math, which occur in a school setting, may have had an interrelated influence, so that when conservation was achieved
the language necessary for explanations had also been acquired.

The findings of these studies suggest that requiring justifications of conservation judgments as a criteria of conservation may result in an inaccurate assessment of the conservation status of young (ages 4 to 6) and/or low verbal children. However, there is also an inflationary effect which is produced when justifications are not required unless a questioning procedure which eliminates "false positives," such as Rothenberg's (1969) two question agreement/disagreement format, is employed.

Stimulus Material

The third area of task variables that needs consideration is that involving the stimulus materials. Several studies have examined the effect of: 1) the size of the aggregate presented; 2) the nature or significance of the materials used; and 3) the number and nature of transformations made.

Both Zimiles (1966) and Baker and Sullivan (1970) found a small aggregate (up to 5) produced an increase in the occurrence of the conservation response under certain conditions. Zimiles found that when the small aggregate condition was the first presented to the subjects, conservation, even of larger aggregates, was facilitated. However, if this condition was preceded by even a single trial
involving a larger aggregate, the effect of the small aggregate in facilitating conservation was lost. Baker and Sullivan found the effect of size with high interest materials but not with low interest materials.

The probability that the desirability of the stimulus materials used in the conservation task might affect the presence of conservation stimulated several studies. Results of studies by Zimiles (1966), Rothenberg (1969), and Roll (1970) indicated no significant differences in conservation performance as a result of the stimulus materials used. Baker and Sullivan (1970) found an interaction effect with aggregate size. High interest materials produced more conservation responses with small aggregates than did low interest materials. This finding did not hold for large aggregates. Thus the desirability of stimulus materials used in the conservation task does not seem to have any significant effect on conservation performance. However, Zimiles (1966) suggests that the results should not be viewed as conclusive since this variable may not have been thoroughly investigated. He points out that in his own study the "neutral" materials also tended to arouse considerable interest among his subjects.

The effect of the nature and number of transformations made during the conservation testing sessions on the conservation responses has also been investigated. Most
studies have utilized only two types of transformations—expanding and collapsing one of two equivalent matched sets. Other types of transformations are possible, however, which provide a larger sample of situations as well as a means of determining how generalizable the typical transformation situations are. Winer (1968) found that conservation of number transformations in which the length of the line of chips was manipulated were less difficult than conservation tasks in which stacks of chips were compared. Rothenberg (1969) compared children's responses to five linear transformations. The transformations included four items requiring conservation of equality--1) lateral displacement; 2) collapsing; 3) resubgrouping; and 4) equal addition--and one item testing for conservation of inequality--5) unequal addition. The results indicated that only a small percentage of children (approximately 6%) conserved on all 5 transformations. The conservation of inequality item had the greatest percentage of conserving responses. Little difference in difficulty appeared for the other four items with approximately an equal number of conserving responses for each. The results indicated that although any single transformation may be typical of others in terms of the conservers it yields, a particular subject should probably not be considered a conserver of number unless he is able to demonstrate his conservation ability through a variety of different problems (p. 404).
Other studies have revealed that significantly more correct responses occur when the correct row is closest to the subject (Kaufman, 1971) and there is an interaction effect of the degree of active participation in the testing situation with the sex of the subject (Fogelman, 1970). Males were shown to perform significantly better than females in conservation tasks in which they were actively involved in making the transformations; females were shown to be superior on tasks in which they were passive observers.

**Procedural Variables**

The third area of methodological considerations to which attention must be given is that involving a variety of procedural questions. These questions, which are primarily concerned with intervention instructional conditions, center about: 1) the number of instructional sessions which are necessary to produce conservation acquisition; 2) the timing of instruction in terms of the child's developmental status; 3) individual versus group training; 4) the effects of the child's active involvement in the instructional sessions; 5) the effect of immediate versus delayed posttesting; 6) the effect of different experimenters (experimenter variables) on performance; and 7) the question of which instructional strategy should be used for most effective results.
Wide variation exists in the number of instructional sessions (1-26) which have been provided under each of the conservation training approaches (see Table 1) with both successes and failures reported at each end of the continuum. Due to the limitations of post hoc comparisons it is impossible to determine an effectiveness-efficiency relationship in the existing studies. The problem is complicated by the fact that different populations have been used with the probability that intervention has occurred at various points along the developmental continuum. Studies which have been effective after one session may have begun at a point much closer to criterion than studies which have been unsuccessful after 8 or more sessions.

Since the effectiveness-efficiency stage-appropriateness relationship has not been empirically explored, decisions regarding the number of instructional sessions to include in intervention attempts or the stage at which intervention should begin must be arbitrary at this time.

The majority of the conservation of number training studies have employed individualized instruction rather than group experiences (see Table 1). Yet Piagetian theory stresses the importance of social interaction as a mechanism to stimulate intellectual growth. Since no direct comparisons have been made of the effectiveness of selected activities under each of these instructional conditions,
there is no way to accurately evaluate either approach. The decision to utilize one or the other of these conditions for training must be based on factors such as time, expense, or whether the outcomes and implications of the study are to be used for theoretical or practical applications.

The effects of the child's active involvement in the instructional sessions have been studied by Sweetland, Sharp, and Willis (1971). One hundred and four white middle class 5- to 8-year-old nonconserving children participated in training sessions in which they either 1) actually manipulated concrete materials and performed transformations or 2) were directed to "imagine" the materials and the transformations. Results of the study indicated that both groups made significant gains in conservation with no significant differences between instructional methods. The findings of this study contradict Piaget's declarations regarding the importance of physical activities with concrete materials. Since there have been no other efforts to examine this phenomenon, the results must be viewed as tentative rather than conclusive.

A study by Sullivan (1969) investigated the effects of immediate versus delayed posttesting on the conservation responses of 42 middle class first grade children who experienced training sessions consisting of film presentation of conservation responses (modeling). Although the training was effective, there were no significant differences
between the group who was posttested one day after training and the group that was posttested seven days later.

A study of the effects of experimenter characteristics on children’s performance on conservation tasks was conducted by Bittner and Shinedling (1968). The results of the study indicated that younger children (6 years and under) were more successful with female experimenters, whereas older children (8 years and up) were more successful with males.

Efforts to determine the factors which are related to teacher effectiveness and student achievement have been extensive (see reviews in Gage, 1963; Flanders and Simon, 1970; Flanders, 1970; and Rosenshine, 1971). Early research, which attempted to identify predictor criteria from variables such as personality, education, background, and intelligence, to name just a few, was unproductive. More substantive results have been gleaned from the more recent studies (since 1952) which focused on teacher behaviors during instruction (Flanders, 1970). The importance of instruction as a crucial variable in producing student achievement has been confirmed. Yet despite the fact that this important variable has been identified, and can be measured through objective systems of instructional analysis (Flanders, 1970; Hough and Duncan, 1970), it continues to be ignored in most of the curriculum related research (Flanders, 1970; Rosenshine, 1971).
In the training studies for conservation of number, there have been no attempts to explore the relative effectiveness of various instructional strategies in stimulating conservation acquisition nor even to control for instruction through an objective observational system. The possibility exists that differences in the effectiveness of similar curricular concepts and activities could be the result of different instructional techniques, or that even differences in the effectiveness of different approaches could be confounded by the nature of instructional behaviors employed.

There are a number of possible instructional strategies that may be employed to facilitate learning. Four basic strategies which have been identified by Hough and Duncan (1970) are: 1) the interactive strategy; 2) the direct communication strategy; 3) the independent strategy; and 4) the group activity strategy. The interactive strategy is defined as a mode of instruction in which there is reciprocal communication. It involves the key behaviors of 1) solicitation of information, 2) requests for clarification, and 3) response. The direct communication strategy is one in which the dominant behavior is the initiation of information by one person. The independent strategy is characterized by silent overt or covert activity on the part of the student(s), whereas in the group activity strategy the emphasis is on multi-directional communication or students-to-students interactions.
Although there is no definitive evidence which indicates that one of these strategies is more effective than another in producing student achievement, there are empirical findings which indicate that certain specific teacher behaviors have strong positive correlations with this criterion. Flanders and Simon (1970) report that a teaching strategy in which the teacher makes use of the students' ideas and opinions tends to be significantly more effective than those which do not. Rosenshine (1971) describes the findings as more tentative and therefore not to be viewed as prescriptions; he does suggest, however, that this is a behavior in need of further investigation.

Therefore, although the information is not conclusive since there is no specifically related empirical data available, it would appear that when providing training for conservation, an instructional strategy which makes use of the child's thoughts and ideas (such as the interactive strategy does) would be the best means of achieving maximum results.

Further support for this position can be drawn from Piagetian theory (and methodology). Piaget states that social interaction or the sharing and confrontation of ideas is a major mechanism of cognitive growth. In addition, in his research he employs a clinical method of exploring through questioning the unique thoughts and ideas expressed
by children in order to better understand their development as well as to stimulate cognitive conflict and consequently cognitive development. This questioning procedure makes use of the children's ideas while at the same time establishing a means of interacting.

**Summary and Conclusions**

From both a theoretical and practical standpoint the conservation problem is very complex. Several theoretical explanations have been shown to account for the attainment of conservation and a number of specific factors have been identified that appear to mediate cognitive transitions. Yet there is no definite evidence which indicates the superiority of one position or set of factors over the others. Practically speaking, although considerable evidence exists which establishes the fact that the acquisition of conservation can be accelerated through a variety of training procedures, the effectiveness of the training is dependent upon a host of methodological considerations (demographic, task, and procedural variables) which have been shown to have influential effects on conservation behavior.
CHAPTER III

PROCEDURES AND STATISTICAL MODEL

As the preceding review of the literature has indicated, a number of training approaches as well as a variety of subject, task, and procedural variables have been investigated in terms of their influential effects on conservation acquisition. This chapter describes the specific procedures used in the present investigation together with the statistical model and procedures used for data analysis.

Population and Sample

The population of this study consisted of all lower socioeconomic status nonconserving children between the ages of 4;0 and 5;11. The 194 participants were drawn from an "available population" of 250 children enrolled in two Head Start programs, eight Title I pre-kindergarten classes, and five social welfare supported preschools and day care centers in Franklin County, Ohio. The sample was comprised of 94 males and 100 females, of which 125 were four-year-olds and 69 were five-year-olds. Racially, the sample included 164 blacks, 29 whites, and 1 oriental. Excluded from the study were 20 children who had participated in the
pilot study, 2 children who were classified as conservers on the pretest, 3 children who refused to take the pretest, 30 children who were absent during the week of pretesting, and 1 child for whom it was impossible to obtain parental permission.

Design

The basic design of this study can be described as a multi-factor treatment-by-levels mixed design with one manipulated and two assigned blocking variables, multiple subjects in each cell, and repeated measures. Based on their pretest performance, subjects were classified into three levels of substage development with respect to conservation of number, and within these levels according to sex. They were then randomly assigned, within blocks, to levels of the treatment conditions. There were three treatment conditions using a pretest-intermediate test-posttest model:

1. Experimental group I (EI): Conservation Approach;
2. Experimental group II (EII): Set Theory Approach;
3. Experimental group III (EIII): Control group I (CI).

In addition to the three main treatment conditions, a fourth group was included in order to assess the effects of repeated testing on the child's performance scores and stage classifications. The fourth group, Experimental group IV (EIV):
Control group II (CII), received only the pretest and posttest with no intermediate testing.

The dependent variables of this investigation were: 1) the acquisition of conservation of number as determined by the number of children exhibiting the conservation response, and 2) the acquisition of conservation related skills as shown by significant differences in the performance scores and stage classifications of 4- and 5-year-old lower socioeconomic status children. The independent variables were: 1) the experimental conditions, 2) the subjects' developmental status, 3) the sex of the subjects, and 4) the number of instructional sessions. All other variables were controlled by means of selection, randomization, tests for homogeneity of variance, order, and consistency.

Testing Procedures

The Instrument

The 4-item conservation of number pretest-posttest, (see Appendix A) which was individually administered to each subject in order to determine his developmental status with respect to conservation of number, was a modified version of the standard Piagetian experimental paradigm. Items 1 and 2 assessed the child's ability to establish equivalent sets, while items 3 and 4 evaluated the extent to which the child was able to maintain this equivalence following
perceptual transformations. In assessing the child's ability to establish equivalent sets (item 1: 6 objects; item 2: 8 objects) three aspects of the child's performance were examined:

1) a behavioral response in which the child was asked to form a set that was equivalent to one formed by the tester (part 1 of items 1 and 2);

2) an agreement-disagreement response in which the child was asked to indicate whether the two sets had the same number of objects (part 2 of items 1 and 2) and whether one set had more objects (part 4 of items 1 and 2); and

3) a response rationale or explanatory aspect in which the child was asked to explain why he responded as he did to each of the two questions regarding equivalence (parts 3 and 5 of items 1 and 2).

Items 3 and 4 (6 objects each), which assessed the child's ability to maintain equivalence following perceptual transformations (expansion and contraction, respectively), did not involve a behavioral response on the part of the child but did include the other two aspects of performance. Following transformations the child was asked whether the two sets had the same number of objects (part 1 of items 3 and 4) and whether one set had more objects (part 3 of
items 3 and 4). As before the child was asked to explain why he responded as he did to the two questions regarding equivalence (parts 2 and 4 of items 3 and 4).

**Scoring**

The standard Piagetian experimental paradigm requires that an adequate response rationale or explanation be a major criterion in assessing conservation status. This criterion was not used in this study because the subjects were lower socioeconomic status children whom earlier research has shown to exhibit language differences and/or deficiencies when compared with middle class norms (Bernstein, 1960, 1967; Hess and Shipman, 1965). Rothenberg (1969) has pointed out that when young lower socioeconomic status children are required to give justifications for their responses in conservation tasks these children tend to be under assessed. However, there is also the possibility of over assessment when justification is not a criteria of conservation (as in this study). The typical conservation question calls for a "yes" response and research (Rothenberg, 1969) has shown that when a young lower socioeconomic status child is unsure of an answer he will tend to agree rather than disagree with the tester. Thus, to fairly assess the young lower socioeconomic status child's understanding of "same" number without requiring a response rationale and at the same time to decrease the incidence of
"false positives" to single event questions, the two ques­
tions agreement-disagreement format (suggested by Rothen­
berg, 1969)—"Are there the same number or amount in each 
row?" and "Does one row have more?"—was used in this study.

Subjects were classified as to their developmental 
status utilizing the following scoring criteria:

**Substage I (Stage Classification Category 1):** 
**Performance Score 0-1**

0--The child was unable to form an equivalent set 
on either item 1 or 2 (part 1).

1--The child was able to form an equivalent set on 
one of the two items (part 1) but was unable to 
establish their equivalence (parts 2 and 4).

**Transition I (Stage Classification Category 2):** 
**Performance Score 2-3**

2--The child was able to form an equivalent set 
on both items 1 and 2 (part 1) but was unable 
to establish the equivalence of either (parts 2 
and 4 of items 1 and 2).

3--The child was able to form an equivalent set on 
one of the items (part 1 of either item 1 or 2) 
and was able to establish its equivalence on 
parts 2 and 4 of that same item.

**Substage II (Stage Classification Category 3):** 
**Performance Score 4-5**

4--The child was able to form an equivalent set on 
both items 1 and 2 (part 1) and was able to
establish the equivalence of one of these (parts 2 and 4 of either item).

5—The child was able to form an equivalent set on both items 1 and 2 (part 1) and was able to establish the equivalence of both of these sets (parts 2 and 4 of both items 1 and 2).

**Transition II (Stage Classification Category 4): Performance Score 6**

6—The child was able to maintain the equivalence of one but not both of the sets following perceptual transformations (parts 1 and 3 of either items 3 or 4).

**Substage III (Stage Classification Category 5): Performance Score 7**

7—The child was able to maintain the equivalence of both sets following perceptual transformations (parts 1 and 3 of both items 3 and 4).

Although the child's explanations of his agreement-disagreement responses were not used as criteria in judging conservation status, his response rationales (parts 3 and 5 of items 1 and 2, and parts 2 and 4 of items 3 and 4) were recorded and evaluated as to their adequacy or inadequacy based on the following criteria:

**Adequate Verbal Responses**

1. Reversibility—i.e., "You can put it back and it will be the same.";
2. Identity/Addition-Subtraction—i.e., "It is the same as before." (substantive identity) or "Nothing has been added or taken away." (operational identity);

3. Compensation—i.e., "One row is longer but it has bigger spaces."

4. Numerical—i.e., "There are x in this row and x in this row. They both have x."

5. Matching or one-to-one correspondence—i.e., "You can match them and there is one for each one."; and

6. Combination of the above.

Inadequate Verbal Responses

1. Limited verbal—i.e., "Cause"; "Don't know"

2. Unrelated—i.e., "Magic"; "Mother said"

3. Other—incoherent; no response.

While not part of the main analysis, changes from inadequate to adequate responses that occurred from pre- to intermediate and pre- to posttests under each treatment condition were analyzed.

Testing Sessions

Pretesting of all subjects took place within a one week period. Each subject was individually tested in a single session lasting 8-10 minutes. Prior to administration of the pretest, there was an introductory session in
which the testers met with the whole group of children to be tested. Following a brief explanation of what was to occur, the children were asked "Who would like to be first?" The first child to be tested was randomly selected from the "volunteers" and the remaining children were tested in a random order. All testing took place in an area separate from each child's classroom.

In order to establish rapport, each individual testing session began with a few minutes of informal conversation between the tester and the subject. The materials (12 red and 12 black checkers) to be used in the conservation of number tasks were shown to the child during this time.

During the testing sessions, subjects received no information regarding the correctness or incorrectness of their answers. In addition to maintaining a neutral position and refraining from giving any external reinforcement, the testers did not undertake any evaluation or scoring. Each child's responses were recorded on a standardized answer sheet (Appendix B).

Since the intermediate test and the posttest were identical to the pretest, the same procedures were employed during each administration of the test. The intermediate test was administered during a four day period midway through the series of instructional sessions. The posttest
was given during the week following the last instructional session.

Testers

Twenty junior and senior white female undergraduate elementary education majors at The Ohio State University served as testers. All were registered in professional education courses and received training prior to the first testing session.

Assignment Procedures

Assignment of Subjects to Treatment Conditions

The pretest was administered to 196 children of whom 95 were males and 101 were females. As a result of the pretest administration, 194 children were identified as eligible for inclusion in the study. The remaining 2 children (1 male and 1 female) were excluded from the study because they were already conservers. The pretest performance score-developmental status-sex distribution is presented in Table 3.
TABLE 3

Pretest Performance Score-Developmental Status-Sex Distribution

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<td>95</td>
<td>101</td>
<td>196</td>
</tr>
</tbody>
</table>

The identification of 194 eligible children allowed for the assignment of 48 children to each of the four treatment conditions. The remaining two children were assigned to EIV as "extras" to be used as substitutes in cases of attrition of original subjects. Because of the skewness of the pretest data, 33 of each group of 48 subjects were at substage I, 10 at transition I, and 5 at substage II. An approximately equal number of males and females were placed at each level. The data matrix for this design is illustrated in Table 4.
TABLE 4
Data Matrix for Three Between Groups-One Within Subjects Design

<table>
<thead>
<tr>
<th>Experimental Groups</th>
<th>Substages</th>
<th>Subjects</th>
<th>Sex</th>
<th>#</th>
<th>Intermediate Test</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Observation</td>
<td>Observation</td>
</tr>
<tr>
<td>I</td>
<td></td>
<td>M 17</td>
<td>F 16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EI</td>
<td>TI</td>
<td>M 5</td>
<td>F 5</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>M 2</td>
<td>F 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td>M 15</td>
<td>F 18</td>
<td></td>
<td></td>
<td>Observation</td>
</tr>
<tr>
<td>EII</td>
<td>TI</td>
<td>M 5</td>
<td>F 5</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>M 2</td>
<td>F 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td>M 17</td>
<td>F 16</td>
<td></td>
<td></td>
<td>Observation</td>
</tr>
<tr>
<td>EIII</td>
<td>TI</td>
<td>M 5</td>
<td>F 5</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>M 2</td>
<td>F 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td>M 19</td>
<td>F 14+2*</td>
<td></td>
<td></td>
<td>Observation</td>
</tr>
<tr>
<td>EIV</td>
<td>TI</td>
<td>M 4</td>
<td>F 6</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>M 1</td>
<td>F 4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*extras
Assignment of Subjects to Instructional Groups

For instructional purposes subjects in treatment conditions EI and EII were divided into instructional groups with an n of 4, thus resulting in a total of 24 instructional groups--12 for EI and 12 for EII. Because instruction had to take place within each participating center and involved "groups" of children rather than individuals, a totally random independent assignment of children to experimental conditions was impossible. Therefore, from a randomly ordered list of subjects in each center, who had been classified according to their sex and developmental status with respect to conservation of number, subjects were assigned in groups of 4 to an instructional group-experimental condition until all EI and EII cells were filled. The remaining children were randomly assigned, according to stage-sex classification, to either EIII or EIV.

Assignment of Instructors to Experimental Conditions and Instructional Groups

Nine instructors were randomly assigned to one of the two experimental conditions. Depending upon the instructor's schedule and/or the number of instructional groups available at the center or centers to which he was also randomly assigned, each instructor was asked to teach either 2, 3, or 4 groups of children. The resulting condition-instructor-group distribution is illustrated in Table 5.
TABLE 5

Condition--Instructor--Group Distribution: 
The Number of Instructors Employing Given 
Experimental Conditions With 
Given Numbers of Groups

<table>
<thead>
<tr>
<th>Experimental Conditions</th>
<th>Number of Groups Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>EI: Instructors</td>
<td>4</td>
</tr>
<tr>
<td>EII: Instructors</td>
<td>1</td>
</tr>
</tbody>
</table>

Each instructor administered identical treatments to each of his groups of subjects. The order in which each instructor met his groups was systematically rotated, however, in order to eliminate possible treatment order bias.

Instructional Procedures

Instructional Sessions

Each subject in treatment groups EI: Conservation Approach and EII: Set Theory Approach participated in twelve 10-15 minute group sessions. Only one lesson was taught per instructional session. Instructional sessions followed a Monday, Wednesday, Friday pattern of occurrence over a five week period extending from January 30 to March 4, 1974. The time at which instruction took place was relatively constant for each instructor-instructional group combination but varied from instructor to instructor.
All instruction took place in an area separate from the regular classroom. The same instructor met with the same group of children for all lessons. Each lesson began with a few minutes of informal conversation in order to establish rapport. The lessons themselves, as well as the general instructional procedures, were standardized or systematized within each experimental condition. Both conditions utilized an interactive instructional strategy and both involved the children as active participants and manipulators of objects. All instructional sessions were tape recorded.

Instructional Activities

There were 12 lessons for each of the two experimental approaches. The nature of each activity (1-12) in EI was similar to each corresponding activity (1-12) in EII. The difference between the two approaches lay in the emphasis placed on the invariant or variant aspects of number in accordance with the following objectives:

Conservation Approach (EI)

1. to develop an understanding of one-to-one correspondence and how this can be used to determine whether two sets are equivalent (or whether one set has "more" or "less" than another);

2. to develop an understanding that changing the arrangement of the objects in the set does not change the number of elements in the set.
**Set Theory Approach (EII)**

1. to develop an understanding of one-to-one correspondence and how this can be used to determine whether two sets are equivalent (or whether one set has "more" or "less" than another);
2. to develop an understanding that adding to or subtracting an element from a set changes the number of elements in the set.

The specific skills and concepts which were emphasized in order to meet the objectives included:

1. matching or one-to-one provoked correspondence with two homogeneously different but related sets;
2. matching or one-to-one spontaneous correspondence of homogeneous sets;
3. provoked discrimination of "same," "more," and "less";
4. cognitive conflict: addition/subtraction versus invariance; and social interaction-confrontation;
5. verbal training and verbal rule instruction; and
6. reinforcement through information feedback.

A detailed description of the activities and the materials used is presented in Appendix C.

**Instructors**

Nine junior and senior white female undergraduate elementary education majors at The Ohio State University
served as instructors. All were registered in professional education courses and participated in a series of training sessions prior to implementing instruction.

Pilot Study—Description and Procedures

Purposes

Prior to the major study, a pilot study was conducted for the following purposes:

1. to test the Conservation of Number Pretest-Posttest instrument and answer sheet in terms of clarity of directions, ease of administration, recording of responses, and scoring, as well as to identify any areas of difficulty;

2. to give the testers experience in administering the Conservation of Number Pretest-Posttest to 4- and 5-year-old lower socioeconomic status children;

3. to test the instructional activities in terms of clarity of directions, ease of administration, general format, interest to the children, and wording, as well as to identify any other areas of difficulty;

4. to give the instructors practice in using the activities, implementing the interactive strategy, using tape recorders to record the instructional sessions, and working with 4- and 5-year-old lower socioeconomic status children; and
5. to assess (via the tape recordings) each instructor's ability to initiate and use the interactive strategy and planned curricular activities, as well as to assess each instructor's interest, enthusiasm, and general approach and attitude while working with 4- and 5-year-old lower socioeconomic status children.

Recruitment and Training of Testers and Instructors

Each of the twenty testers and nine instructors was a white female junior or senior undergraduate elementary education major at The Ohio State University. All were registered in professional education courses. Testers and instructors were selected as participants first through an interview and then reevaluated following training. No participants were excluded as a result of the reevaluation.

Training sessions for testers and instructors were separate but both involved demonstrations, discussions, and opportunities to work with 4- and 5-year-old lower socioeconomic status children. A general description of each of the training sessions is as follows:

Testers

Session 1: orientation to the project--purposes, procedures, and requirements; examination and discussion of the testing instrument and answer sheet; demonstration
of testing procedures and recording
of responses.

Session 2: testers administered the test to three
lower socioeconomic status preschool
children.

Session 3: discussion of the testing session--
identification of problems, suggestions,
and clarifications.

Instructors

Session 1: orientation to the project--purposes,
procedures, and requirements; examina-
tion and discussion of the curricular
activities; discussion of the interactive
strategy; demonstration of the inter-
active strategy and implementation of
the curricular activities; discussion
of taping procedures.

Session 2: each instructor taught one lesson to
a group of 4 lower socioeconomic status
preschool children.

Session 3: discussion of the instructional ses-
tions--identification of problems,
suggestions, and clarifications; lis-
tened to the tapes--feedback given.
Session 4: each instructor taught a second lesson to the same 4 children.

Session 5: discussion as in session 3; model tape played and discussed.

Session 6: each instructor taught a third lesson to the same 4 children.

Session 7: separate individual discussion and feedback session with each instructor.

Additional training was informally provided periodically throughout the major study when instructional activities and materials were given to the instructors. During each contact, problems, if any, were discussed and suggestions and feedback were given.

Results of the Pilot Study

No major changes were made in the design and procedures, activities, or testing instrument as a result of the pilot study. Minor alterations were made, however, in wording and instructional directions.

Statistical Model and Procedures

Major Hypotheses

The main analysis concerned the effectiveness and efficiency of two types of instructional experiences in facilitating the acquisition of 1) conservation of number or 2) conservation related skills by nonconserving 4- and
5-year-old lower socioeconomic status children and the
differential effectiveness and efficiency of treatment con­
ditions with children classified according to their develop­
mental status and/or sex.

The effectiveness and efficiency of training condi­
tions in facilitating the acquisition of conservation of
number was determined through an analysis of the number of
children in each condition exhibiting the conservation
response on the intermediate test and on the posttest.
Analysis of variance was used to determine if significant
differences (α ≤ .05) existed on the intermediate test
and/or posttest in the performance scores and stage class­
ifications of children under each treatment condition, thus
indicating the effectiveness and efficiency of instruction
in facilitating the acquisition of conservation related
skills.

Stated in the null, the major hypotheses that were
tested (α ≤ .05) are:

1. There are no significant differences in the
 acquisition of
    a. conservation of number; and/or
    b. conservation related skills

 by 4- and 5-year-old lower socioeconomic status
 children on the conservation of number inter­
 mediate test and/or posttest as a result of
treatment conditions.
2. There are no significant differences in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills
   by 4- and 5-year-old lower socioeconomic status children on the conservation of number intermediate test and/or posttest as a function of their stage of development in interaction with treatment conditions.

3. There are no significant differences in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills
   by 4- and 5-year-old lower socioeconomic status children on the conservation of number intermediate test and/or posttest as a result of the sex of the subjects in interaction with treatment conditions.

4. There are no significant differences in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills
   by 4- and 5-year-old lower socioeconomic status children on the conservation of number intermediate test and/or posttest as a function of their stage of development and sex in interaction with treatment conditions.
Related Questions—Additional Analysis

In addition to the main analysis, a number of other related questions were also investigated and analyzed.

Age

Although two age levels were included in the study (4-year-olds and 5-year-olds), age was not used as a blocking variable. Therefore, an analysis of variance was run to determine if there was a differential effectiveness ($\alpha \leq .05$), in terms of performance scores and stage classifications, on the intermediate and/or posttest, for each age level under each treatment condition and in interaction with treatment conditions and stages of development. It was not possible to also include the variable sex in this analysis due to the existence of empty cells.

Instructional Strategy

In order to insure that instruction was a constant in the study, an analysis of variance was run to determine if any significant differences ($\alpha \leq .05$) existed in the degree to which individual instructors employed the interactive strategy. Also the Fisher's t test for significant differences ($\alpha \leq .05$) between means was used to determine if the mean interactive strategy index of the conservation group (all instructors combined) was significantly different
from the mean interactive strategy index for the set theory group (all instructors combined).

Instructor Effectiveness

Analysis of variance was also used to determine if significant differences ($\alpha \leq .05$) existed in the effectiveness of each instructor in stimulating increases in performance scores and stage classifications on either the intermediate test or posttest.

Language

Although the child's response rationales on the conservation of number test were not used as classification criteria, they were recorded according to their adequacy or inadequacy and the number of changes from inadequate to adequate responses on both the intermediate and posttest as a function of treatment conditions was tested for significance ($\alpha \leq .05$) using a Chi Square analysis.

Repeated Testing

The overall effects of repeated testing (i.e., the intermediate test) as well as the interactive effects of repeated testing, stages of development, and/or sex were also assessed through analysis of variance ($\alpha \leq .05$).
CHAPTER IV

ANALYSIS AND INTERPRETATION OF THE DATA
AND DISCUSSION OF THE RESULTS

The findings of the study are analyzed, interpreted, and discussed in this chapter. The major hypotheses are considered first and then attention is given to the related questions. Finally, the overall results of the study are summarized and assessed in relation to the questions posed and purposes stated in Chapter I.

The Final Sample

Due to the loss of some subjects through absences and moving, complete data were collected and analyzed for 151 of the original 194 subjects (Appendix D). The final sample was composed of 74 males and 77 females of whom 95 were four-year-olds and 56 were five-year-olds. Table 6 presents the numerical breakdown of subjects for each treatment condition (EI: Conservation; EII: Set Theory; EIII: Control I—intermediate testing; and EIV: Control II—no treatment), stage of development (I: "Global Comparisons"; TI: Transition period I; and II: "Intuitive Thought"), and sex category.
**TABLE 6**

Data Distribution for Treatment Conditions, Stages of Development, and Sex

<table>
<thead>
<tr>
<th>Stages</th>
<th>Sex</th>
<th>EI</th>
<th>EII</th>
<th>EIII</th>
<th>EIV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>11</td>
<td>14</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>TI</td>
<td>M</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>M</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>35</td>
<td>37</td>
<td>37</td>
<td>42</td>
</tr>
<tr>
<td>Grand Total</td>
<td>151</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The data collected on the 109 subjects in treatment conditions EI, EII, and EIII (Table 6) were used in testing the main hypotheses as well as the related questions concerning instructional strategy, instructor effectiveness, language, and sex. Treatment condition EIV was used as a control in comparison with treatment condition EIII in order to test the related question as to the effects of repeated testing on subjects.

Table 7 presents the numerical breakdown of subjects for each treatment condition, stage of development, and age categories.
Table 7

Data Distribution for Treatment Conditions, Stages of Development, and Age

<table>
<thead>
<tr>
<th>Stages</th>
<th>Age</th>
<th>EI</th>
<th>EII</th>
<th>EIII</th>
<th>EIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>4</td>
<td>16</td>
<td>20</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>II</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>37</td>
<td>37</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>151</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The numerical breakdown presented in Table 7 was used to test the related question concerning the possible effects of age in interaction with treatment conditions and stages of development as functions of repeated measures. No information is presented for the finer breakdown of treatment conditions, stages of development, sex, and age since it could not be used in analysis due to the existence of empty cells.

Analysis and Interpretation of the Data

The Major Hypotheses

The major hypotheses of the study were concerned with the effectiveness and efficiency of treatment conditions in facilitating the acquisition of 1) conservation...
of number or 2) conservation related skills by 4- and 5-year-old lower socioeconomic status children, and the interactive effects with stages of development and/or sex. The results of the study related to the acquisition of conservation of number are presented and discussed first. Following this, attention is given to the results of the analyses associated with the acquisition of conservation related skills.

The effectiveness and efficiency of treatment conditions in facilitating the acquisition of conservation of number was to be tested through a Chi Square analysis of the number of children in each condition who exhibited that response. This analysis could not be done, however, due to the existence of empty cells; nor was it warranted because of the low observed frequencies of acquisition (3/109). Tables 8 through 11 present, respectively, the number of children achieving conservation of number on the intermediate test and posttest as a result of 1) treatment conditions; 2) treatment conditions and stages of development; 3) treatment conditions and sex; and 4) treatment conditions, stages of development, and sex.
TABLE 8

Conservers and Nonconservers on the Intermediate and Posttest as a Result of Treatment Conditions

<table>
<thead>
<tr>
<th>Treatment Conditions</th>
<th>Intermediate Test</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conservers</td>
<td>Nonconservers</td>
</tr>
<tr>
<td>EI</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>EII</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td>EIII</td>
<td>1</td>
<td>36</td>
</tr>
</tbody>
</table>

TABLE 9

Conservers and Nonconservers on the Intermediate and Posttest as a Function of Stages of Development and Treatment Conditions

<table>
<thead>
<tr>
<th>Treatment Conditions</th>
<th>Intermediate Test</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conservers</td>
<td>Nonconservers</td>
</tr>
<tr>
<td>Stages</td>
<td>I</td>
<td>TI</td>
</tr>
<tr>
<td>EI</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>EII</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>EIII</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
### TABLE 10

Conservers and Nonconservers on the Intermediate and Posttest as a Function of Sex and Treatment Conditions

<table>
<thead>
<tr>
<th>Treatment Conditions</th>
<th>Intermediate Test</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conservers</td>
<td>Nonconservers</td>
</tr>
<tr>
<td></td>
<td>Sex  M  F</td>
<td>M  F</td>
</tr>
<tr>
<td>EI</td>
<td>0  0</td>
<td>19  16</td>
</tr>
<tr>
<td>EII</td>
<td>0  0</td>
<td>18  19</td>
</tr>
<tr>
<td>EIII</td>
<td>1  0</td>
<td>17  20</td>
</tr>
</tbody>
</table>
TABLE 11

Conservers and Nonconservers on the Intermediate and Posttest as a Function of Stages of Development, Sex, and Treatment Conditions

<table>
<thead>
<tr>
<th>Treatment Conditions</th>
<th>Stages</th>
<th>Sex</th>
<th>Intermediate Test</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>M</td>
<td>0</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>M</td>
<td>0</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>EII</td>
<td>I</td>
<td>M</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TI</td>
<td>M</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>M</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>EIII</td>
<td>I</td>
<td>M</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TI</td>
<td>M</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>M</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
The findings of the study regarding the effectiveness and efficiency of treatment conditions in facilitating the acquisition of conservation of number were insufficient to warrant rejection ($\alpha \leq .05$) of the omnibus null hypotheses:

There are no significant differences in the acquisition of conservation of number by 4- and 5-year-old lower socioeconomic status children on either the intermediate test or posttest as a result of

H1-a--treatment conditions;
H2-a--the interaction of treatment conditions and stages of development;
H3-a--the interaction of treatment conditions and sex; and
H4-a--the interaction of treatment conditions, stages of development, and sex.

After 12 instructional sessions, neither the Conservation Approach nor the Set Theory Approach was effective in facilitating the acquisition of conservation of number by 4- and 5-year-old lower socioeconomic status children as a group. Also, there was no differential effectiveness shown by either approach with children at different stages of development. In addition, although it was not possible to show significant differential effectiveness with each sex, it is interesting to note that of the three
children who did achieve conservation status, all were males.

Significant differences ($\alpha = .05$) in a) performance scores and b) stage classifications on the intermediate test and/or posttest were used to determine the effectiveness and efficiency of treatment conditions in facilitating the acquisition of conservation related skills. A three between groups-one within subjects analysis of variance was run on each of these dependent variables in order to assess the effects of treatment conditions as well as the interactive effects of treatment conditions, stages of development, and/or sex as functions of repeated measures. The results of the analysis of stage classifications would be expected to parallel the results of the analysis on performance scores because each of the stage classifications was determined by collapsing over two levels of the performance score categories.

Due to the existence of unequal n's together with the fact that instructional groups were not nested within the blocking variables, the method of unweighted mean analysis of individual scores was employed. This method results in a very conservative estimation of the F statistic (Kennedy, 1974). Tables 12 and 13 summarize and present, respectively, the results of this analysis for the two dependent variables, performance scores and stage classifications.
TABLE 12

A Three Between Groups-One Within Subjects Analysis of Variance of the Effects of Treatment Conditions, Stages of Development, and/or Sex on Performance Scores as Functions of Repeated Measures Using the Method of Unweighted Means

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Ss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment (T)</td>
<td>2</td>
<td>5.5214</td>
<td>2.7607</td>
<td>0.6209</td>
<td>0.5397***</td>
</tr>
<tr>
<td>Stages (St)</td>
<td>2</td>
<td>137.5357</td>
<td>68.7679</td>
<td>15.4658</td>
<td>0.0000</td>
</tr>
<tr>
<td>Sex (S)</td>
<td>1</td>
<td>15.0494</td>
<td>15.0494</td>
<td>3.3846</td>
<td>0.0691</td>
</tr>
<tr>
<td>T x St</td>
<td>4</td>
<td>37.4919</td>
<td>9.3728</td>
<td>2.1097</td>
<td>0.0862</td>
</tr>
<tr>
<td>T x S</td>
<td>2</td>
<td>6.7913</td>
<td>3.3956</td>
<td>0.7637</td>
<td>0.4689</td>
</tr>
<tr>
<td>St x S</td>
<td>2</td>
<td>2.6412</td>
<td>1.3206</td>
<td>0.2970</td>
<td>0.7438</td>
</tr>
<tr>
<td>T x St x S</td>
<td>4</td>
<td>20.6996</td>
<td>5.1749</td>
<td>1.1638</td>
<td>0.3321</td>
</tr>
<tr>
<td>Subjects/TStS</td>
<td>91</td>
<td>404.6272</td>
<td>4.4465</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Ss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeated Measures (R)</td>
<td>1</td>
<td>0.4461</td>
<td>0.4461</td>
<td>0.4064</td>
<td>0.5254</td>
</tr>
<tr>
<td>T x R</td>
<td>2</td>
<td>9.4094</td>
<td>4.7047</td>
<td>4.1024</td>
<td>0.0197**</td>
</tr>
<tr>
<td>St x R</td>
<td>2</td>
<td>2.6578</td>
<td>1.3289</td>
<td>1.1587</td>
<td>0.3185</td>
</tr>
<tr>
<td>S x R</td>
<td>1</td>
<td>0.0005</td>
<td>0.0005</td>
<td>0.0004</td>
<td>0.9837</td>
</tr>
<tr>
<td>T x St x R</td>
<td>4</td>
<td>1.1673</td>
<td>0.2918</td>
<td>0.2545</td>
<td>0.9063</td>
</tr>
<tr>
<td>T x S x R</td>
<td>2</td>
<td>2.8944</td>
<td>1.4472</td>
<td>1.2619</td>
<td>0.2880</td>
</tr>
<tr>
<td>St x S x R</td>
<td>2</td>
<td>2.2707</td>
<td>1.1354</td>
<td>0.9900</td>
<td>0.3755</td>
</tr>
<tr>
<td>T x St x S x R</td>
<td>4</td>
<td>1.1380</td>
<td>0.3449</td>
<td>0.3007</td>
<td>0.8768</td>
</tr>
<tr>
<td>Subjects x R/TStS</td>
<td>91</td>
<td>104.3618</td>
<td>1.1468</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** p < .0001
**  p < .02
*   p < .05
TABLE 13

A Three Between Groups-One Within Subjects Analysis of Variance of the Effects of Treatment Conditions, Stages of Development, and/or Sex on Stage Classifications as Functions of Repeated Measures Using the Method of Unweighted Means

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Ss</td>
<td>108</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment (T)</td>
<td>2</td>
<td>0.4204</td>
<td>0.2102</td>
<td>0.2146</td>
<td>0.8072</td>
</tr>
<tr>
<td>Stages (St)</td>
<td>2</td>
<td>32.5938</td>
<td>16.2969</td>
<td>16.6398</td>
<td>0.0000***</td>
</tr>
<tr>
<td>Sex (S)</td>
<td>1</td>
<td>5.6934</td>
<td>5.6934</td>
<td>5.8132</td>
<td>0.0179**</td>
</tr>
<tr>
<td>T x St</td>
<td>4</td>
<td>14.3708</td>
<td>3.5927</td>
<td>3.6683</td>
<td>0.0081***</td>
</tr>
<tr>
<td>T x S</td>
<td>2</td>
<td>2.6156</td>
<td>1.3078</td>
<td>1.3353</td>
<td>0.2682</td>
</tr>
<tr>
<td>St x S</td>
<td>2</td>
<td>1.6247</td>
<td>0.8123</td>
<td>0.8293</td>
<td>0.4396</td>
</tr>
<tr>
<td>T x St x S</td>
<td>4</td>
<td>9.2138</td>
<td>2.3034</td>
<td>2.3519</td>
<td>0.0599</td>
</tr>
<tr>
<td>Subjects/TStS</td>
<td>91</td>
<td>89.1250</td>
<td>0.9794</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Ss</td>
<td>109</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeated Measures</td>
<td>91</td>
<td>89.1250</td>
<td>0.9794</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(R)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T x R</td>
<td>2</td>
<td>1.9518</td>
<td>0.9759</td>
<td>3.0361</td>
<td>0.0529**</td>
</tr>
<tr>
<td>St x R</td>
<td>2</td>
<td>0.2371</td>
<td>0.1185</td>
<td>0.3687</td>
<td>0.6926</td>
</tr>
<tr>
<td>S x R</td>
<td>1</td>
<td>0.0066</td>
<td>0.0066</td>
<td>0.0206</td>
<td>0.8863</td>
</tr>
<tr>
<td>T x St x R</td>
<td>4</td>
<td>0.2347</td>
<td>0.0587</td>
<td>0.1825</td>
<td>0.9469</td>
</tr>
<tr>
<td>T x S x R</td>
<td>2</td>
<td>0.6239</td>
<td>0.3119</td>
<td>0.9705</td>
<td>0.3828</td>
</tr>
<tr>
<td>St x S x R</td>
<td>2</td>
<td>0.3697</td>
<td>0.1848</td>
<td>0.5750</td>
<td>0.3647</td>
</tr>
<tr>
<td>T x St x S x R</td>
<td>4</td>
<td>0.9139</td>
<td>0.2285</td>
<td>0.7108</td>
<td>0.5866</td>
</tr>
<tr>
<td>Subjects x R/TStS91</td>
<td>91</td>
<td>29.2503</td>
<td>0.3214</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>--</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
</tbody>
</table>

*** p < .0001
** p < .02
* p < .05
** p < .053
Examination of Tables 12 and 13 for the higher level interaction effects of interest revealed that the observed F's for the effects of:

1) the third order interaction of treatment conditions x stages of development x sex x repeated measures on
   a) performance scores (F=0.3007; df 4/91; p=.88); and
   b) stage classifications (F=0.7108; df 4/91; p=.59);

2) the second order interaction of treatment conditions x sex x repeated measures on
   a) performance scores (F=1.2619; df 2/91; p=.29); and
   b) stage classifications (F=0.9705; df 2/91; p=.39); and

3) the second order interaction of treatment conditions x stages of development x repeated measures on
   a) performance scores (F=0.2545; df 4/91; p=.91); and
   b) stage classifications (F=0.1825; df 4/91; p=.95)

all exceeded the a priori established level (i.e., $\alpha \leq .05$) of significance. Therefore, it was not possible to reject the omnibus null hypotheses of no significant differences in the acquisition of conservation related skills by 4- and 5-year-old lower socioeconomic status children on either the intermediate test or posttest as a function of:
H4-b—the interaction of treatment conditions, stages of development, and sex; H3-b—the interaction of treatment conditions and sex; and H2-b—the interaction of treatment conditions and stages of development.

Thus, it must be concluded that there were no significant differences on either test in the acquisition of conservation related skills by children of different stages of development and/or sex under each treatment condition. No further analyses were warranted by the non-significant F statistics.

Examining Tables 12 and 13 for the first order interaction effects of treatment conditions x repeated measures revealed that significant F's for the effects on a) performance scores (F=4.1024; df 2/91; p=.02); and

b) stage classifications (F=3.0361; df 2/91; p=.05) were observed. Therefore, the omnibus null hypothesis, H1-b, of no significant differences in the acquisition of conservation related skills by 4- and 5-year-old lower socioeconomic status children on either the intermediate test or posttest as a result of treatment conditions, was rejected. Further analyses were necessary in order to determine the nature of the interaction as well as to identify which means contributed to the significant F statistic.
Graph I presents the unweighted mean performance scores for each treatment condition as a function of repeated measures. Graph II presents the unweighted mean stage classifications for each treatment condition as a function of repeated measures.

As is shown in Graphs I and II, respectively, the unweighted mean performance scores and the unweighted mean stage classifications for each treatment condition as functions of repeated measures revealed marked departures from parallelism in terms of both magnitude and differential effectiveness, thus indicating disordinal first order interactions. Since disordinal first order interactions were indicated, it was not necessary to examine the main effects of treatment conditions. Attention was immediately directed towards determining the source of these significant interactions.

Dunn's multiple comparison procedure was applied to 6 a priori established comparisons \((\bar{X}_1-2 - \bar{X}_2-2; \bar{X}_1-2 - \bar{X}_3-2; \bar{X}_2-2 - \bar{X}_3-2; \bar{X}_1-1 - \bar{X}_2-2; \bar{X}_1-1 - \bar{X}_3-1; \bar{X}_2-1 - \bar{X}_3-1)\) at the specified collective alpha risk of .05 in order to determine which of the unweighted mean performance score comparisons were significantly different. The critical \(t\) value for 6 comparisons at the .05 level (.05/6) and 91 df, conservatively interpolated from Dunn's Table, was found to be 2.70. Thus the \(\Psi_{\text{Dunn}}\) (difference in cell means) needed
THE UNWEIGHTED MEAN PERFORMANCE SCORES FOR EACH TREATMENT CONDITION AS A FUNCTION OF REPEATED MEASURES
THE UNWEIGHTED MEAN STAGE CLASSIFICATIONS FOR EACH TREATMENT CONDITION AS A FUNCTION OF REPEATED MEASURES
for significance at .05/6 for both equal and unequal n comparisons was 0.68. The observed differences between the 6 unweighted mean comparisons of interest are presented in Table 14.

**TABLE 14**

Performance Score Unweighted Mean Comparison Matrix for Dunn's Test

<table>
<thead>
<tr>
<th>Treatment Means</th>
<th>Treatment Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \bar{X}_{3-2} )</td>
<td>( \bar{X}_{1-1} )</td>
</tr>
<tr>
<td>2.78</td>
<td>3.01</td>
</tr>
<tr>
<td>1.23**</td>
<td>.53</td>
</tr>
<tr>
<td>.56</td>
<td>.17</td>
</tr>
</tbody>
</table>

**4.01** \( \bar{X}_{1-2} \) > \( \begin{cases} \frac{2.78}{\bar{X}_{3-2}} \end{cases} \) \( p < .05/6 \) \( \bar{X}_{1-1} \) EII: Con.-Int. Test \( n=35 \) " Posttest

\* 4.01 \( \bar{X}_{1-2} \) > \( \begin{cases} \frac{3.34}{\bar{X}_{2-2}} \end{cases} \) \( p \geq .05/6 \) \( \bar{X}_{2-1} \) EIII: Set Int. Test \( n=37 \) " Posttest

\( \bar{X}_{3-1} \) EIII: Control I-Int. Test \( n=37 \)
\( \bar{X}_{3-2} \) Control I-Posttest

The results of Dunn's test revealed that the posttest unweighted mean performance score for the Conservation group, EI (4.01) was significantly higher than the posttest unweighted mean performance score of EIII: Control group I (2.78). In addition, the posttest unweighted mean performance score for the Conservation group, EI (4.01) just
missed (by .01) being significantly higher than the post-test unweighted mean performance score of the Set Theory Approach, EII (3.34). No significant differences were observed between the posttest unweighted mean performance scores of the Set Theory Approach (EII) and EIII: Control group I, nor were there any significant differences revealed in any of the intermediate test comparisons.

In order to determine which of the stage classification unweighted means were significantly different, Dunn's multiple comparison procedure was applied to 6 a priori established comparisons (X1-1—X2-1; X1-1—X3-1; X2-1—X3-1; X1-2—X2-2; X1-2—X3-2; X2-2—X3-2) at the specified collective alpha risk of .05. The critical t value for 6 comparisons at the .05 level (.05/6) and 91 df, conservatively interpolated from Dunn's Table, was found to be 2.70. Thus the $\Psi_{\text{Dunn}}$ (difference in cell means) needed for significance at .05/6 for unequal n (n=35; n=37) comparisons was .28 and for equal n (n=37) comparisons was .35. The observed differences between the 6 unweighted mean comparisons are presented in Table 15.
TABLE 15
Stage Classification Unweighted Mean Comparison
Matrix for Dunn's Test

<table>
<thead>
<tr>
<th>Treatment Means</th>
<th>Treatment Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1-1 2.32</td>
<td>X1-2 2.77</td>
</tr>
<tr>
<td>X2-2 2.34</td>
<td>X3-2 2.35</td>
</tr>
<tr>
<td>X3-2 2.35</td>
<td>X2-1 2.44</td>
</tr>
<tr>
<td>X2-1 2.53</td>
<td>X3-1 2.34</td>
</tr>
<tr>
<td>X1-2</td>
<td>2.77</td>
</tr>
</tbody>
</table>

.43* .42* .09
.21 .09
.12 .01

The results of Dunn's test revealed that the post-test unweighted mean stage classification of the Conservation group EI (2.77) was significantly higher than the posttest unweighted mean stage classifications of both the Set Theory group, EII (2.34) and EIII, Control group I (2.35). No significant differences were observed between the posttest unweighted mean stage classifications of EII, Set Theory group and EIII, Control group I, nor were there any significant differences revealed in any of the intermediate test unweighted mean stage classification comparisons.
In order to further illustrate the pattern of performance which occurred for each treatment condition from the beginning to the end of the study, Graphs III and IV have been included. These graphs differ from Graphs I and II only to the extent that the unweighted mean pretest scores and the unweighted mean pretest stage classifications (which were used as blocking variables and which were not significantly different) are presented along with the unweighted mean intermediate test and unweighted mean posttest scores and stage classifications.

Several conclusions appear appropriate on the basis of the data. Children who participated in 12 Conservation Approach instructional sessions over a five week period exhibited significantly higher performance scores and stage classifications on the posttest than did children in the Control group (EIII: Control I) who did not receive any training. In addition, the posttest stage classifications of the Conservation group (EI) were significantly higher than the posttest stage classifications of children in the Set Theory group (EII). Also, the posttest mean performance score of the Conservation group (EI) just missed (by .01) being significantly higher than the posttest mean performance score of the Set Theory group (EII). Thus after 12 instructional sessions over a five week period, the Conservation Approach (EI) was shown to be the most effective means of facilitating the acquisition of conservation related skills.
THE PATTERN OF PERFORMANCE FOR EACH TREATMENT CONDITION FROM PRETEST TO POSTTEST AS SHOWN BY THE UNWEIGHTED PERFORMANCE SCORE MEANS AS A FUNCTION OF REPEATED MEASURES
THE PATTERN OF STAGE CLASSIFICATIONS FOR EACH TREATMENT CONDITION FROM PRETEST TO POSTTEST AS SHOWN BY THE UNWEIGHTED STAGE CLASSIFICATION MEANS AS A FUNCTION OF REPEATED MEASURES
No significant differences were shown to exist on the intermediate test (after 6 instructional sessions over a two week period) between any of the treatment conditions. It is interesting to note, however, that while the Conservation group (EI) exhibited significantly higher performance scores and stage classifications than the other two groups, on the intermediate test it was the lowest of the three. As is indicated in Graphs III and IV, the Conservation group (EI) showed a steady increase from pretest to posttest in performance scores and stage classifications, whereas the other two groups showed increases, and then decreases, in performance.

In comparing the Set Theory group (EII) to the Control group (EIII: Control I), no significant differences were shown to exist on either the intermediate test or posttest in terms of performance scores and stage classifications. An interesting observation, however, is that while the Set Theory (EII) group exhibited the highest performance scores on the intermediate test, the corresponding stage classifications were lower than the Control group (EIII: Control I). This phenomenon is accounted for by the decreased variation within the stage classification groupings.

Although the posttest performance scores and stage classifications of the Conservation group were shown to
be significantly higher than those of both the Control group I and the Set Theory group, the unweighted means of the three groups (EI, EII, and EIII) do not appear to be very different. The similarity in the unweighted means, despite significant differences, raises questions regarding the feasibility of making educational applications of the major findings of this study.

In response to these questions, it is important to recognize that the unweighted means and the unweighted means analysis of variance are very conservative estimates of the true means and of the true differences in variances of the treatment groups (Kennedy, 1974). In addition, it is also important to note that, since the scoring range was very narrow (0-7 for performance scores; 0-5 for stage classifications) and the scores were ordinal, not interval, an increase or difference of even a single point reflects a marked increase or difference in the development of numerical skills and concepts (i.e., the ability to establish one-to-one correspondence; the ability to establish the equivalence of sets; . . .). With these facts in mind, further information about the specific gains made by individual children in each treatment condition can be obtained by examining the raw data (Appendix D) and the information presented in Tables 29 and 30 (Appendix E).
Table 29 presents 1) the number of children from each pretest performance score category achieving given intermediate or posttest scores; 2) the total number of each type of change (+, -, 0) exhibited by children of each category and each condition; and 3) the total number of points gained (+) or lost (-) by children in each category and each treatment condition, as shown on both the intermediate test and the posttest. The diagonal line on Table 29, which cuts through the points indicating no change in status, is used to facilitate visual evaluation of positive (to the right of the line) and negative (to the left of the line) changes. Table 30 presents 1) the number of children from each pretest stage classification category achieving given intermediate or posttest classifications; and 2) the total number of each type of change (+, -, 0) exhibited by children in each category and each treatment condition, on both the intermediate test and the posttest. The diagonal line serves the same purpose as it did in Table 29.

As can be seen from an examination of these data (Appendix D and Appendix E), a much larger number of children who received training (either Conservation or Set) showed definite increases in performance scores and stage classifications than did children in the Control group (EIII: CI). The Conservation group showed the
largest number (29/35 and 17/35, respectively) of post-test increases (X = 2.0 and 1.5, respectively). In addition, children in the Conservation group showed fewer decreases in performance scores and stage classifications than did children in the other two groups. Thus the overall effect of Conservation training was a very definite and marked facilitation of the acquisition of conservation related skills by 4- and 5-year-old lower socioeconomic status children.

Related Questions
Age

Although children of two age levels (4-year-olds and 5-year-olds) were included in this study, age was not used as a blocking variable. Therefore, it appeared important to determine if there was a differential effect (α = .05), on either the intermediate test or posttest, as a function of treatment conditions, and/or the interaction of treatment conditions and stages of development, in terms of a) performance scores and/or b) stage classifications, for each age level. Tables 16 and 17 present, respectively, the results of the unweighted mean analyses for the two dependent variables: performance scores and stage classifications. It was not possible to include sex as a variable in the analyses due to the existence of empty cells.
TABLE 16
A Three Between Groups-One Within Subjects Analysis of Variance of the Effects of Treatment Conditions, Stages of Development, and Age on Performance Scores as Functions of Repeated Measures Using the Method of Unweighted Means

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Ss</strong></td>
<td>108</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment (T)</td>
<td>2</td>
<td>17.6091</td>
<td>8.8045</td>
<td>2.0668</td>
<td>0.1325</td>
</tr>
<tr>
<td>Stages (St)</td>
<td>2</td>
<td>122.6097</td>
<td>61.3048</td>
<td>14.3910</td>
<td>0.0000**</td>
</tr>
<tr>
<td>Age (A)</td>
<td>1</td>
<td>11.1347</td>
<td>11.1347</td>
<td>2.6183</td>
<td>0.1091</td>
</tr>
<tr>
<td>T x St</td>
<td>4</td>
<td>18.5873</td>
<td>4.6468</td>
<td>1.0908</td>
<td>0.3659</td>
</tr>
<tr>
<td>T x A</td>
<td>2</td>
<td>9.3333</td>
<td>4.6666</td>
<td>1.0955</td>
<td>0.3388</td>
</tr>
<tr>
<td>St x A</td>
<td>2</td>
<td>5.8733</td>
<td>2.9366</td>
<td>0.6894</td>
<td>0.5045</td>
</tr>
<tr>
<td>T x St x A</td>
<td>4</td>
<td>27.6074</td>
<td>6.9018</td>
<td>1.6202</td>
<td>0.1759</td>
</tr>
<tr>
<td>Subjects/TStA</td>
<td>91</td>
<td>387.6549</td>
<td>4.2599</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Within Ss</strong></td>
<td>109</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeated Measures (R)</td>
<td>1</td>
<td>0.0034</td>
<td>0.0034</td>
<td>0.0031</td>
<td>0.9560</td>
</tr>
<tr>
<td>T x R</td>
<td>2</td>
<td>4.6622</td>
<td>2.3311</td>
<td>2.0694</td>
<td>0.1322</td>
</tr>
<tr>
<td>St x R</td>
<td>2</td>
<td>1.9686</td>
<td>0.9843</td>
<td>0.8738</td>
<td>0.4208</td>
</tr>
<tr>
<td>A x R</td>
<td>1</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.9916</td>
</tr>
<tr>
<td>T x St x R</td>
<td>4</td>
<td>0.3306</td>
<td>0.0827</td>
<td>0.0734</td>
<td>0.9901</td>
</tr>
<tr>
<td>T x A x R</td>
<td>2</td>
<td>6.0071</td>
<td>3.0035</td>
<td>2.6663</td>
<td>0.0749</td>
</tr>
<tr>
<td>St x A x R</td>
<td>2</td>
<td>0.3623</td>
<td>0.1812</td>
<td>0.1608</td>
<td>0.8517</td>
</tr>
<tr>
<td>T x St x A x R</td>
<td>4</td>
<td>2.2541</td>
<td>0.5635</td>
<td>0.5002</td>
<td>0.7356</td>
</tr>
<tr>
<td>Subjects x R/TStA</td>
<td>91</td>
<td>102.5099</td>
<td>1.1265</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>--</td>
<td>-------</td>
<td>--------</td>
<td>--------</td>
<td>-------</td>
</tr>
</tbody>
</table>

**p < .0001
<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Ss 108</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment (T)</td>
<td>2</td>
<td>2.5467</td>
<td>1.2734</td>
<td>1.3204</td>
<td>0.2721</td>
</tr>
<tr>
<td>Stages (St)</td>
<td>2</td>
<td>25.7678</td>
<td>12.8839</td>
<td>13.3597</td>
<td>0.0000**</td>
</tr>
<tr>
<td>Age (A)</td>
<td>1</td>
<td>3.3769</td>
<td>3.3769</td>
<td>3.5016</td>
<td>0.0645</td>
</tr>
<tr>
<td>T x St</td>
<td>4</td>
<td>6.3040</td>
<td>1.5760</td>
<td>1.6342</td>
<td>0.1724</td>
</tr>
<tr>
<td>T x A</td>
<td>2</td>
<td>4.3786</td>
<td>2.1893</td>
<td>2.2701</td>
<td>0.1091</td>
</tr>
<tr>
<td>St x A</td>
<td>2</td>
<td>1.4024</td>
<td>0.7012</td>
<td>0.7271</td>
<td>0.4861</td>
</tr>
<tr>
<td>T x St x A</td>
<td>4</td>
<td>6.2018</td>
<td>1.5504</td>
<td>1.6077</td>
<td>0.1791</td>
</tr>
<tr>
<td>Subjects/TStA</td>
<td>91</td>
<td>87.7591</td>
<td>0.9644</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Ss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeated Measures (R) 109</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T x R</td>
<td>1</td>
<td>0.0006</td>
<td>0.0006</td>
<td>0.0019</td>
<td>0.9650</td>
</tr>
<tr>
<td>St x R</td>
<td>2</td>
<td>0.8899</td>
<td>0.4449</td>
<td>1.4123</td>
<td>0.2489</td>
</tr>
<tr>
<td>St x R</td>
<td>2</td>
<td>0.3899</td>
<td>0.1949</td>
<td>0.6187</td>
<td>0.5409</td>
</tr>
<tr>
<td>A x R</td>
<td>1</td>
<td>0.0598</td>
<td>0.0598</td>
<td>0.1899</td>
<td>0.6640</td>
</tr>
<tr>
<td>T x St x R</td>
<td>4</td>
<td>0.2132</td>
<td>0.0533</td>
<td>0.1692</td>
<td>0.9536</td>
</tr>
<tr>
<td>T x A x R</td>
<td>2</td>
<td>1.4509</td>
<td>0.7255</td>
<td>2.3028</td>
<td>0.1059</td>
</tr>
<tr>
<td>St x A x R</td>
<td>2</td>
<td>0.0397</td>
<td>0.0198</td>
<td>0.0630</td>
<td>0.9390</td>
</tr>
<tr>
<td>T x St x A x R</td>
<td>4</td>
<td>0.8945</td>
<td>0.2236</td>
<td>0.7098</td>
<td>0.5873</td>
</tr>
<tr>
<td>Subjects x R/TStA 91</td>
<td></td>
<td>28.6697</td>
<td>0.3151</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>--</td>
<td>------</td>
<td>---------</td>
<td>---------</td>
<td>-------</td>
</tr>
</tbody>
</table>

**p < .0000
Examination of Table 16 for the higher level interaction effects of interest revealed that the observed F's for the effects on performance scores of
1) the third order interaction of treatment condition x stages of development x age x repeated measures (F=0.5002; df 4/91; p=.74); and
2) the second order interaction of treatment conditions x age x repeated measures (F=2.6663; df 2/91; p=.07)
both exceeded the a priori established level (i.e., \( \alpha \leq .05 \)) of significance. Thus it appears that there were no differential effects of treatment conditions for each age level or in interaction with stages of development on the performance scores of lower socioeconomic status children on either the intermediate or posttest.

Examination of Table 17 also showed that for the higher level interaction effects of interest, the observed F for the effects on stage classifications of
1) the third order interaction of treatment conditions x stages of development x age x repeated measures (F=0.7098; df 4/91; p=.59); and
2) the second order interaction of treatment conditions x age x repeated measures (F=2.3028; df 2/91; p = .10)
both exceeded the a priori established .05 level of significance. Thus it appears that there were no differential
effects of treatment conditions for each age level or in interaction with stages of development on the stage classifications of lower socioeconomic status children on either the intermediate test or posttest.

As the preceding analyses indicated, no significant effects, on either performance scores or stage classifications were shown to exist as a result of age in interaction with 1) treatment conditions and repeated measures, or 2) treatment conditions, stages of development, and repeated measures. Thus it can be concluded that the differences that were shown to exist, in both performance scores and stage classifications, as a result of treatment conditions and repeated measures, were not the result of differential age effects. It can also be said that the treatment conditions were equally effective in producing increases in performance scores and stage classifications with both 4-year-old and 5-year-old lower socioeconomic status children.

Instructional Strategy

The interactive instructional strategy, characterized by the use of a questioning procedure to stimulate and explore the thoughts and ideas of students, was the main instructional strategy intended for both the Conservation and the Set Theory treatment conditions. In order to ensure that instruction was a constant, the Observational
System of Instructional Analysis (OSIA) was applied to four tape recorded lessons for each of the nine instructors. The four lessons were chosen through a systematic random selection process in which one lesson from each of the four lesson groupings (Lessons 1-3, 4-6, 7-9, and 10-12) was selected for analysis. Following analysis, a substantive interactive strategy index was computed for each observation from the percentage of behaviors which occurred which are characteristic of the substantive interactive strategy. The mean substantive interactive strategy index for each instructor and each treatment condition was then calculated and statistically analyzed in order to determine if any significant differences ($\alpha \leq .05$) existed. Graph V presents the average substantive interactive strategy for each instructor and for each treatment condition.

Table 18 presents the one way analysis of variance of the individual instructors interactive strategy index means.

**TABLE 18**

One Way Analysis of Variance of Individual Instructors Interactive Strategy Index Means

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructors</td>
<td>8</td>
<td>1498.847</td>
<td>187.3558</td>
<td>5.5967**</td>
</tr>
<tr>
<td>Error</td>
<td>27</td>
<td>903.858</td>
<td>33.4762</td>
<td></td>
</tr>
</tbody>
</table>

**$p < .01$**
THE MEAN INTERACTIVE STRATEGY INDICES FOR INDIVIDUAL INSTRUCTORS AND EACH TREATMENT CONDITION
As is indicated in Table 18, a significant $F$ ($F=5.5967; \text{df } 8/27; p < .01$) for the instructor interactive strategy indices was observed. In order to determine which of the individual interactive strategy indices means were significantly different, Scheffe's multiple comparison procedure was applied at the .05 alpha risk level. The critical difference in cell means for the .05 level df 8/27 was found to be 17.55. The observed differences which were greater than the critical value are presented in Table 19.

**TABLE 19**

Instructor Interactive Strategy Index Mean Comparison Matrix for Scheffe's Test**

<table>
<thead>
<tr>
<th></th>
<th>$\bar{X}9$</th>
<th>$\bar{X}5$</th>
<th>$\bar{X}4$</th>
<th>$\bar{X}8$</th>
<th>$\bar{X}7$</th>
<th>$\bar{X}3$</th>
<th>$\bar{X}2$</th>
<th>$\bar{X}6$</th>
<th>$\bar{X}1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>55.2</td>
<td>58.2</td>
<td>62.2</td>
<td>65.6</td>
<td>67.3</td>
<td>68.1</td>
<td>72.8</td>
<td>73.1</td>
<td>75.0</td>
<td></td>
</tr>
</tbody>
</table>

19.8* 16.8*<sup>†</sup> 75.0 $\bar{X}1$
17.9* 73.1 $\bar{X}6$
17.6* 72.8 $\bar{X}2$

<table>
<thead>
<tr>
<th></th>
<th>$\bar{X}6$</th>
<th>$\bar{X}9$</th>
<th>$\bar{X}1$</th>
<th>$\bar{X}5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>68.1</td>
<td>67.3</td>
<td>67.3</td>
<td>65.6</td>
<td></td>
</tr>
<tr>
<td>65.6</td>
<td>62.2</td>
<td>58.2</td>
<td>55.2</td>
<td></td>
</tr>
</tbody>
</table>

* $p < .05$
† approaching significance
** all comparisons were made; however, only those which were significant or which approached significance are recorded here.
The results of Scheffe's test revealed that the interactive index means of instructors 1 (75.0 Conservation), 6 (73.1 Set), and 2 (72.8 Conservation) were significantly higher than the mean of instructor 9 (55.2 Set). In addition, the mean of instructor 1 (75.0 Conservation) approached being significantly higher than the mean of instructor 5 (58.2 Conservation). Thus it is evident that significant differences occurred between individual instructors both within and between treatment conditions in the degree to which each instructor utilized the interactive instructional strategy. However, all instructors exhibited a high percentage of behaviors characterized as interactive (55.2—75.0%) and there tended to be a similar pattern of performance between treatment conditions (Graph V). Further examination of the behaviors of the high and low (index means) instructors in each treatment condition revealed that the instructors who were lower in substantive interactive behaviors tended to be higher in 1) teacher directed substantive, 2) teacher interactive managerial, and 3) student interactive substantive behaviors than the instructors who had the highest substantive interactive strategy index means. And, interestingly, the two instructors who had the lowest indices both instructed children in the same two Head Start centers, whereas the two instructors who had the highest indices both worked with children
enrolled in public school pre-kindergarten classes. This latter observation suggests two immediately evident possible explanations. The first is that the previous experiences of the children tended to influence the degree to which the given instructional strategy could be affected. The second is that random assignment (chance) resulted in the placement of similar instructors (in terms of their ability to use the interactive strategy) in similar educational settings.

Fisher's $t$ test was used to test for significant differences ($\lambda \leq .05$) between the interactive strategy index means of each treatment condition. The results of this analysis are presented in Table 20.

As is shown in Table 20, the observed $t$ ($t=0.40$; $df$ $7$; $p > .05$) failed to reach the critical value ($t=2.36$) needed for significance at the $.05$ level. No significant differences were shown to exist between the interactive strategy index means of the Conservation instructors (67.3) and the Set Theory instructors (65.4). Therefore, it can be concluded that, although significant differences existed between individual instructors, instruction was a constant across treatment conditions and did not contribute to the significance in performance scores and stage classifications that was shown to exist between treatment conditions.
**TABLE 20**

Fisher's $t$ Test for Significant Differences Between the Uncorrelated Interactive Strategy Index Means of Treatment Conditions EI and EII

<table>
<thead>
<tr>
<th>Individual Instructor's Treatment Interactive Strategy Index Means</th>
<th>$x$</th>
<th>$x^2$</th>
<th>df</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EI</td>
<td>75.0</td>
<td>7.7</td>
<td>59.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>72.8</td>
<td>5.5</td>
<td>30.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>68.1</td>
<td>0.8</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>62.2</td>
<td>5.1</td>
<td>26.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>58.5</td>
<td>8.8</td>
<td>77.4</td>
<td></td>
</tr>
<tr>
<td>Sum</td>
<td>336.6</td>
<td>Sum 193.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>67.3</td>
<td>67.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                              | 73.1| 7.7  | 59.3|
|                              | 67.3| 1.9  | 3.6 |
|                              | 65.8| 0.4  | 0.2 |
|                              | 55.2| 10.2 | 104.0|
| Sum                          | 261.4| Sum 167.1|
| Mean                         | 65.4| 65.4|

**Instructor Effectiveness**

Since significant differences were shown to exist in the extent to which individual instructors utilized the interactive strategy, it also appeared important to determine if any of the instructors differed significantly ($\alpha \leq .05$) in their effectiveness in stimulating the acquisition of conservation related skills. A one between groups-one within subjects analysis of variance for the
effects of instructors and repeated measures was run for each of the dependent variables, performance scores and stage classifications, and the results are presented in Tables 21 and 22 respectively.

Examination of Table 21 for the higher level interactive effects of interest revealed that the observed \( F \) (\( F=0.9111; \text{df } 16/126; p=0.56 \)) for the effects of instructors and repeated measures on performance scores exceeded the a priori established level (i.e., \( \alpha \leq 0.05 \)) of significance. No instructors were shown to be significantly more effective than any others in increasing the performance scores of their students on either the intermediate or posttest. Therefore, the differences that were shown to exist between treatment conditions were not the result of differential instructor effectiveness.

The data in Table 22 showed that for the higher level interaction effects of instructors and repeated measures on stage classifications, the observed \( F \) (\( F=1.3035; \text{df } 16/126; p=0.20 \)) exceeded the a priori established 0.05 level of significance. No instructors were shown to be significantly more effective than any others in increasing the stage classifications of their students on either the intermediate or posttest. Therefore, the differences that were shown to exist in the posttest stage classifications of the two treatment conditions were not caused by differential instructor effectiveness.
TABLE 21
A One Between Groups-One Within Subjects Analysis of Variance of the Effects of Instructors and Repeated Measures on Performance Scores of 4- and 5-Year-Old Lower Socioeconomic Status Children

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td></td>
<td>71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructors (I)</td>
<td>8</td>
<td>81.3890</td>
<td>10.1736</td>
<td>1.7289</td>
<td>0.1091</td>
</tr>
<tr>
<td>Subjects (S)</td>
<td>63</td>
<td>370.7174</td>
<td>5.8844</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>154</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeated Measures</td>
<td>2</td>
<td>127.6759</td>
<td>63.8380</td>
<td>46.5004</td>
<td>0.0000**</td>
</tr>
<tr>
<td>I x R</td>
<td>16</td>
<td>20.0121</td>
<td>1.2508</td>
<td>0.9111</td>
<td>0.5582</td>
</tr>
<tr>
<td>S x R</td>
<td>126</td>
<td>172.9786</td>
<td>1.3728</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p < .001

TABLE 22
A One Between Groups-One Within Subjects Analysis of Variance of the Effects of Instructors and Repeated Measures on the Stage Classifications of 4- and 5-Year-Old Lower Socioeconomic Status Children

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td></td>
<td>71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructors (I)</td>
<td>8</td>
<td>17.9463</td>
<td>2.2433</td>
<td>1.8479</td>
<td>0.0846</td>
</tr>
<tr>
<td>Subjects (S)</td>
<td>63</td>
<td>76.4796</td>
<td>1.2140</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>154</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeated Measures</td>
<td>2</td>
<td>30.3981</td>
<td>15.1991</td>
<td>42.1664</td>
<td>0.0000**</td>
</tr>
<tr>
<td>I x R</td>
<td>16</td>
<td>7.5179</td>
<td>0.4699</td>
<td>1.3035</td>
<td>0.2050</td>
</tr>
<tr>
<td>S x R</td>
<td>126</td>
<td>45.4173</td>
<td>0.3604</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p < .001
Language

Although the child's response rationales on the conservation of number test were not used as scoring or classification criteria, they were recorded and evaluated according to their adequacy or inadequacy. This information is presented in Table 23.

TABLE 23

The Number of Adequate and Inadequate Response Rationales for Each Treatment Condition on the Pretest, Intermediate Test, and Posttest

<table>
<thead>
<tr>
<th>Treatment Conditions</th>
<th>Pretest</th>
<th>Intermediate Test</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>EI (Cons.)</td>
<td>2</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>EII (Set)</td>
<td>0</td>
<td>36</td>
<td>5</td>
</tr>
<tr>
<td>EIII (Control I)</td>
<td>1</td>
<td>36</td>
<td>4</td>
</tr>
</tbody>
</table>

As can be seen in Table 23, the number of children giving adequate response rationales for their conservation related responses was very low in all conditions both before and after treatment. A Chi Square analysis was made in order to determine if significant differences existed in the number of increases which occurred in adequate response rationales from pre- to intermediate and pre- to posttests as a result of treatment conditions. The results of this analysis are presented in Table 24.
TABLE 24
Chi Square Analysis for Significant Differences in the Number of Positive Changes in Response Rationales from Pre- to Intermediate and Pre- to Posttests as a Result of Treatment Conditions

<table>
<thead>
<tr>
<th>Treatment Conditions</th>
<th>Pre- to Intermediate</th>
<th>Pre- to Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+ Changes</td>
<td>No Change</td>
</tr>
<tr>
<td>EI</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>EII</td>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>EIII</td>
<td>3</td>
<td>34</td>
</tr>
<tr>
<td>(X^2)</td>
<td>0.77</td>
<td>2.55</td>
</tr>
</tbody>
</table>

Examination of Table 24 revealed that the observed Chi Square statistics for significant differences in the number of positive changes in response rationales from pre-to intermediate (\(X^2 = 0.77; \text{ df } 2; p > .05\)) and pre- to posttests (\(X^2 = 2.55; \text{ df } 2; p > .05\)) failed to reach the critical value (\(X^2 = 5.99; \text{ df } 2\)) needed for significance at the .05 level. No significant increases in the adequacy of response rationales were shown to exist as a result of treatment conditions. Relating this to the main findings, it is interesting that while participation in Conservation Approach instructional sessions did significantly increase the conservation related skills of lower socioeconomic status 4- and 5-year-old children, it did not affect their ability to explain their agreement-disagreement responses. This finding reemphasizes Rothenberg's (1969) conclusion
that requiring explanations of lower socioeconomic status children leads to an underestimation of their abilities.

Repeated Testing

Also investigated were the overall effects, as well as the interactive effects with stages of development and/or sex, of repeated testing (i.e., the additional intermediate test) on performance scores and/or stage classifications of 4- and 5-year-old lower socioeconomic status children. The data collected on treatment conditions EIII (Control I--intermediate testing) and EIV (Control II) were analyzed by a three-way analysis of variance using the method of unweighted means. As indicated previously, this method of analysis results in a very conservative F statistic (Kennedy, 1974). Tables 25 and 27 present, respectively, the unweighted mean analysis of variance results for the two dependent variables, performance scores and stage classifications, as a function of treatment conditions (i.e., repeated testing), stages of development, and sex. Table 25 is presented and discussed first and then attention is given to Table 27.
TABLE 25

A Three-Way Analysis of Variance of the Effects of Repeated Testing (Treatment Conditions III and IV), Stages of Development, and Sex on Performance Scores of 4- and 5-Year-Old Lower Socioeconomic Status Children Using the Method of Unweighted Means

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeated Testing (R)</td>
<td>1</td>
<td>16.0086</td>
<td>16.0086</td>
<td>6.3027</td>
<td>0.0145**</td>
</tr>
<tr>
<td>Stage of Development (St)</td>
<td>2</td>
<td>41.4407</td>
<td>20.7204</td>
<td>8.1578</td>
<td>0.0007***</td>
</tr>
<tr>
<td>Sex (S)</td>
<td>1</td>
<td>0.1072</td>
<td>0.1072</td>
<td>0.0422</td>
<td>0.8378</td>
</tr>
<tr>
<td>R x St</td>
<td>2</td>
<td>53.7226</td>
<td>26.8613</td>
<td>10.5756</td>
<td>0.0001***</td>
</tr>
<tr>
<td>R x S</td>
<td>1</td>
<td>10.3595</td>
<td>10.3595</td>
<td>4.0787</td>
<td>0.0474</td>
</tr>
<tr>
<td>St x S</td>
<td>2</td>
<td>1.0097</td>
<td>6.5048</td>
<td>0.1988</td>
<td>0.8202</td>
</tr>
<tr>
<td>R x St x S</td>
<td>2</td>
<td>13.4245</td>
<td>6.7122</td>
<td>2.6427</td>
<td>0.0786</td>
</tr>
<tr>
<td>Subjects/RStS</td>
<td>67</td>
<td>170.1756</td>
<td>2.5399</td>
<td></td>
<td></td>
</tr>
<tr>
<td>**p &lt; .001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>***p &lt; .01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>**p &lt; .02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*p &lt; .05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Examination of Table 25 revealed that for the effects of the higher level second order interaction of treatment conditions (repeated testing), stages of development, and sex on performance scores, the observed F (F=2.64; df 2/67; p=.08) exceeded the a priori established .05 level of significance. Thus no significant differences in the performance scores of 4- and 5-year-old lower socioeconomic status children were shown to exist as a function of the
interaction of treatment conditions (repeated testing), stages of development, and sex.

Referring to the first order interactions of interest, a significant F (p < .05) was observed for both the effects of 1) treatment conditions and stages of development (F=10.5756; df 2/67; p = .0001) and 2) treatment conditions and sex (F=4.0787; df 1/67; p = .05) on the performance scores of 4- and 5-year-old lower socioeconomic status children. Further analysis was necessary in order to determine the nature of these interactions as well as to determine which of the unweighted means contributed to the significant F statistic.

Graphs VI and VII present, respectively, the unweighted mean performance scores of each treatment condition as a function of 1) stages of development, and 2) sex.

As is shown in Graph VI, the posttest unweighted mean performance scores for each treatment condition as a function of stages of development exhibited a marked departure from parallelism in terms of both magnitude and differential effectiveness, indicating a disordinal first order interaction.

In order to determine which of these unweighted mean performance score comparisons were significantly different, Dunn's multiple comparison procedure was applied to three comparisons at the specified collective alpha risk
THE POSTTEST UNWEIGHTED MEAN PERFORMANCE SCORES OF EACH TREATMENT CONDITION AS A FUNCTION OF STAGES OF DEVELOPMENT
The posttest unweighted mean performance scores of each treatment condition as a function of sex.
of .05. The critical $t$ value for three comparisons at the .05 level (.05/3) and 67 df, conservatively interpolated from Dunn's Table, was found to be 2.46. Thus the $\psi_{\text{Dunn}}$ (difference in cell means) needed for significance at .05/3 for Stage II ($n=4$, $n=5$) was found to be 2.63; for Transition I ($n=7$; $n=8$) to be 2.03; and for Stage I ($n=26$; $n=29$) to be 1.06. The observed differences between the three unweighted mean comparisons of interest are presented in Table 26.

### Table 26

Performance Score Unweighted Mean Comparison Matrix for Dunn's Test

<table>
<thead>
<tr>
<th>$\bar{X}_{2-1}$</th>
<th>$\bar{X}_{1-1}$</th>
<th>$\bar{X}_{2-3}$</th>
<th>$\bar{X}_{1-2}$</th>
<th>$\bar{X}_{2-2}$</th>
<th>$\bar{X}_{1-3}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.80</td>
<td>0.81</td>
<td>1.00</td>
<td>2.04</td>
<td>2.77</td>
<td>5.50</td>
</tr>
</tbody>
</table>

4.50*   5.50 $\bar{X}_{1-3}$
0.73     2.77 $\bar{X}_{2-2}$

2.04 $\bar{X}_{1-2}$
1.00 $\bar{X}_{2-3}$
0.81 $\bar{X}_{1-1}$
0.80 $\bar{X}_{2-1}$

- $\bar{X}_{1-1}$ EIII-Stage I $n=26$
- $\bar{X}_{2-1}$ EIV -Stage I $n=29$
- $\bar{X}_{1-2}$ EIII-Trans.I $n=7$
- $\bar{X}_{2-2}$ EIV -Trans.I $n=8$
- $\bar{X}_{3-1}$ EIII-Stage II $n=4$
- $\bar{X}_{3-2}$ EIV -Stage II $n=5$

The results of Dunn's test revealed the posttest unweighted mean performance score of Stage II children in the intermediate testing group EIII: Control I (5.50) to
be significantly higher than the posttest unweighted mean performance score of Stage II children in the EIV: Control group II (4.50). No significant differences in performance were shown to exist between treatment conditions for either Transition I or Stage I children. Thus it can be concluded that repeated testing (i.e., the intermediate test) tended to cause significant differences in performance for Stage II children, but not for Transition I or Stage I children, when compared to a control group that did not receive the additional test.

Graph VII revealed that the posttest unweighted mean performance scores for each treatment condition as a function of sex showed a marked departure from parallelism in terms of magnitude, but not in terms of differential effectiveness, thus indicating an ordinal first order interaction. The ordinal nature of this interaction necessitated an overall interpretation of the main effects of treatment conditions on performance scores rather than a first order interaction interpretation. Examining Table 25 for the main effects of treatment conditions on performance scores revealed the observed $F (F=6.3027; df 1/67; p=.01)$ significant beyond the .05 level. Examination of the treatment conditions means indicated that it was the unweighted mean performance score of the intermediate testing group EIII: Control I (2.78) that was significantly higher than
that of EIV: Control group II (1.52). Children who received an intermediate test performed significantly better on the posttest than children who did not. It is important to note, however, that a difference in magnitude of performance was observed, with males in the intermediate testing group EIII: Control I, performing higher than the intermediate testing group females, whereas in EIV: Control II, the males did not perform as well as the females.

Table 27 presents the analysis of variance results for the effects of treatment conditions, stages of development, and sex on stage classifications.

### TABLE 27

A Three-Way Analysis of Variance of the Effects of Repeated Testing (Treatment Conditions III and IV), Stages of Development, and Sex on Stage Classifications of 4- and 5-Year-Old Lower Socioeconomic Status Children Using the Method of Unweighted Means

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeated Testing (R)</td>
<td>1</td>
<td>6.3156</td>
<td>6.3156</td>
<td>11.4331</td>
<td>0.0001***</td>
</tr>
<tr>
<td>Stage of Development (St)</td>
<td>2</td>
<td>10.8483</td>
<td>5.4242</td>
<td>9.8194</td>
<td>0.0001***</td>
</tr>
<tr>
<td>Sex (S)</td>
<td>1</td>
<td>0.5991</td>
<td>0.5991</td>
<td>1.0846</td>
<td>0.3014</td>
</tr>
<tr>
<td>R x St</td>
<td>2</td>
<td>14.8005</td>
<td>7.4002</td>
<td>13.3966</td>
<td>0.0000***</td>
</tr>
<tr>
<td>R x S</td>
<td>1</td>
<td>3.5234</td>
<td>3.5234</td>
<td>6.3785</td>
<td>0.0139**</td>
</tr>
<tr>
<td>St x S</td>
<td>2</td>
<td>1.8044</td>
<td>0.9022</td>
<td>1.6333</td>
<td>0.2030</td>
</tr>
<tr>
<td>R x St x S</td>
<td>2</td>
<td>4.5893</td>
<td>2.2946</td>
<td>4.1540</td>
<td>0.0195**</td>
</tr>
<tr>
<td>Subjects/RStS</td>
<td>67</td>
<td>37.0104</td>
<td>0.5524</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>--</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td></td>
</tr>
</tbody>
</table>

*** p < .001
** p < .01
*  p < .05
Examination of Table 27 revealed that, for the higher level second order interaction of treatment conditions, stages of development, and sex on stage classifications, the observed F (F=4.1540; df 2/67; p=.02) was significant beyond the a priori established (i.e., $\alpha = .05$) level of significance. Before attempting to interpret this significant second order interaction, it was necessary to determine which, if any, of the simple first order interaction combinations were also significant and thus contributing to the second order interaction. Examining Table 27 again revealed that two of the three first order interactions, 1) treatment conditions and sex (F=6.3785; df 1/67; p=.01) and 2) treatment conditions and stages of development (F=13.3966; df 2/67; p=.00001), were significant beyond the .05 level. Further analysis was necessary to determine the nature of each of these first order interactions as functions of the third variables, as well as to identify the specific stage classification unweighted means which were contributing to the significant F statistic.

Graph VIII presents the posttest unweighted mean stage classification for each treatment condition at each stage of development as a function of sex. Graph IX presents the posttest unweighted mean stage classification for each treatment condition and each sex as a function of stages of development.
GRAPH VIII

POSTTEST UNWEIGHTED MEAN STAGE CLASSIFICATION OF EACH TREATMENT CONDITION AND EACH STAGE OF DEVELOPMENT AS A FUNCTION OF SEX
POSTTEST UNWEIGHTED MEAN STAGE CLASSIFICATIONS OF EACH TREATMENT CONDITION AND EACH SEX AS A FUNCTION OF STAGES OF DEVELOPMENT
As is shown in Graph VIII, the posttest unweighted mean stage classifications for each treatment condition and each stage of development as a function of sex showed departures from parallelism in terms of magnitude and differential effectiveness at Stage I and Transition I. At Stage II the departure from parallelism was only in terms of magnitude, thus indicating both qualitative and quantitative differences in the interactive effects of treatment conditions and stages of development as a function of sex.

As is shown in Graph IX, the posttest unweighted mean stage classifications for each treatment condition and each sex as a function of stages of development showed marked departures from parallelism in terms of magnitude and differential effectiveness. In addition, there were also pronounced differences in the overall pattern of performance for each sex, indicating qualitative as well as quantitative differences.

Since both quantitative and qualitative differences existed in each of the interaction effects as functions of each of the third variables, no simple first order interpretations were made. Instead, each of the interactions were interpreted as it specifically related to third variable levels. However, before these interpretations could be made, it was necessary to determine which of the unweighted means were significantly different. Dunn's
multiple comparison procedure was applied to 12 comparisons at the specified collective alpha risk of .05. The critical $t$ needed for 12 comparisons at the .05 level (.05/12) and 67 df, conservatively interpolated from Dunn's Table, was found to be 2.96. Thus the $\psi_{\text{Dunn}}$ (difference in cell means) needed for significance at .05/12 for each comparison was as follows:

$X_{113} - X_{213} = 2.69$
$X_{113} - X_{123} = 2.54$
$X_{123} - X_{223} = 1.80$
$X_{223} - X_{213} = 2.01$
$X_{222} - X_{122} = 1.69$
$X_{222} - X_{212} = 1.59$
$X_{112} - X_{122} = 1.69$
$X_{112} - X_{212} = 1.59$
$X_{221} - X_{121} = 0.82$
$X_{211} - X_{221} = 0.82$
$X_{121} - X_{111} = 0.82$
$X_{211} - X_{111} = 0.82$

The observed differences between the 12 unweighted mean comparisons of interest are presented in Table 28.

The results of Dunn's test revealed the unweighted mean stage classification of Stage II males in the intermediate testing group, EIII: Control I, (5.0) to be significantly higher than the unweighted mean stage classification of Stage II males in EIV: Control II (1.0). No other unweighted mean comparisons were shown to be significant. Thus it can be concluded that Stage II males exhibited significantly higher stage level classifications as a result of receiving an additional test than did Stage II males who did not receive it. However, since there was
<table>
<thead>
<tr>
<th>X213</th>
<th>X221</th>
<th>X111</th>
<th>X211</th>
<th>X121</th>
<th>X222</th>
<th>X122</th>
<th>X212</th>
<th>X112</th>
<th>X222</th>
<th>X123</th>
<th>X213</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>1.20</td>
<td>1.30</td>
<td>1.36</td>
<td>1.38</td>
<td>1.67</td>
<td>1.75</td>
<td>1.80</td>
<td>2.00</td>
<td>2.33</td>
<td>2.67</td>
<td>5.00</td>
</tr>
</tbody>
</table>

4.00*

| | 1.00 | 2.33 | 5.00 | X113 |
| | .58  | .53  | 2.67  | X123 |
| | .25  | .20  | 2.33  | X222 |
| | .67  | .18  | 2.00  | X112 |
| | .16  | .08  | 1.80  | X212 |
| | .16  | .06  | 1.75  | X122 |
| | .18  | .08  | 1.67  | X223 |
| | .18  | .08  | 1.38  | X121 |
| | .16  | .06  | 1.36  | X211 |
| | .16  | .06  | 1.30  | X111 |
| | .16  | .06  | 1.20  | X221 |
| | .16  | .06  | 1.00  | X213 |

*p < .05/12

**TABLE 28**

Stage Classification Unweighted Mean Comparison Matrix for Dunn's Test

- X111 EIII-Male-Stage I n=13
- X112 EIII-Male-Trans. I n=3
- X113 EIII-Male-Stage II n=1
- X121 EIII-Female-Stage I n=13
- X122 EIII-Female-Trans. I n=4
- X123 EIII-Female Stage II n=3
- X211 EIV-Male-Stage I n=14
- X212 EIV-Male-Trans. I n=5
- X213 EIV-Male-Stage II n=2
- X221 EIV-Female-Stage I n=15
- X222 EIV-Female-Trans. I n=3
- X223 EIV-Female-Stage II n=3
only one male in this cell, the results are only tentative, but they do suggest the need for further investigation with a larger cell size.

Summary and Further Discussion

In order to more fully assess and evaluate the results of the study, the major findings are summarized and discussed in relation to the questions posed and purposes stated in Chapter I. As indicated in Chapter I, and further supported in Chapter II, a variety of training approaches, emphasizing various component concepts of conservation, have been successful in accelerating the acquisition of conservation. However, as also indicated, the subjects in many of these studies were of middle socioeconomic status and possessed some aspects of conservation behaviors (i.e., the ability to establish one-to-one correspondence) prior to inclusion in the study. Thus one of the questions asked was whether the "successful" conservation training procedures would also be "successful" with lower socioeconomic status children and/or with children who do not possess conservation related skills prior to instruction.

The results of this study revealed that, when compared with a Control group (EIII: Control I) that did not receive any training, the Conservation Approach (EI) did
not produce any significant differences in the acquisition of conservation by 4- and 5-year-old lower socioeconomic status children no matter at what stage of development they were prior to training. Thus the previously "successful" training approaches were not shown to be "successful" with the population used in this study. It is important and interesting to note, however, that children in the Conservation group (EI) did exhibit significant differences in their acquisition of conservation related skills as shown by their significantly higher performance scores and stage classifications than did children who received no training. This finding indicates that the Conservation Approach is "successful" in accelerating the acquisition of conservation related skills and suggests the possibility that continued experiences may have resulted in conservation acquisition.

As is indicated in Graphs III and IV, the children in the Conservation group (EI) showed continued increases from pretest to posttest with no indication that the asymptote had been reached. Thus it appears that although an attempt was made to measure the effect of time and number of instructional sessions in interaction with treatment conditions on achievement, the length of time and number of lessons chosen may have been insufficient to produce optimum results. Therefore, no definite conclusions can be
drawn about the inappropriateness of these experiences in stimulating conservation acquisition by 4- and 5-year-old lower socioeconomic status children until further study resolves this question. However, it can be said that the Conservation Approach is a successful means of establishing basic mathematical and conservation related skills with these children.

Since an understanding of numerical operations is presumed to depend upon a prior understanding of numerical constancies, a second question that was raised concerned the extent to which a Set Theory Approach, which is the basis of most readiness programs in mathematics, facilitates the acquisition of conservation or conservation related skills. The results of the study revealed that no significant differences were shown to exist between the Set Theory group (EII) and the Control group (EIII: Control I) in terms of conservation acquisition or the acquisition of conservation related skills. This same finding was also true for children at each stage of development. Thus it can be concluded that the provision of mathematical or numerical readiness experiences, which emphasize sets and the variance in number brought about through operations on sets, prior to the acquisition of conservation, will not result in an understanding of numerical constancies. It also will not result in any significant increases in the
conservation related skills of one-to-one correspondence and the concepts of "same" and "more" in relation to number.

A third purpose of the study was to 1) compare the effectiveness of each of these two types of experiences in facilitating the acquisition of conservation of number or conservation related skills and 2) determine if there are stage appropriate activities by comparing the relative effectiveness of each of these approaches for each of the levels of development. No significant differences were shown to exist in the acquisition of conservation by 4- and 5-year-old lower socioeconomic status children under each treatment condition, nor were there any significant differences when analyzed for each stage of development. As for the acquisition of conservation related skills, the Conservation group (EI) was shown to be significantly (borderline) higher than the Set group (EII), although there were no differences for any of the developmental stages. If the acquisition of conservation of number by the Conservation group (EI) had been shown to be significantly greater than that acquired by the Set Theory group (EII), it would have been possible to suggest that perhaps the greater similarity between treatment and the testing situation had contributed to this difference. However, this was not the case. The main difference between the groups tended to be
in terms of the ability to 1) set up one-to-one correspondence and 2) establish that the sets were equivalent and that neither set had "more." It is interesting to note that the development of both of these skills was a common objective for both treatment conditions. Examination of the activities, in an attempt to explain the difference, revealed that in the Conservation group primary emphasis was placed upon development of the concept of "same" with respect to one-to-one correspondence, whereas in the Set group there was an approximately equal emphasis on "same," "more" and "less." Thus it appears that a unified single concept emphasis, rather than a multiple concept emphasis, is more effective in the initial establishment of basic mathematical concepts with 4- and 5-year-old lower socio-economic status children.

An additional purpose of this study was to determine the efficiency of each of these approaches (Conservation and Set), in developing numerical understandings, by assessing the amount of time or number of instructional sessions needed to facilitate the acquisition of conservation of number or conservation related skills. Neither group was shown to be more "efficient" since there were no significant differences on the intermediate test in terms of either conservation of number acquisition or the acquisition of conservation related skills for either treatment.
condition. This same finding was true for each stage of
development. The only conclusion possible at this time is
that significant differences have been shown to exist in
the acquisition of conservation related skills after partici-
cipation in 12, but not 6, Conservation instructional ses-
sions. No significant differences were shown to exist for
the Set Theory (EII) group even after 12 lessons and, in
fact, a decrease in performance (although not significant)
ocurred between the sixth and twelfth lessons (from inter-
mediate to posttest).

A final question that was raised was whether there
would be significant differences in the effectiveness of
each treatment condition for each sex. Although in two
previous studies (Baker and Sullivan, 1970; and Wasik and
Wasik, 1971) with lower socioeconomic status children,
males tended to score significantly higher than females,
this was not found to be the case in this study. No signi-
ficant sex differences were shown to exist in terms of the
acquisition of conservation of number or conservation re-
lated skills as a function of treatment conditions and in
interaction with stages of development. It is important
to note, however, that of the three children who did
achieve conservation all were males.
CHAPTER V

SUMMARY, DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

Summary

The present investigation was conducted in order to determine the effectiveness and efficiency of two types of training approaches (Conservation and Set Theory) in facilitating the acquisition of 1) conservation of number and/or 2) conservation related skills in nonconserving 4- and 5-year-old lower socioeconomic status children. A second major purpose was to determine if the effectiveness and/or efficiency of the training approaches were influenced by the developmental status and/or sex of the subjects. The study was directed by five major questions:

1. How effective are training procedures based on component concepts of conservation in facilitating the acquisition of conservation of number or conservation related skills in lower socioeconomic status children, and what is the effect of these experiences for children at each of the conservation of number substages of development?

2. How effective are training procedures based on a set theory approach to numerical understanding in facilitating the acquisition of conservation of number or conservation related skills in lower socioeconomic status children, and what is the effect of these experiences for children at each of the conservation of number substages of development?
3. Are there any significant differences in the effectiveness of experiences emphasizing the component concepts of conservation and the effectiveness of experiences based on a set theory approach to number in facilitating the acquisition of conservation of number or conservation related skills, or in the effectiveness of each of these experimental conditions at each of the conservation of number substages?

4. Are there any significant differences in the efficiency of each of the approaches in facilitating the acquisition of conservation of number or conservation related skills, or for each of the substages of development?

5. Are there any significant sex differences in the effectiveness and/or efficiency of each of these approaches in facilitating the acquisition of conservation of number or conservation related skills or in interaction with each of the substages of development?

The null hypotheses of the study were:

1. There are no significant differences in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills
   by 4- and 5-year-old lower socioeconomic status children on the conservation of number intermediate test and/or posttest as a result of treatment conditions.

2. There are no significant differences in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills
   by 4- and 5-year-old lower socioeconomic status children on the conservation of number intermediate test and/or posttest as a function of their stage of development in interaction with treatment conditions.

3. There are no significant differences in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills
   by 4- and 5-year-old lower socioeconomic status children on the conservation of number intermediate test and/or posttest as a result of the
sex of the subjects in interaction with treatment conditions.

4. There are no significant differences in the acquisition of
   a. conservation of number; and/or
   b. conservation related skills
by 4- and 5-year-old lower socioeconomic status children on the conservation of number intermediate test and/or posttest as a function of their stage of development and sex in interaction with treatment conditions.

In addition to the main hypotheses, a number of related questions were also investigated:

1. Are there any significant differences in the effectiveness of treatment conditions for each age level (4's and 5's)?

2. Are there any significant individual and/or group differences in the degree to which instructors employed the interactive strategy?

3. Are there any significant differences in the effectiveness of instructors?

4. Are there any significant differences in the adequacy of response rationales as a result of treatment conditions?

5. Are there any significant effects of repeated testing?

The 194 subjects in the study were drawn from Head Start centers, Title I kindergarten programs, and social welfare supported preschool and day care centers in Franklin County, Ohio. Following pretesting, subjects were classified according to their developmental status with respect to conservation of number and by sex. Subjects were then randomly assigned within the stage/sex classification blocks to levels of the treatment conditions.
There were three experimental conditions using a pretest-intermediate test-posttest model:

1. Experimental group I (EI): Conservation Approach
twelve 10-15 minute instructional sessions
emphasizing the component concepts of conservation and the invariant aspects of number;

2. Experimental group II (EII): Set Theory Approach
twelve 10-15 minute instructional sessions
emphasizing the concepts of sets and the variant aspects of number; and

3. Experimental group III (EIII): Control I
no treatment.

In addition a fourth group was included in order to assess the effects of repeated testing. This group, Experimental group IV (EIV): Control II, received only the pretest and posttest with no intermediate testing.

All subjects were tested individually in an area separate from their regular classroom. The testers were 20 junior and senior white female undergraduate elementary education majors at The Ohio State University. The testing instrument, which was used as the pretest, intermediate test, and posttest, was a modified version of the standard Piagetian paradigm. Rather than requiring a response rationale as a criteria for conservation status, Rothenberg's (1969) two questions agreement/disagreement response format ("Are there the same number?"--"Are there more?") was employed. Rather than classify children as "conservers" or "nonconservers," an ordinal scoring system, for performance scores and corresponding stage classifications,
was used in order to more specifically indicate or represent the status of each child with respect to his ability to 1) set up one-to-one correspondence, 2) establish the equivalence of matched sets, and 3) maintain the equivalence during perceptual transformations.

Each subject in treatment conditions EI: Conservation Approach and EII: Set Theory Approach participated in twelve 10-15 minute group (n=4) sessions. Only one lesson was taught per instructional session and instructional sessions followed a Monday, Wednesday, Friday pattern of occurrence. The lessons themselves, as well as the general instructional procedures, were standardized or systematized within each experimental condition. Both conditions used an interactive instructional strategy and both involved children as active participants and manipulators of objects. Although the nature of the activities for the two approaches was similar, they differed in their emphasis on the invariant or variant aspects of number. The specific skills and concepts which were emphasized included: 1) matching or one-to-one correspondence; 2) provoked discrimination of "same," "more," and "less"; 3) cognitive conflict through both organism-object and organism-organism conflict situations; 4) verbal training and verbal rule instruction; and 5) reinforcement through information feedback. Nine junior and senior white female
undergraduate elementary education majors at The Ohio State University served as instructors.

Due to attrition factors, data were collected and analyzed for 151 of the 194 original subjects. The main analysis concerned 1) the effectiveness and efficiency of the two types of instructional experiences (Conservation and Set Theory) in facilitating the development of conservation of number and/or conservation related skills by 4- and 5-year-old lower socioeconomic status children, and 2) the differential effectiveness and efficiency of training conditions with children classified according to their developmental status and/or sex. The effectiveness and efficiency of training conditions in facilitating the acquisition of conservation was determined through an analysis of the number of children in each condition exhibiting the conservation response on the intermediate test and posttest. Analysis of variance was used to determine if significant differences existed on the intermediate test and posttest in the performance scores and stage classifications of children under each treatment condition, thus indicating the effectiveness and efficiency of instruction in facilitating the acquisition of conservation related skills.

Results of the study related to the acquisition of conservation of number revealed that only 3 children (2 in
EI: Conservation and I in EIII: Control I) exhibited the conservation response on the posttest. The existence of empty cells and the very low observed frequencies of acquisition negated use of the Chi Square analysis of significant differences. The findings were insufficient to warrant rejection ($\alpha = .05$) of the omnibus null hypotheses:

There are no significant differences in the acquisition of conservation of number by 4- and 5-year-old lower socioeconomic status children on either the intermediate test or posttest as a result of:

- $H_1-a$: treatment conditions;
- $H_2-a$: the interaction of treatment conditions and stages of development;
- $H_3-a$: the interaction of treatment conditions and sex; and
- $H_4-a$: the interaction of treatment conditions, stages of development, and sex.

After 12 instructional sessions, neither the Conservation Approach nor the Set Theory Approach was effective in facilitating the acquisition of conservation of number by 4- and 5-year-old lower socioeconomic status children as a group. Also, there was no differential effectiveness shown by either approach with children at different stages of development. In addition, although it is not possible to show significant differential effectiveness with each
sex, it is interesting to note that of the three children who did achieve conservation status, all were males.

The analysis of variance results for the interaction effects of 1) treatment conditions and stages of development; 2) treatment conditions and sex; and 3) treatment conditions, stages of development, and sex revealed no significant differences in performance scores or stage classifications on either the intermediate or posttest. Therefore, it was not possible to reject ($\alpha = .05$) the omnibus null hypotheses:

There are no significant differences in the acquisition of conservation related skills by 4- and 5-year-old lower socioeconomic status children on either the intermediate test or posttest as a function of:

- $H4-b$--the interaction of treatment conditions, stages of development, and sex;
- $H3-b$--the interaction of treatment conditions and sex; and
- $H2-b$--the interaction of treatment conditions and stages of development.

Treatment conditions were not differentially effective or efficient with children of different stages of development and/or either sex.

Significant differences were shown to exist in the overall acquisition of conservation related skills by 4- and 5-year-old lower socioeconomic status children as a
result of treatment conditions. Therefore, it was possible to reject ($\alpha \leq .05$) the omnibus null hypothesis, H1-b, of no significant differences in the acquisition of conservation related skills by 4- and 5-year-old lower socioeconomic status children on either the intermediate test or posttest as a result of treatment conditions.

Post hoc analysis revealed that children who participated in 12 Conservation Approach instructional sessions over a five week period exhibited significantly higher performance scores and stage classifications on the posttest than did children in the Control group (EIII: Control I) who did not receive any training. In addition, the posttest stage classifications of the Conservation group (EI) were significantly higher than the posttest stage classifications of children in the Set Theory group (EII). Also, the mean performance score of the Conservation group (EI) just missed (by .01) being significantly higher than the mean performance score of the Set Theory group (EII). Thus, after 12 instructional sessions over a five week period, the Conservation Approach (EI) was shown to be the most effective means of facilitating the acquisition of conservation related skills.

The results of the analyses performed in order to resolve the related questions indicated that:
1. There were no significant differences in the effectiveness of treatment conditions for each age level (4's and 5's).

2. Significant differences did exist in the extent to which individual instructors employed the interactive strategy, although they all exhibited a high percentage of behaviors characterized as interactive (55.2-75%). However, when instructors were grouped according to treatment conditions, no significant differences were shown to exist, thus indicating that instruction was a constant across treatments.

3. No instructors were shown to be significantly more effective than any others.

4. No significant differences were shown to exist in the adequacy of response rationales as a result of treatment conditions.

5. Repeated testing resulted in significantly higher performance scores for children who received the intermediate test as compared to children who did not. In addition, there was also a qualitative difference with males scoring higher than females in the testing condition but lower than the females in the non-testing condition. In terms of stage classifications, an interaction effect of repeated
testing, stage of development, and sex was revealed. Post hoc analysis indicated that it was Stage II males in the repeated testing condition who scored significantly higher. However, as there was only one subject in this cell, results should be viewed as tentative. Nevertheless, the results do suggest the need for further investigation with a larger cell size.

**Discussion and Conclusions**

In reflecting upon the findings of the present investigation in relation to the various theoretical explanations of conservation acquisition and the results of corresponding previous studies several conclusions become apparent.

After 12 instructional sessions, the previously successful training approaches for conservation of number (emphasizing various component concepts of conservation) were not found to be successful in facilitating the acquisition of conservation by the population used in this study. However, the Conservation Approach (EI) was shown to be significantly more effective than the control (EIII: CI) in accelerating the acquisition of conservation related skills (one-to-one correspondence, and an understanding of "same," "more," and "less"). Also only the EI group showed consistent increases in performance scores and stage classifications from pretest to posttest.
In light of these findings, a number of possible explanations can be suggested for the failure of the Conservation Approach to stimulate conservation acquisition despite significant acquisition of conservation related skills. The first possible explanation, which is drawn from Piagetian theory, is that although an appropriate experiential basis may have been provided (as indicated by the significant acquisition of conservation related skills) these children may not have possessed sufficient maturation to permit the formation of new cognitive structures which would allow a general shift in intellectual functioning from pre-operational to concrete operational thought. A second related explanation is that while the experiential basis may have been appropriate and/or necessary for facilitating the acquisition of conservation related skills, it may not have been sufficient to induce conservation acquisition. Also there is the possibility that both a lack of maturation and an insufficient experiential basis may have been operating to prevent the acquisition of conservation and the corresponding entrance into the period of concrete operations.

Another possible explanation is that the teacher substantive interactive instructional strategy may have provided insufficient opportunity for student-student social interaction. Social interaction, within Piagetian
theory, is assumed to be an important factor in the breakdown of egocentrism and the corresponding decentering of perceptions which are necessary for conservation to occur. Still another possible explanation, and one that is perhaps most evident on the basis of the data, is that the length of time and number of instructional sessions used in this study may have been insufficient to produce optimum results. The fact that EI children showed consistent increases in performance from pretest to posttest suggests the possibility that continued experiences may have resulted in conservation acquisition. Thus the lack of effectiveness of the Conservation Approach may have been more a function of time and the number of instructional sessions than a result of the activities employed.

Since the Conservation Approach was shown to be a successful means of facilitating the development of basic mathematical and conservation related skills and concepts, in 4- and 5-year-old lower socioeconomic status children, it can be concluded that it is important to provide these children with conservation experiences or experiences which emphasize the invariant aspects of number. However, because of the number of factors which could possibly account for the fact that the previously successful conservation approach did not result in conservation acquisition by the population in this study, no definite conclusions
can be drawn about the inappropriateness of these experiences in stimulating the acquisition of conservation of number. Further study is needed in order to determine whether continued experiences would have resulted in conservation. Additional research is also needed in order to determine 1) the effect of instructional strategy on conservation attainment; and 2) the effects of the Conservation Approach with an older (6- and 7-year-old) and more mature group of nonconserving children.

The Set Theory Approach, which is the basis for most readiness programs in mathematics, was not shown to significantly facilitate the acquisition of conservation of number or conservation related skills in 4- and 5-year-old lower socioeconomic status children. Two possible general explanations can be suggested for the failure of the Set Theory Approach to facilitate the acquisition of conservation. The first refers to the Piagetian related factors of maturation, experience, and social interaction. As with the Conservation Approach, the children may not have been at a maturational level which would have permitted the intellectual shifts necessary for conservation, the experiences provided may not have been (and probably were not, as shown by the lack of effectiveness in facilitating the acquisition of conservation related skills) of the type necessary for learning to occur, or both. Also,
as in the Conservation Approach, the instructional strategy used may have provided insufficient opportunity for student-student social interactions which are presumed necessary for stimulating a breakdown in egocentrism and a corresponding decentering of perceptions. The second general explanation concerns the complexity of thinking required for the child to conclude and then infer that "since an operation (addition, subtraction . . .) on a set resulted in a change in the number of the set, no operation means no change in number." Such an inference requires the child to coordinate dimensions, see relationships, attend to transformations, reverse his thought, and recognize cause and effect, as well as reflect upon the totality of the situation. Such a level of thought has not been shown to be possible for the pre-operational (nonconserving) child.

While the failure of the Set Theory Approach to result in significant acquisition of conservation of number by 4- and 5-year-old lower socioeconomic status children is not particularly surprising because of the factors just mentioned, the failure of this approach to significantly facilitate the acquisition of conservation (and basic mathematical) related skills was unexpected. This latter finding was further underscored by the fact that the Conservation Approach did result in significant
acquisition of these skills and there was a significant difference between the two approaches. In order to attempt to explain this difference the specific activities employed in the two approaches were examined critically. This examination revealed that the Conservation activities placed primary emphasis upon the development of the concept of "same" with respect to one-to-one correspondence, while the Set Theory activities placed approximately equal emphasis upon the concepts of "same," "more," and "less." This finding seems to suggest that a unified single concept emphasis rather than a multiple concept emphasis is more effective in the initial establishment of basic mathematical skills and concepts with 4- and 5-year-old lower socioeconomic status children.

A possible explanation for the greater successfulness of the unified single concept emphasis of the Conservation Approach can be drawn from integrating the research regarding children's understanding of the relational terms used in questioning procedures with either Piaget's equilibration theory or a learning theory description of the formation of response sets. Results of previous investigations (Beilin, 1965; and Pratoomraj, Siegel, and Goldstein, 1969) of young children's (aged 4 to 7) understanding of relational terminology indicate that while these children seem to understand the relational terms "more"
and "less," the majority do not understand the meaning of "same." Within Piagetian theory, this suggests that in a situation where all three terms receive approximately equal emphasis the children may tend to focus on the familiar aspects of the situation (i.e., their understanding of "more" and "less" meaning different). They assimilate (rather than accommodate) the unfamiliar term "same" (especially when used in relation to perceptual transformations) into their existing schemata of "different" without recognition of how the two "differences" were brought about (i.e., operation or transformation). In the Conservation Approach, however, the consistency of emphasis on the unfamiliar concept and terminology ("same") may have prevented assimilation thus resulting in disequilibrium. In order to resolve this disequilibrium, the children were forced to accommodate their thinking and thus "learn" the meaning of "same." Similarly, from a learning theory basis, it might be suggested that in the Set Theory Approach the greater opportunity to respond to changes and therefore differences which can be described by familiar terminology ("more" or "less") established a response set which generalized to unfamiliar "changes" (transformations) and corresponding terminology ("same"). Again, in the Conservation Approach, the consistent attention to and emphasis on the unfamiliar concept of "same," without
the interfering familiarity of responses to "more" and "less," may have provided the necessary practice in making correct responses required for establishment of an appropriate response set to "same:"

While it is not possible to completely explain why the differences between the Set Theory Approach and the Conservation Approach occurred, the specific findings with respect to the lack of effectiveness of the Set Theory Approach in providing successful mathematical readiness experiences for 4- and 5-year-old lower socioeconomic status children are of great educational importance. Not only was the Set Theory Approach unsuccessful in establishing an understanding of numerical constancy but it was also unsuccessful in facilitating the development of basic mathematical and conservation related skills of one-to-one correspondence or the concepts of "same" and "more" in relation to number. Thus it must be concluded that a change in the type of basic mathematical readiness experiences provided for 4- and 5-year-old lower socioeconomic status children appears warranted. However, it must be remembered that the long term effects of these two approaches have not been assessed; nor has it been determined whether similar results would be found with older (6- and 7-year-old) nonconserving children or with children of other socioeconomic status levels.
The acquisition of conservation or conservation related skills was not shown to be affected by the children's pretest developmental status and there was no differential effectiveness of treatment conditions shown with children at various stages of development. Children at each stage of development within each treatment condition did not differ significantly in the achievements they exhibited.

These findings were surprising and somewhat difficult to explain. One possible explanation is that the marked disproportionate stage cell sizes (SI~25; TI~8; SII~3) within each treatment condition and/or the conservative unweighted means analysis of variance necessitated by the unequal n's may have resulted in an estimate of variance much more conservative than the true population variance. Further study with an equal number of subjects at each stage of development is necessary in order to resolve this question. At this point it can be concluded, however, that 1) since the Conservation Approach was shown to significantly facilitate the acquisition of basic mathematical and conservation related skills and concepts and 2) since this acquisition was not affected by the children's pretest developmental status, training using the Conservation Approach can begin for 4- and 5-year-old lower socioeconomic status children at any stage of development (SI, TI, SII).
No significant sex differences were shown to exist in terms of the acquisition of conservation of number or conservation related skills as a function of treatment conditions or in interaction with stages of development. This finding is consistent with the majority of studies which have not indicated any significant differences between males and females in their natural performance or in their performance following training on conservation tasks (Almy, Chittenden, and Miller, 1966; Shantz and Sigel, 1967; Pattison, 1969; Rothenberg and Orost, 1969; Peters, 1970; Roll, 1970; Figurelli and Keller, 1972; and Hamel, Van der Veer, and Westerhof, 1972). However, it is inconsistent with the findings of Baker and Sullivan, 1970, and Wasik and Wasik, 1971, who indicated that lower socioeconomic status males tend to score significantly higher than lower socioeconomic status females. Further examination of the performance of males and females in the present investigation revealed that 1) males in all treatment conditions tended to exhibit higher performance scores and stage classifications than females, and 2) of the three children who achieved conservation all were males. Such findings prevent definite conclusions regarding the inexistence of sex differences in the conservation development of lower socioeconomic status children. Further examination of the factors which tend to produce sex differences is warranted.
The efficiency of the Conservation Approach and the Set Theory Approach in facilitating the acquisition of conservation of number or conservation related skills was to be determined by assessing the amount of time or number of instructional sessions needed by each approach to effectively facilitate these acquisitions. Since no significant differences were shown to exist on the intermediate test (after 6 lessons) and since only the Conservation Approach was effective in producing significant differences on the posttest (after 12 lessons) neither the Set Theory Approach nor the Conservation Approach was shown to be more efficient although the Conservation Approach was shown to be more effective. The only conclusion possible is that the efficiency of the two approaches could not really be evaluated due to the fact that the Set Theory Approach was not shown to be effective even after 12 lessons.

No significant differences were found to exist in the effectiveness of treatment conditions for each age level. One possible explanation for this finding is that the absolute difference in ages was not as great as implied by the two year age range used for inclusion in the study. Sixty-two and four tenths percent of the children were between the ages of 4 years-6 months and 5 years-2 months (68/109); 76.1% (83/109) were between the ages of 4-3 and
5-2; while 87.2% (95/109) were between the ages of 4-3 and 5-6. Another possible explanation is that at the 4- and 5-year-old age level, age is not an important influencing factor with lower socioeconomic status nonconserving children.

The finding regarding age is of importance, however, because it suggests that the use of an "effective" training approach (i.e., the Conservation Approach) for basic mathematical and conservation related skills and concepts can begin for lower socioeconomic status children, at either age level. What remains to be determined is if there is a long-term difference in the effectiveness of this training or if other socioeconomic status groups would react differently.

Despite the fact that both verbal rule instruction and instruction in relational terminology were provided, no significant differences were shown to exist in the adequacy of response rationales given by 4- and 5-year-old lower socioeconomic status children as a result of treatment conditions. This finding is especially interesting in view of the significant increases in conservation related skills shown by children in the Conservation Approach group. Although these children exhibited the ability to correctly establish the equivalence of two sets ("Are there the same number in each row?") and to
correctly deny the inequivalence of the same two sets ("Does one row have more?"), they were unable to explain their agreement-disagreement responses. This finding lends support to Piaget's contention that the formation of mental structures precedes language development. It also reemphasizes Rothenberg's (1969) conclusion that requiring explanations of lower socioeconomic status children leads to an underestimation of their abilities. In order to more accurately assess the abilities of young and/or lower socioeconomic status children, assessment techniques are needed which provide an opportunity for cognitive processes to be exhibited without requiring a corresponding competence in language.

The nature of instruction is known to be a critical factor in student achievement. Although previous studies have failed to control for this important variable, this was not the case in the present investigation. Individual instructors were found to differ significantly (even after training) in the degree to which they affected the interactive strategy. The two instructors who had the lowest mean interactive strategy indices tended to have higher indices for teacher directed substantive behaviors, teacher interactive managerial behaviors, and student interactive substantive behaviors than the two instructors who had the highest mean interactive strategy indices. And interestingly, the two instructors who had the lowest indices both
instructed children in the same two Head Start centers, whereas the two instructors who had the highest indices both worked with children enrolled in public school pre-kindergarten classes. This latter observation suggests two immediately evident possible explanations. First, the previous experiences of the children may have influenced the degree to which the given instructional strategy could be affected. Second, random assignment (chance) may have resulted in the placement of similar instructors (in terms of their ability to use the interactive strategy) in similar educational settings.

Despite the significant differences in the degree to which individual instructors affected the interactive strategy, no significant differences were shown to exist in the effectiveness of individual instructors. Furthermore, and perhaps even more importantly, no significant differences were shown to exist in the mean interactive strategy indices of the two approaches, thus indicating that instruction was a constant across treatment conditions. The importance of these findings is that they emphasize the need to control for instruction through objective observational systems if "results" are to be meaningful. In addition, the high interactive strategy indices (55.2-75%) of the instructors in this study reaffirms the fact that instructors can be trained (and in a very short period of time) to use a particular instructional strategy.
While establishing that the differences in the effects of training approaches were not due to the instructional strategy employed in the study, the question remains as to whether the interactive strategy is the most effective means of instruction with respect to these concepts and/or this particular population. Further study is necessary to resolve this question as well as to determine whether the nature of the children's previous experiences may affect the degree to which a given instructional strategy may be affected.

Finally, exposure to an additional testing situation was shown to increase significantly the performance of 4- and 5-year-old lower socioeconomic status children, especially males. Since no feedback was given as to the correctness or incorrectness of the children's responses, the significant difference cannot be explained by principles of reinforcement or learning via the development of correct response sets. The most evident explanation for this finding thus appears to be that the additional test provided the opportunity for the children to become familiar with the testers and/or provided the opportunity to practice and become comfortable in responding to direct requests in a testing situation.

The importance of the finding is that it suggests that practice items and/or practice testing situations
should be provided if a true evaluation of these children is to occur. In addition, it suggests that when single assessments are made in order to determine the conservation of number status of 4- and 5-year-old lower socioeconomic status children, the results should be viewed as conservative estimates of the children's true abilities.

Implications

The results of the present investigation and the literature reviewed in Chapter II warrant a number of implications for both education and further research.

Education

The educational implications which can be drawn from this study relate primarily to the interrelated areas of classroom practice, curriculum development, and teacher education:

1. Since the Conservation Approach was significantly more effective than the traditional Set Theory Approach in facilitating the development of basic mathematical and conservation related skills by 4- and 5-year-old lower socioeconomic status children, there is a need to revise the nature of mathematical readiness experiences at least for children of this age and status. Nonconserving children of this age and status need to have specific experiences which emphasize the invariant aspects of number in
order to establish basic mathematical and conservation related skills and concepts.

2. A unified single concept approach, emphasizing the concept of "same" with respect to number, appears to be the more effective means of initially establishing the basic mathematical and conservation related skills of one-to-one correspondence and an understanding of "same," "more" and "less" with respect to number. A multiple concept approach which places equal emphasis on developing an understanding of all three terms was found to be less effective.

3. Effective mathematical training (using the Conservation Approach) for the basic skills and concepts of one-to-one correspondence, and the understanding of "same" and "more" with respect to matched sets, can begin as early as age 4 with lower socioeconomic status children.

4. Due to the fact that young and/or lower socioeconomic status children may not possess verbal skills consistent with their intellectual functioning, assessment techniques which provide an opportunity for cognitive processes to be exhibited without requiring a corresponding competence in language are needed and/or should be employed if true evaluations are to occur.

5. Since exposing 4- and 5-year-old lower socioeconomic status children to an additional testing situation
significantly increased their acquisition of conservation related skills, there is a need for the provision of practice items and/or practice testing situations in order to help these children become accustomed to testing procedures and consequently insure more accurate assessments of the children's true abilities.

6. Single assessments of 4- and 5-year-old lower socioeconomic status children should be regarded as only conservative estimates of their abilities.

7. Since instructors can be trained in a very short period of time to effectively control their own behaviors and affect a given instructional strategy, there is a need to give more attention to this critical factor in educational training.

Further Research

The implications for further research are mainly concerned with 1) refinements, extensions, and elaborations of the findings, methods, and procedures used in the present investigation, and 2) determining the generalizability of the specific findings to children of other ages, stages, and/or economic statuses:

1. There is a need to determine whether continued experiences with the Conservation Approach would result in conservation acquisition.
2. There is a need to determine whether children who show significantly greater increases in the acquisition of conservation related skills as a result of conservation training will conserve sooner (without additional training) than children who did not exhibit the increases.

3. There is a need to determine whether there are any significant long-term differences in the effects of Conservation or Set Theory training.

4. There is a need to determine whether there would be significant differences in the effectiveness of Conservation and/or Set Theory training for middle socioeconomic status children.

5. There is a need to determine if the results of the present investigation would be duplicated with older (6- and 7-year-old) nonconserving children.

6. Due to the marked disproportionate number of subjects at each stage of development in the present investigation, further study of the possible interactive effects of treatment conditions and developmental status, with an equal number of subjects at each stage, is warranted.

7. Further study of the factors which result in sex differences in conservation development of lower socioeconomic status children is needed.

8. There is a need to confirm the finding regarding the greater effectiveness of a unified single concept approach as opposed to a multiple concept approach in the
initial establishment of basic mathematical and conservation related skills and concepts.

9. There is a need to determine the effects of a unified single concept approach and the effects of a multiple concept approach in establishing basic mathematical and conservation related skills and concepts with middle socioeconomic status children.

10. There is a need to determine if differential effects of treatment conditions would occur with children who understand "more" and "less" but not "same" and children who lack an understanding of all three terms.

11. There is a need to determine whether the amount of time between instructional sessions affects the results.

12. The effectiveness of other instructional strategies, especially ones with more student-student interaction, in facilitating the acquisition of conservation of number related skills needs to be determined.

13. There is a need to determine whether the nature of children's previous experiences affects the degree to which a given instructional strategy can be affected.

14. Since instructors can be trained in a very short period of time to effectively control their own behaviors and affect a given instructional strategy, there is a need to give more attention to this critical factor in educational research.
15. Since exposing 4- and 5-year-old lower socioeconomic status children to an additional testing situation significantly increases their acquisition of conservation related skills, it appears important to determine the effect of additional testing and/or testing over time on performance and, also, whether this finding holds with middle socioeconomic status children.

16. Finally, and perhaps most importantly, there is a need to determine the effectiveness of training (Conservation or Set) which is provided by the child's own teacher and which evolves as a natural outgrowth of the ongoing activity and interests of the children.
APPENDIX A

CONSERVATION OF NUMBER
PRETEST-POSTTEST
**Introduction of the Materials**

Following a few minutes of informal conversation between the tester and the subject, in order to establish rapport, the materials (12 red and 12 black checkers) to be used in the conservation of number tasks shall be shown to the child. When introducing the materials to the child, the tester shall ask: "Do you know what these are called?" If the child answers correctly, he shall be told "Yes, that is right, these are 'checkers.'" If the child answers "No," does not respond, or gives an incorrect answer, he shall be told that they are called "checkers."

If the child has not already reached for the checkers and begun playing with them, the tester shall encourage him to do so by asking "Would you like to touch the checkers—or pick them up?" While the child is manipulating the checkers the tester shall then indicate the "red checkers" and the "black checkers." After allowing for a minute or two of manipulation and informal conversation, the tester shall tell the child that the checkers are going to be used in a game they are going to play. The tester shall then put on the table "the game board" which shall be a 14" x 9" piece of white poster board. The tester shall ask the child which color checkers he would like to use, and then put them in a pile in front of the child. If the child does not indicate a preference, the
The tester shall either arbitrarily give him one color or else give him the color he seemed most attracted to during the warm-up time.

The Test

Item 1

The tester shall begin the test by saying "I'm going to put some of my checkers in a row on the game board."

(Tester places 6 checkers in a row on the board.)

"This is my row," (point to the row of checkers).

1) Then the tester shall say to the child "I want you to make a row with your checkers that has the same number or amount as mine."

2) After the child has placed his checkers on the board, whether correctly or incorrectly, he is to be asked "Are there the same number or amount of checkers in each row?"

3) Following the child's response whether "Yes" or "No," the tester shall ask "Why?"

4) The tester shall then ask the child "Does one row have more?"

5) "Why?"
Item 2

Repeat item 1 with 8 checkers.

Item 3

If the child successfully completed parts 1, 2 and 4 of items 1 and 2, then the equivalence of the two rows to be used in items 3 and 4 will be evident. If the child was unsuccessful on items 1 and 2, then the tester must establish the equivalence of the rows and explain to the child that there are the same number or amount in each row because for every black checker there is a red checker and for every red checker there is a black checker.

1) The tester shall then direct the child "Watch what I do" as he extends his (the tester's) row. The tester shall then ask the child "Are there the same number or amount of checkers in each row?"
2) "Why?"
3) "Does one row have more?"
4) "Why?"
**Item 4**

Exactly the same as item 3 except that this time after the equivalence is established, the tester contracts (rather than expands) his row.
APPENDIX B

ANSWER SHEET FOR CONSERVATION

OF NUMBER PRETEST-POSTTEST
Name __________________________ Date __________________________
Age __________________________ Sex  M  F
Birth Date ______________________ Race __________________________
School __________________________ Time __________________________
Teacher __________________________ Instructional Group ___________
Tester __________________________ Test 1  2  3

Classification:  SSI  TI  SSII  TII  SSIII

Item 1

1.  ______Correctly formed row ______by matching ______by counting ______other--record

   ______Incorrectly formed row
   ______No response*
   *If after 3 attempts he still gives no response discontinue testing.

2.  "Are there the same number or amount in each row?"
   Record exactly


4.  "Does one row have more?"  Record exactly.

5.  "Why?"

Item 2

1.  ______Correctly formed row ______by matching ______by counting ______other--record

   ______Incorrectly formed row

2.  "Are there the same number or amount in each row?"
3. "Why?"

4. "Does one row have more?"

5. "Why?"

**Item 3**
1. "Are there the same number or amount of checkers in each row?"
2. "Why?"
3. "Does one row have more?"
4. "Why?"

**Item 4**
1. "Are there the same number or amount of checkers in each row?"
2. "Why?"
3. "Does one row have more?"
4. "Why?"
There are 12 lessons for each of the two experimental approaches. The nature of the activities for the two approaches is similar, the differences lie in the emphasis placed on the invariant or variant aspects of number in accordance with the following objectives:

**Conservation Approach (EI)**

1. to develop an understanding of one-to-one correspondence and how this can be used to determine whether two sets are equivalent or whether one set has "more" or "less" than another;

2. to develop an understanding that changing the arrangement of the objects in the set does not change the number of elements in the set.

**Set Theory Approach (EII)**

1. to develop an understanding of one-to-one correspondence and how this can be used to determine whether two sets are equivalent or whether one set has "more" or "less" than another;

2. to develop an understanding that adding to or subtracting an element from a set changes the number of elements in the set.
The specific skills and concepts which are emphasized in order to meet the objectives include:

1. matching or one-to-one provoked correspondence with two homogeneously different but related sets;
2. matching or one-to-one spontaneous correspondence of homogeneous sets;
3. provoked discrimination of "same," "more," and "less";
4. cognitive conflict--addition/subtraction versus invariance; social interaction and confrontation of ideas;
5. verbal training and verbal rule instruction; and
6. reinforcement through information feedback.

At the beginning of each instructional session, the instructor should take a few minutes to talk informally with the children in order to establish rapport. In teaching each lesson several guidelines should be observed:

1. Several (or all) children should be encouraged to respond to each question.
2. Interesting responses should be explored further by asking for clarifications, elaborations, or more information.
3. Interaction between children should be encouraged.
4. Responses should be summarized and reflected back to the children before manipulations (i.e., Johnny and Billy think__________but Mary and Sandy think__________. Let's see who's right).

5. Children should do all matchings.

6. Children should be encouraged to explain (verbalize) their reasons for choices.

7. Following manipulations, acknowledgement for correct responses should be given.

8. The wording used in the activities may be altered slightly as long as the general format remains the same and emphasis is placed on the key terms and concepts.
Activity 1 Conservation Concepts

"Musical Chairs" (provoked correspondence)

Today we're going to play musical chairs. Have you ever played musical chairs? RESPONSES (If "yes"—Could someone tell us how to play?) Everyone get a chair and we'll put them in a line (all face the same direction). Does everyone have a place to sit? Why? Are there any chairs without children? Are there any children who don't have a chair? We have the same number of chairs as children because everyone has a place to sit and there are no empty chairs.

I'm going to clap my hands and I want you to march around the chairs. When I stop clapping you sit on a chair. Do you think everyone will have a place to sit? Why? Do you think there will be any chairs left over? Why? Let's find out. Ready to march? CLAP MARCH STOP SIT

Are there the same number of chairs as children? How do you know? Does everyone have a chair? Are there any chairs left over? We have the same number of chairs as children because . . . (above).

Repeat--march in other direction.

Repeat--SPREAD OUT THE CHAIRS What did I do? Are there the same number of chairs as children? Why? Will everyone have a place to sit? Will there be any empty chairs? How do you know? How can we find out? CLAP MARCH STOP SIT

Do we have the same number of chairs as children? How do you know? Does everyone have a place to sit? Are there any chairs left over? Since there was a chair for every child and a child for every chair, we have the same number of chairs as children. Does it make any difference if the chairs are spread apart? We still have the same number because . . .

Repeat--SPREAD THE CHAIRS OUT FURTHER What did I do? (Repeat questioning procedure above)
Repeat--BRING THE CHAIRS BACK TOGETHER
What did I do? (Repeat questioning procedure above)

Repeat--PUSH THE CHAIRS CLOSER TOGETHER
What did I do? (Repeat questioning procedure above)

Activity 2 Conservation Concepts

"Fingers and Rings" (provoked correspondence)

Today we're going to play some finger games.
Can you show me your fingers?
Do you have the same number of fingers on one hand as on
the other? RESPONSES
How do you know? You can match them one finger for one
finger (demonstrate). Since each finger on one hand is
matched with a finger on the other hand, you have the
same number of fingers on each hand.
Do you have the same number of fingers as other people in
the room?
How do you know?
Find out (match one for one).

What would happen if you spread out your fingers?
Would you still have the same number?
How can you tell?
How can you find out? (match)

What would happen if you put your fingers close together?
Would you still have the same number as when they were
spread apart?
How can you tell?
How can you find out? (match)

Put one hand on the table.
Here are some rings (paper rings) (5).
Do you have enough rings for each finger on your hand?
Do you have the same number of rings as fingers on that
hand? How do you know?
Do you have any fingers, on that hand, without rings?
Do you have any rings that aren't on your fingers?
You have the same number of rings as fingers because....

Put your rings on the table in front of your fingers.
Spread out the rings.
Do you still have the same number of rings as fingers?
How do you know?
Do you still have a ring for each finger?
Do you have any rings left over?
You have the same number of rings as fingers.  
Does it make any difference if they are spread out?  
You still have the same number because...  
Put your rings on the table in front of your fingers.  
Push the rings close together.  
Do you still have the same number of rings as fingers?  
How can you tell?  
(Repeat questioning procedures above)  
Repeat with 10 rings.  

Activity 3 Conservation Concepts  
"The Three Bears" (provoked discrimination)  
Read the story of The Three Bears. Following the story:  
Here are some sets of bears. (Present 3 sets of bears*)  
\[
\begin{array}{ccc}
B & B \\
B & B & B \\
B & B & B & B \\
\end{array}
\]
Which set is the 3 bears?  
How do you know?  
There's a bear for the papa bear, a bear for the mama bear, and a bear for the baby bear.  
In the story, each of the bears has a bowl of porridge.  
(Present sets of 2 green bowls, 3 red bowls, and 4 blue bowls.)  
\[
\begin{array}{ccc}
B & B & B \\
b & b \\
b & b & b \\
b & b & b & b \\
\end{array}
\]
Which set has the same number of bowls as bears?  
How do you know?  
How can we find out? (Let children match)  
Since there is one for the papa bear, one for the mama bear, and one for the baby bear, we have the same number of bowls as bears.  
Repeat for spoons*  
\[
\begin{array}{ccc}
B & B & B \\
s & s & s \\
s & s \\
s & s \\
\end{array}
\]
Repeat for chairs*  
\[
\begin{array}{ccc}
B & B & B \\
c & c & c \\
c & c \\
c & c & c & c \\
\end{array}
\]
Repeat for beds*

\[\text{B B B}\]

\[b b b b\]

\[b b b\]

*cutouts

Activity 4 Conservation Concepts

"Snowmen" (provoked discrimination)

Today we're going to pretend we're making a snowman. We want everyone to have a snowman to dress. We need the same number of snowmen as children. (Present 3 sets of snowmen*.) Which set of snowmen should we use so that everyone has one and there are none left over?

\[S S S S\]

\[S S S\]

\[S S S S S\]

How did you decide which set to choose? (Pass them out.) Does everyone have a snowman? Are there any snowmen left over? Do we have the same number of snowmen as children? Why? (because. . .)

Let's put a hat on our snowman. We need the same number of hats as snowmen. (Present 3 sets of hats*.) Which set of hats should we choose so that every snowman has a hat and there are no hats left over?

\[S S S S\]

\[h h h h h\] (blue)

\[h h h\] (green)

\[h h h h\] (red)

Why do you think it's that set? How can you find out if it's the same number? (match) It's the same number because. . .

Repeat the above activities with scarves*

\[S S S S\]

\[s s s s s\] (green)

\[s s s s\] (blue)

\[s s s\] (red)

Repeat with mittens*

\[S S S S\]

\[mm mm mm mm\] (blue)

\[mm mm mm mm\] (green)

\[mm mm mm mm\] (red)
Activity 5 Conservation Concepts

"Matching Game" (spontaneous correspondence)

Today we're going to play a matching game. Do we have the same number of boys as girls? (If there are not the same number give half the children green tags and half blue tags, change wording to "people with blue tags and people with green tags.)

How do you know?
How can you find out? (match)
Does everyone have a partner?
Are there any people left over?
We have the same number of boys as girls because everyone has a partner and there are no people left over?

Would we have the same number of boys as girls if the boys spread out? Why?
Try it and find out.
Do we still have the same number?
How can you tell? (Use pieces of string to connect partners)
Since each boy has a girl partner and each girl has a boy partner we have the same number of boys as girls.
Does it make any difference if we're close together or far apart? Why?
We have the same number because . . .

What would happen if the girls spread way out?
Would we still have the same number of boys as girls? Why?
Try it and find out.
How can you tell we still have the same number?

Repeat--have the girls come close together.
Repeat questioning procedure.

Now we're going to match things. I have some blocks. (4)
Can you make a row that has the same number as mine?
Is there a red block for every blue block?
Is there a blue block for every red block?
Do we have the same number? Why?
We have the same number in each row because . . .
What would happen if we spread out one row?  Would we still have the same number? Why?
How can we find out? (spread out—connect pairs with strips)
Is there still a blue block for every red block?
Is there still a red block for every blue block?
Do we have the same number? Why?

Repeat—spreading out farther.

Repeat with spoons (7); cups (5); pennies (6).

Activity 6 Conservation Concepts

"Matching Game" (spontaneous correspondence)

Today we're going to show you a set of things and I want you to find another set that has the same number in it. (Present a standard set of 4 yellow flowers*; present sets of 3, 4, and 5 orange flowers.*)

\[
\begin{array}{cccc}
F & F & F & F \\
F & F & F & F \\
F & F & F & F \\
\end{array}
\]

Find the set of orange flowers that has the same number as the set of yellow flowers. (match)

Why do you think it's that set?
How do you know it has the same number?
It has the same number because . . .

Watch what I do. (Change the arrangement of the correct row keeping all the other rows the same.) Does it still have the same number of flowers as the yellow set? How do you know? How can you find out?
Does it make any difference how much space there is between the flowers?
We still have the same number because . . .

Repeat with balls.* (8)

\[
\begin{array}{cccccccc}
b & b & b & b & b & b & b & b & \text{(red)} \\
b & b & b & b & b & b & b & b \\
b & b & b & b & b & b & b & b & \text{ (green)} \\
b & b & b & b & b & b & b \\
\end{array}
\]

Repeat with apples.* (6)

\[
\begin{array}{cccccccc}
a & a & a & a & a & a & \text{ (green)} \\
a & a & a & a & a & a & a & \text{ (red)} \\
a & a & a & a & a & a \\
a & a & a & a & a \\
\end{array}
\]
Activity 7 Conservation Concepts

"Fishermen" (provoked correspondence)

Today we're going to play a fishing game. Have any of you ever gone fishing? What do you do when you go fishing? The first thing we need is a fishing pole. __________, will you give each person a fishing pole. Does everyone have a fishing pole? Are there any fishing poles left over? We have the same number of fishing poles as children because everyone has a fishing pole and there are none left over.

Now we need to put some fish in the pond. __________, will you give everyone a fish.* Did everyone get a fish? Are there any fish left over? There are the same number of fish as children because. . .

Now put your fish in the pond. Did everyone put a fish in the pond? Does everyone have a fish to catch? Why? Will there be any fish left over? Why? Let's find out. GO FISH Did everyone catch a fish? Are there any fish left in the pond? Does it make any difference how far apart they are? There are still the same number of fish as children because...

Repeat—spread out farther. Repeat—questions. Repeat—bring the fish closer together. Repeat—bring the fish closer together. *cutouts
Activity 8 Conservation Concepts

"Party" (provoked correspondence)

Today we're going to have a little party. The first thing we need is to put out the same number of plates as people. (5)
Who would like to pass out the same number of plates as people?
Did ______________ pass out the same number?
How do you know?
Does everyone have a plate?
Are there any plates left over?
There are the same number because . . .

What if I spread the plates out in front of you, would there still be the same number of plates as children? Why?
How do you know?
Does everyone still have a plate?
Are there any plates left over?
There are the same number of plates as people because . . . Does it make any difference how they are spread out?

Repeat questions and procedures for
  1) napkins
  2) cookies
  3) forks
  4) cups
  5) spoons
  6) cookies again
Activity 9 Conservation Concepts

"Clowns" (provoked discrimination)

Today we're going to make clowns. We want everyone to have a clown to make so we need the same number of clowns as children. (Present 3 sets of clowns*)

Which set of clowns* should we use so that everyone has a clown and there are none left over? LET THE CHILDREN MATCH

Does everyone have a clown?
Are there any clowns left over?
Do we have the same number of clowns as children? Why?
We have the same number because . . .

What would happen if we spread out this set of clowns? (do it) Would everyone still have a clown? Why?
Would there be any clowns left over? Why?
Would we have the same number of clowns as children? Why?
We still have the same number because . . .

Let's put a hat* on our clown. We need the same number of hats as clowns. Which set of hats should we choose so that every clown has a hat and there are none left over? (Present 3 sets of hats.)

Let THE CHILDREN MATCH.
Why did you choose that set?
Are there the same number? Why?
There are the same number because . . .

Watch what I do? (change the arrangement of the correct set)
Are there still the same number of hats as clowns? Why?
Does every clown have a hat? Are there any hats left over?
There are still the same number because . . .

Did the spaces between the hats make any difference?

Repeat for gloves.* Repeat for shoes.* Repeat for balloons*

*cutouts
Activity 10 Conservation

"Matching Game"
Today we're going to play a matching game. Can someone put out the same number of dogs* as people? (5)
How do you know it's the same number? (It's the same number because...)
Would we still have the same number of dogs as people if we spread out the dogs? Why? TRY IT
Is there a dog for every person; a person for every dog? We still have the same number of dogs as people.
Does it make any difference if they're spread out? Why?
Would we still have the same number if we pushed the dogs close together? Why?
Is there still a... We still have the same number of dogs as people. Does it make any difference if they are close together?

Repeat questions and procedures for:
- dog houses*
- bones*
- bowls*
- balls*

Activity 11 and 12 Conservation

"Matching Game"
Today we're going to play the matching game again. I'm going to put out some apples* (6) and I want you to make a row that has the same number of apples as mine.
How do you know it's the same number? (It's the same number because...)
Would we still have the same number if we pushed the apples close together? Why? DO IT
Is there an apple in my row for every apple in your row? Is there an apple in your row for every apple in my row? We still have the same number of apples in each row.
Does it make any difference how close together they are? Would we still have the same number if the apples in your row were spread out? DO IT Why? Is there still...

Repeat questions and procedures for:
- Act. 11: happy faces* (9), purple sticks* (8), trains* (7), macaroni circus wheels (10)
- Act. 12: paper clips (5), stars* (7), cars* (8), flowers* (6), bunnies* (9), hearts* (10)

*cutouts
Activity 1 Set Theory

"Musical Chairs" (provoked correspondence)

Today we're going to play musical chairs. Have you ever played musical chairs? RESPONSES (If "yes"—will someone tell us how to play?) Everyone get a chair and we'll put them in a line. Does everyone have a place to sit? Why?
Are there any chairs left over?
Are there any children who don't have a chair?
We have the same number of chairs as children because everyone has a place to sit and there are no empty chairs.

I'm going to clap my hands and I want you to march around the chairs. When I stop clapping you sit down on a chair. Do you think everyone will have a place to sit? Why?
Do you think there will be any chairs left over? Why?
Let's find out. Ready to march
CLAP MARCH STOP SIT

Does everyone have a chair?
Are there any chairs left over?
Do we have the same number of chairs as children? Why?
We have the same number of chairs as children because . . .

Repeat—REMOVE A CHAIR
What did I do?
Are there the same number of chairs as children?
How do you know?
How can you find out?
CLAP MARCH STOP SIT

Do we have the same number of chairs as children? Why?
Are there any chairs left over?
Are there any children who don't have a chair?
Since we have a child without a chair we have more children than chairs.

Repeat—ADD A CHAIR (have the same number again)
Repeat questioning procedure.

Repeat—ADD ANOTHER CHAIR (now we have less children than chairs or we could say we have more chairs than children because. . .)
Activity 2 Set Theory

"Fingers and Rings" (provoked correspondence)

Today we're going to play some finger games. Can you show me your fingers? Do you have the same number of fingers on one hand as on the other? How do you know? How can you find out? (Match them—demonstrate) You have the same number of fingers on each hand because for each finger on one hand you have a finger on the other hand. Do you have the same number of fingers as other people in the room? How do you know? How can you find out? (match) You have the same number of fingers as other people because...

Put one hand on the table.
Here are some rings (paper rings) (5).
Do you have enough rings for each finger on your hand? Do you have the same number of rings as fingers? How do you know? Do you have any fingers on that hand without rings? Do you have any rings that aren't on your fingers? You have the same number of rings as fingers because...

If you put all the rings from your fingers on the fingers of your other hand, would you have enough? Why? Try it and find out. Do you have a ring for every finger? Does every finger have a ring? You have the same number of rings as fingers.

Repeat with 10 rings.
Repeat—TAKE A RING AWAY What did I do? Repeat questioning procedures (Have more fingers because you have a finger without a ring; have less rings because you don't have enough rings for your fingers).

Repeat—ADD A RING What did I do? Repeat questioning procedures. (Have the same number.)

Repeat—ADD A RING What did I do? Repeat questioning procedures. (Have more rings because have one left over; have less fingers because there is no place to put the ring.)

To have the same number again, what would we have to do?
Activity 3 Set Theory

"The Three Bears" (provoked discrimination)

Read the story of The Three Bears. Following the story present 3 sets of bears.*

B B
B B B
B B B B
Which set is the 3 bears? How do you know? How can you find out? (Match)

There's a bear for the papa bear, a bear for the mama bear, and a bear for the baby bear.

In the story, each of the bears has a bowl of porridge.

(Present sets of bowls*)

B B B
b b (green)
b b b b (blue)
b b b (red)
Which set has the same number of bowls as bears? How can we find out? (Match)

What happened when we matched the blue bowls? (There were more bowls because there was a bowl left over.)

What happened when we matched the green bowls? (There were less bowls; more bears because we did not have enough bowls--there was a bear left over.)

What happened when we matched the red bowls? (We had the same number because there was a bowl for the papa bear, a bowl for the mama bear, and a bowl for the baby bear. Every bear got a bowl and there weren't any left over.)

Repeat for spoons* Repeat for chairs* Repeat for beds*

B B B B B B B
s s s s c c c
s s c c c
s s c c

Now Goldilocks* comes to visit.
Could we still use the red bowls? Why?

There are more people than bowls.
Which set of bowls should we use? Why?
If we use the blue bowls will we have the same number of bowls as people? Why?

*cutouts
Activity 4 Set Theory

"Snowmen" (provoked discrimination)

Today we're going to pretend we're making a snowman. We want everyone to have a snowman to dress. We need the same number of snowmen as children. (Present 3 sets of snowmen.*)

Which set of snowmen should we use so that everyone has one and there are none left over? LET CHILDREN PASS THEM OUT

Why do you think it is that set?
Does everyone have a snowman?
Are there any snowmen left over?
We have the same number of snowmen as children because everyone has a snowman and there are none left over.

Let's put a hat on our snowman. We need the same number of hats as snowmen. (Present 3 sets of hats.*)

Which set of hats should we choose so that every snowman has a hat and there are none left over? LET CHILDREN MATCH
How do you know that it is that set?
What would happen if we used the red hats? TRY IT
(We would have less hats than snowmen because we don't have enough hats.)
What would happen if we used the blue hats? TRY IT
(We would have more hats than snowmen because we would have a hat left over.)
Which set is the only set that has the same number of hats as snowmen? Why?
(There is a hat for every snowman and none left over.)
Repeat for scarves.* Repeat for brooms.* Repeat for mittens.*

What if I wanted to make a snowman too? Which set of snowmen would we have to use so that we would have the same number of snowmen as people? How do you know?

*cutouts
Activity 5 Set Theory

"Matching Game" (spontaneous correspondence)

Today we're going to play a matching game.
Do we have the same number of boys as girls?
How do you know?
How can we find out? (Match)
Does every boy have a partner? Does every girl have a partner? We have (the same, more, or less) boys as girls because . . .

How could we have more boys/girls (or the same if already different)? Let's try it and see.
Why is it more (same)?

Now let's play the matching game with things.
I have some blocks. (4)
Can you make a row of blocks that has the same number as mine?
Is there a red block for every blue block?
Is there a blue block for every red block?
There are the same number of blocks in each row because . . .

Can you make your row have more blocks than mine?
How do you know it has more? How did you make it have more? It has more because . . .

Can you make your row have the same number as mine again?
How do you know they are the same?

Can you make your row have less than mine?
How do you know it has less?
How did you do it?
Your row has less because . . .

Repeat with spoons (7).
Repeat with pennies (6).
Repeat with cups (5).
Activity 6 Set Theory

"Matching Game" (spontaneous correspondence)

Today we're going to play a matching game. I'm going to show you a set of things and I want you to find a set that has the same number in it. (Present a standard set of 4 yellow flowers* and 3 sets of orange flowers.)

F F F F (yellow)
F F F
F F F F
F F F F F (orange)

Which set of orange flowers has the same number as the set of yellow flowers?
How do you know it has the same number? (Match)
It has the same number because there is an orange flower for every yellow flower and there are no flowers left over.

Can you find a set that has more flowers?
How do you know it has more?
It has more because . . .

Can you find a set that has less than the set of yellow flowers? How do you know it has less?
It has less because . . .

Repeat with balls* (8)

b b b b b b b b (red)

Repeat with apples* (6)

a a a a a a a a (green)

Repeat with stars* (7)

s s s s s s s (blue)

Repeat with triangles* (9)

t t t t t t t t t (green)

s s s s s s s s s (yellow) t t t t t t t t t t t t (purple)

*cutouts
Activity 7 Set Theory

"Fishermen" (provoked correspondence)

Today we're going to play a fishing game. Have any of you ever gone fishing? What do you do when you go fishing? The first thing we need is a fishing pole. ________, will you give each person a fishing pole. Does everyone have a fishing pole? Are there any fishing poles left over? We have the same number of fishing poles as children because everyone has a fishing pole and there are none left over.

Now we need to put some fish* in the pond. ________, will you give everyone a fish. Did everyone get a fish? Are there any fish left over? There are the same number of fish as children because . . .

Now put your fish in the pond. Did everyone put a fish in the pond? Does everyone have a fish to catch? Why? Will there be any fish left over? Why? Let's find out. GO FISH Did everyone catch a fish? Why? Were there any fish left in the pond? Why? We had the same number of fish as children because . . .

Repeat--ADD A FISH What did I do? Will everyone have a fish to catch? Will there be any fish left over in the pond? Do we have the same number of fish as children? Let's find out. GO FISH Did everyone catch a fish? Were there any fish left in the pond? Do we have the same number of fish as children? We have more fish than children because there was a fish left over.

Repeat--TAKE AWAY A FISH Repeat questions--same number because . . .

Repeat--TAKE AWAY ANOTHER FISH Repeat questions--less fish than children because . . .

*cutouts
Activity 8 Set Theory

"Party" (provoked correspondence)

Today we're going to have a little party. The first thing we need is to put out the same number of plates as people. (5)
Who would like to pass out the same number of plates as people?
Did _______ pass out the same number?
How do you know?
Does everyone have a plate?
Are there any plates left over?
There are the same number because . . .

What if I put out another plate, would we still have the same number of plates as people? Why?
Since we have an extra plate, we have more plates than people.
How can we have the same number again?
It's the same number because . . .

Repeat questions and procedures for

1) napkins--same, less, same
2) cookies--same
3) forks--same, more, same
4) cups--same, more, same
5) spoons--same, less, same
6) cookies--same
Activity 9 Set Theory

"Clowns" (provoked discrimination)

Today we're going to make clowns. We want everyone to have a clown to make so we need the same number of clowns as children. (Present 3 sets of clowns*)

\[
\begin{array}{cccc}
C & C & C & C \\
C & C & C \\
C & C & C & C & C
\end{array}
\]

Which set of clowns should we use so that everyone has a clown and there are none left over? LET THE CHILDREN MATCH

Does everyone have a clown? Are there any clowns left over? We have the same number of clowns as children because. . .

Let's put a hat* on our clowns. We need the same number of hats as clowns. Which set is it? LET CHILDREN MATCH

\[
\begin{array}{cccc}
C & C & C & C \\
\ h & \ h & \ h & \ (blue) \\
\ h & \ h & \ h & \ h & \ (red) \\
\ h & \ h & \ h
\end{array}
\]

Why do you think that set has the same number of hats as clowns?

What would happen if we used the red set? TRY IT We would have more hats than clowns because there would be a hat left over.

What would happen if we used the blue set? TRY IT We would have less hats than clowns because there would be a clown without a hat.

Which is the only set that has the same number of hats as clowns? Why? The only set that has the same number of hats as clowns is the green set because there is a hat for every clown and no hats left over.

Repeat for gloves.*

\[
\begin{array}{cccc}
C & C & C & C \\
gg & gg & gg & gg & gg & (blue) \\
gg & gg & gg & gg & \ (red) \\
gg & gg & gg & \ (green)
\end{array}
\]

Repeat for shoes.*

\[
\begin{array}{cccc}
C & C & C & C \\
ss & ss & ss & ss \\
ss & ss & ss & ss & ss \\
ss & ss & ss
\end{array}
\]

Repeat for balloons.*

\[
\begin{array}{cccc}
C & C & C & C \\
b & b & b & \ (red) \\
b & b & b & b & \ (blue) \\
b & b & b & b & b & \ (green)
\end{array}
\]

*cutouts
Activity 10 Set

"Matching Game"

Today we're going to play a matching game. Can someone put out the same number of dogs* as people (5)? How do you know it's the same number? (It's the same number because . . .) How can we have more dogs than people? (DO IT) How do you know it's more? We have more dogs than people because . . . How can we make it the same number again? (DO IT)

Repeat questions and procedures for
dog houses* (same, less, same)
bones* (same, more, same)
bowls* (same, more, same)
balls* (same, less, same)

Activity 11 and 12 Set

Today we're going to play the matching game again. I'm going to put out some apples* (6) and I want you to make a row that has the same number of apples as mine. How do you know it's the same number? It's the same number because . . . Can you make a row that has more in it? How do you know it has more? (It has more because . . .)

Repeat questions and procedures for
Act. 11 happy faces* (9) purple sticks* (8) trains* (7) macaroni circus wheels (10) Act. 12 paper clips (5) stars* (7) cars* (8) flowers* (6) bunnies* (9) hearts* (10)

*cutouts
APPENDIX D

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## Experimental group I: Conservation Approach

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APPENDIX E

TABLES 29 AND 30

238
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TABLE 30

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