A COMPARISON OF METHODOLOGIES: SELF-DISCOVERY VERSUS DISCOVERY-COLLOQUIUM IN THE FACILITATION OF SCIENCE PROCESS ACHIEVEMENT

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Education

by

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Committee Chairman

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DEDICATION

This thesis is dedicated to the writer's loving family.

D.R.B.
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The writer takes great pride in acknowledging several helpful people who gave their time and energies in support of this thesis.

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Fifty children who participated as learners.
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ABSTRACT

A COMPARISON OF METHODOLOGIES: SELF-DISCOVERY VERSUS DISCOVERY-COLLOQUIUM IN THE FACILITATION OF SCIENCE PROCESS ACHIEVEMENT

by

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The purpose of this study was to investigate the effects of two methodologies, self-discovery and discovery-colloquium, on the science process achievement mean scores of a sample of third grade students. Further, the study attempted to derive from Piaget's theories a number of general principles to use as a framework in formulating the teaching methodologies labeled self-discovery and discovery-colloquium.

The general hypothesis for the study was that there would be no significant difference in science process achievement between children who experienced the discovery-colloquium instruction and self-discovery instruction.

A Pretest-Posttest Two Group Design was employed. Following the pretests, Group I and Group II experienced process-centered instruction in science through the use of
materials that children could manipulate and problems they could investigate. In addition, Group I pooled observations in a colloquium following the exploration activity. Both groups received ninety minutes of instruction four times a week for a period of fourteen weeks. The posttests were given at the conclusion of the treatment period.

The \( t \) test for correlated data was applied to pre-post test data for each group on two levels of the Science Subtest of the Comprehensive Tests of Basic Skills Form S and combined test score data. Significant \( t \) ratios were attained at the 0.01 level in all cases.

The \( t \) test for uncorrelated data was applied to pre-post test comparison of the two groups on two levels of the Science Subtest of the Comprehensive Tests of Basic Skills Form S as well as the combined test scores. The findings indicated no significant differences.

Within the parameters of this study, it may be concluded that process learning can take place in both the self-discovery and discovery-colloquium methods if meaningful concrete experiences in which the child can explore in his own way are provided; and if opportunities are given for listening to him tell of his own experiences, in his own language, clarified through interchange with his peers. However, this study did not detect significant differences in the relative effectiveness of the two methods of process instruction. The inclusion of a colloquium to encourage further social interaction in the classroom did
not produce any measurable improvement in process instruction.
CHAPTER I

STATEMENT OF THE PROBLEM

The purpose of this study was to investigate the effects of two methodologies, self-discovery and discovery-colloquium, on the science process achievement mean scores of a sample of third grade students.

Rationale for the Study

The work which is most relevant to the present study is primarily the result of a vast amount of research by one man, Jean Piaget. More than any contemporary researcher, he has extracted fundamental ideas about the ways children's mental processes develop. The present study attempted to derive from his theories a number of general principles applicable to a child's acquisition of knowledge and further, to use these principles as a framework in formulating the teaching methodologies labeled self-discovery and discovery-colloquium.

In Piaget's view, one of the major sources of learning is the intrinsic activity of the child. The child must act upon things to understand them. In describing the role of physical experience in intellectual development, Hein (1972) points out that if it is true that the
development of intelligence is an active process, one that requires interaction with the world and activity initiated by the child, then there must be relevant things to do in the classroom. According to Hein:

What we know about how children learn tells us that they must have "stuff." It's not just that it makes children happy to play with pendulums and sand and gerbils, it is necessary that they do these things. It's not just that some of the discipline problems disappear when there are things in the classroom to occupy the children, but that intelligence will not develop fully unless children have the chance to test themselves against, and come to terms with, all sorts of chunks of the world of experience (p. 8).

Almy et al. (1966), Chittenden (1969), Ginsburg and Opper (1969), and others have all emphasized the point that learning has to be an active process, because knowledge is a construction from within.

Duckworth (1964) selected the highlights of the statement Piaget made on education in 1964:

... As far as education is concerned, the chief outcome of this theory of intellectual development is a plea that children be allowed to do their own learning ... You cannot further understanding in a child simply by talking to him. Good pedagogy must involve presenting the child with situations in which he himself experiments, in the broadest sense of the term—trying things out to see what happens, manipulating symbols, posing questions and seeking his own answers, reconciling what he finds one time with what he finds at another, comparing his findings with those of other children ... (p. 2).

This statement expresses the view that physical experience and concrete manipulation are not the only ways in which a child learns. Another type of experience leading to understanding of the environment is social experience, or interaction with other persons. Commenting on the
principle of social interaction in Piaget's theory of intellectual development, Ginsburg and Opper (1969) write:

... When one child talks to another he comes to realize that his is not the only way of viewing things... Interaction inevitably leads to conflict and argument. The child's views are questioned. He must defend his ideas and he must justify his opinions. In doing this he is forced to clarify his thoughts (p. 228).

An additional principle which accounts for the advance from one stage of intellectual development to the next is the process of equilibration which is critical to the child's internal construction of knowledge. In equilibration the child reacts in two ways to experiences: He assimilates them—that is, he incorporates aspects of these experiences into his own frame of reference, subconsciously selecting those aspects that fit his mental scheme. He also accommodates to these experiences—that is, he alters his usual pattern of behavior because of these environmental encounters. Together, these complementary processes of assimilation and accommodation make up the self-regulating system of learning Piaget termed equilibration.

Piaget calls the more stable periods between stages of maturation, periods of equilibrium, and the intermediate stages, periods of disequilibrium. In describing the role of disequilibrium in intellectual development, Hein (1973) has advocated that:

... It is at these times of crisis, of disequilibrium, that we can learn a great deal from children, and at which time they are susceptible to new ideas and able to absorb new experiences (p. 8).
This view suggests that children need to have reached a requisite level of intellectual development before related learning can take place.

Piaget's identification of three interrelated mechanisms, physical experience, social interaction, and equilibration, account for the advance from one state of intellectual development to the next. The present study attempted to use these mechanisms as a framework to formulate the teaching methodologies labeled self-discovery and discovery-colloquium. The study attempts to measure differences in the science process achievement mean scores of third-grade students who experienced these two treatments in process-centered instruction.

**Definition of Terms**

For the purposes of this study, the following terms are operationally defined.

**Comprehensive Tests of Basic Skills: Science Subtest, Level 1 and Level C:** (CTBS/S), a testing instrument (McGraw-Hill, 1973) designed to test the students' command of the processes of science. The processes include knowing, classifying and comparing, measuring, summarizing data, recognizing valid hypotheses, and evaluating an experimental design. The content areas cover the biological, physical, and earth sciences.

**Process:** For the intent of the present study, the
meaning of process centers upon Gagne's (1966) idea that what is taught to children should resemble what scientists do—the "processes" that they carry out in their own scientific activities, for example classifying, measuring, inferring, making hypotheses, and performing experiments.

Self-Discovery: A methodology in which the stress is on the experience, not on what is learned. The student is presented with materials chosen to illustrate certain concepts and to reveal related phenomena through their interaction. The children are faced with the materials and told to "see what you can find out." In exploration the children raise questions themselves, answer them in their own way, and come to their own conclusions. The teacher's role is to facilitate discovery by introducing more complex materials after a child has discovered the essential relationships. During the exploration, the teacher responds to the actions of individuals rather than giving a generalized response to all of the children.

Discovery-Colloquium: A self-discovery methodology followed by an organized colloquium in which the children pool observations to make individuals aware of common data seen from different viewpoints. The role of the teacher is to select the proper moment to organize the colloquium, to help the children to perceive accurately, to juxtapose discrepant events, to supply the right word at the right time, to redirect thoughts at moments of impasse, and to
arrange for the recording of the Investigator's Log which represents the children's consensus in their own language.

Group I: Twenty-five students in the third grade who were exposed to the discovery-colloquium treatment. Each had a measured I.Q. of 100 or above as determined by the Otis Intelligence Test administered in May of 1973.

Group II: Twenty-five students in the third grade who were exposed to the self-discovery treatment. Each had a measured I.Q. of 100 or above as determined by the Otis Intelligence Test administered in May of 1973.

Research Hypotheses

The intent of the present study was to test and interpret the following null hypotheses:

Hypothesis 1: There will be no significant difference in the Level C pretest and posttest science process achievement mean scores for Group I.

Hypothesis 2: There will be no significant difference in the Level 1 pretest and posttest science process achievement mean scores for Group I.

Hypothesis 3: There will be no significant difference in the Level C and Level 1 combined pretest and posttest
Hypothesis 4: There will be no significant difference in the Level C pretest and posttest science process achievement mean scores for Group II.

Hypothesis 5: There will be no significant difference in the Level 1 pretest and posttest science process achievement mean scores for Group II.

Hypothesis 6: There will be no significant difference in the Level C and Level 1 combined pretest and posttest science process achievement mean scores for Group II.

Hypothesis 7: There will be no significant difference between Group I and Group II on the Level C science process achievement pretest mean scores.

Hypothesis 8: There will be no significant difference between Group I and Group II on the Level 1 science process achievement pretest mean scores.

Hypothesis 9: There will be no significant difference between Group I and Group II on the Level 1 and Level C combined science process achievement pretest mean scores.

Hypothesis 10: There will be no significant difference between Group I and Group II on the Level C science process achievement posttest mean scores.

Hypothesis 11: There will be no significant difference
between Group I and Group II on the Level 1 science process achievement posttest mean scores.

**Hypothesis 12:** There will be no significant difference between Group I and Group II on the Level 1 and Level C combined science process achievement posttest mean scores.

### Research Question

Once the child has acted on an object or a situation, does the role of language in social collaboration serve to internalize the experience as a complete learning activity.

### Limitations of the Study

This study was conducted in the third grade of a public elementary school which: (1) drew from an upper-middle class community, (2) had good parent-teacher communication and parental support, and (3) had a cooperative administrator and teaching staff. Therefore, this study can only be generalizable to schools with similar conditions.
CHAPTER II

REVIEW OF RELATED LITERATURE

In addition to maturation, Piaget has identified three interrelated mechanisms which give criteria for the types of experiences which are likely to lead to learning and to the development of knowledge. These mechanisms are: physical experience, social interaction, and equilibration. The related literature which focuses on these mechanisms as a theoretical framework for process-centered instruction will be reported.

**Physical Experience**

In describing the emphasis Piaget places on the role of activity in intellectual development, Ginsburg and Opper (1969) state:

... In Piaget's view, one of the major sources of learning, if not the most essential one, is the intrinsic activity of the child. The child must act on things to understand them. Almost from birth, he touches objects, manipulates them, turns them around, looks at them, and in these ways he develops an increasing understanding of their properties. It is through manipulation that he develops schemes relating to objects (p. 221).

The rate at which a child moves through the various stages of intellectual development is dependent on the richness of his environment. In support of an activity-
Studies of young children stress their restlessness, ceaseless activity, and short attention span; these characteristics are particularly noticeable in the restraining atmosphere of the classroom. The belief persists that this perpetual motion distracts from the daily business of the classroom, that the business of learning could proceed with dispatch if children would only sit still. But this belief is a misconception because the growth of logical thought depends on activity, on experiencing, on handling and manipulating. Activity should be encouraged, not just as an expedient by which to arouse interest or to allow children to "prove" a statement in the textbook but because thought in young children evolves from physical actions (p. 35).

Children in the early years of elementary school should have the opportunity to handle many different materials and engage in a diversified range of activities. Gagné (1968) had indicated that:

... Although they are able to classify, count, and arrange objects in order and reverse the order, children must still work from concrete materials because vocabulary and imagery are immature. From experiences with these materials such concepts are causality, probability, invariance, and conservation arise. Intellectual skills cannot be learned as abstractions. You cannot tell a child to measure, to infer, the "think," nor can you reasonably expect that he will use these skills unless he has already had experience in concrete situations with them (p. 2).

The demand for direct experience with nature and the need for children to act on and in turn be acted on by natural phenomena has been supported by Suchman (1964). He has written:

When you present children with problems in very concrete terms, without the esoteric terminology, the definitions, the symbols, and the other conventions of a formalized science, the children begin to go to work on these problems in logical and productive ways (p. 108).
Bruner (1961) proposed that the learner shifts from dependence on extrinsic to intrinsic rewards as an outcome of discovery teaching. According to Bruner:

Autonomous reward arises from confidence in one's ability to discover; that is mastery becomes inner-directed. The child who successfully generalizes from his own observations and manipulations learns that he can predict certain consequences of his discoveries and in a limited way can control his environment. In every child's growth there is a period of intense curiosity, of desire to find out. For younger children this stage is a magnificent opportunity for the discovery of autonomous reward. Many children (and adults) never realize "intellectual happiness" because their learning experiences were never planned to provide the reinforcement that comes from the thrill and satisfaction of discovery (p. 22).

**Social Interaction**

Social interaction provides for communication among peers. A child attempting to solve a problem in a group can make a number of trial responses which, when made publicly in the group, can be criticized, analyzed, and evaluated. Since group members vary in their information and knowledge, a child can obtain information he does not have and can get clarification of concepts and generalizations that he did not adequately understand.

Piaget believed strongly that for intellectual development the interaction among children is as important as the child's interaction with adults. In practice, social interactions among children are allowed more than they are expressly encouraged as a means of actively involving the children in juxtaposing different points of
view. Kamii (1970) has advocated that:

... Without the opportunity to see the relativity of perspectives, the child remains prisoner of his own naturally egocentric point of view. A clash of convictions among children can readily cause an awareness of different points of view. Other children at similar cognitive levels can often help the children more than the adult can to move out of his egocentricity (p. 200).

The proposal that elementary schools should encourage children to work and learn cooperatively has been expressed by Duckworth (1964). She has written:

... Group learning fosters intellectual growth. As children work with other children and adults, the other points of view they encounter help them restructure their ideas and lead them to a more critical point of view, to a different way of looking at their environment (p. 4).

Hein (1973) stressed the importance of interaction between the child and the world around him. According to Hein:

... when a person interacts with a part of the world in some way, he doesn't just learn that little piece of information that is the result of the interaction, he also learns how to interact with the world. When a child interacts with people, things, or problems, he doesn't just learn to solve the problem or how to interact with that person, he learns something about solving problems and about interacting with people. When children play, they learn generally how to play. So in order to have intelligence develop, it is necessary to have lots of experience, lots of active engagement and especially, to have many varieties of experience (p. 8).

As children gain practice in manipulating sets of objects, they bring more experience and greater expectancies to their science investigations; their perception is sharpened. Social interaction among peers pinpoints the need for accuracy as it builds expectancies. Blackwood and
others (1971) have commented that:

... We believe that self-initiated learning together with its expression in the learner's own words organizes learning into a whole interactive system, into meaning for the learner (p. 107).

Huff (1971) indicated that science processes require that the child be able to describe properties of objects, to interpret events, and to tell what he has found out. In her study of the effects of the use of science process instruction on oral communication skills, she stated, "As he investigates the world around him, he is provided with something to talk about and to read about (p. 3)."

According to Vygotsky (1962), a purpose of education is to coalesce thought and language. He has written:

... Thought and language stem from different roots. There can be words without thoughts and thoughts without words. Thought is not merely expressed in words, it comes into existence through them (p. 105).

This process is illustrated in the colloquium. The experience evokes language; language produces thought; thought may require new language and so on. The colloquium brings preverbal thought which the exploration engenders to interaction with the words and thoughts of co-workers.

The implication of Piaget's view is that social interaction should play a significant part in the classroom. Children should talk with one another. They should converse, share experiences, and argue. Duckworth (1964), in quoting Piaget, writes:
When I say "active," I mean it in two senses. One is acting on material things. But the other means doing things in social collaboration, in a group effort. This leads to a critical frame of mind, where children must communicate with each other. This is an essential factor in intellectual development. Cooperation is indeed co-operation (p. 207).

**Equilibration**

As a child responds to experiences he undertakes a series of actions that Piaget refers to as equilibration. This mechanism emphasizes that self-regulatory processes are the basis for genuine learning. In the equilibration process, the child assimilates experiences—that is, he incorporates aspects of these experiences into existing thought patterns. The child is in conflict when his information can no longer fit into the existing thought patterns. He also accommodates to these experiences—that is, he alters his usual pattern of behavior because of these environmental encounters. When the conflict has been resolved, the child can continue to assimilate further information into the new thought pattern at a higher level of equilibrium.

The equilibration mechanism is defined by Gorman (1972) as:

... The active process by which a person responds to disturbances in his ordinary way of thinking through a system of compensations; the result is new understanding and satisfaction, i.e., equilibrium (p. 112).

This mechanism is critical to the child's internal construction of knowledge. Labinowich (1974) further defines
equilibration as:

... an active mechanism involving the interplay of two complementary processes called assimilation and accommodation, which integrates the effects of both physical experience and social interaction (p. 2).

To further clarify the role of equilibration in Piaget's theory of intellectual development, Schwebel and Raph (1973) write:

... Piaget views the assimilation process as the more conservative, providing the gradualness and the continuity of intellectual development; whereas accommodatory acts result in the child's continually extending and applying new concepts and actions to new and different experiences. The developmental changes that occur in the child's construction of knowledge come about, in a sense, as he searches to regulate the mechanisms of assimilation and accommodation, to consolidate what he has already internalized, and to readjust to new stimuli that disturb existing internalizations (p. 111).

Teacher's Role

The intellectual development of a child points out an important role for teachers. Both Kamii (1973) and Hein (1973) assign the teacher the difficult and delicate role of finding out what the child knows, and how he thinks prior to asking the right questions which would help him to build his own knowledge. The right question at the right time could sharpen the contradictions in the child's thinking at points of disequilibrium. Hein describes the teacher's role during these periods:

... It is the task of the teacher to find these points of disequilibrium, to note when the child is intellectually uncomfortable, to provide new inputs, to show the way to new explanations, and to help with the experience and the explanations that can lead from.
disequilibrium to a new satisfaction based on an incorporation of wider experience (p. 10).

Duckworth (1972) agrees that the right question at the right time can move children to peak levels of thought and excitement. However, she feels that the task of knowing when to ask the right question of a specific child is nearly impossible for a teacher having responsibility for thirty children. She emphasizes that, with the right environment, children can raise the right question for themselves. Her view is in accord with Piaget's emphasis on the child as the active operator in his own learning and development.

It is important that the teacher take the opportunity to learn from children by watching their activities and listening to their verbalizations. It is the teacher who selects challenging materials; who encourages children to find meaning in their experiences; who provides the environment to explore, to find dead ends and change direction, to raise questions, to supply answers—in short, to learn.

During self-discovery, it is the atmosphere the teacher creates, as well as the materials he presents, which provide for learning. This atmosphere is reflected by the teacher's personality, the kind of support and encouragement he offers each child, and his awareness of the process skill goals. The materials the teacher presents to the children must be chosen to reveal related
phenomena through their interaction. The teacher facilitates discovery by introducing more complex materials after a child has discovered the essential relationships. During the exploration, the teacher responds to the actions of individuals rather than giving a generalized response to all of the children.

During the colloquium, the basic role of the teacher is to create a situation where learning can take place. The teacher must choose the precise moment before interest in the materials has abated, but after a certain satisfaction of discovery is evident. The teacher helps the children to perceive accurately. The right word at the right time can facilitate reference to an object and also correct a misconception. The teacher has the opportunity to juxtapose discrepant events and put the responsibility for the solution back to the colloquium. A difficult part of the teacher's role in a colloquium is to redirect the thinking at moments of impasse or when the children run off the track. The teacher's final responsibility in relation to the colloquium is to arrange for the recording of an Investigator's Log which represents the children's consensus in their own language.

The teacher in a self-discovery or discovery-colloquium setting must provide the kind of environment that challenges the child to test his ideas and present him with the right phenomena and feedback so that he can question some of his beliefs.
The review of the related literature focused on three major implications of Piaget's views for educational practice. These implications have been developed into guidelines for effective instruction.

First, children need to manipulate things in order to learn. The child must physically act on his environment. This activity constitutes a major portion of genuine knowledge, the passive reception of facts is only a minor part of understanding.

Second, children should talk in school, should argue and debate. Social interaction, particularly when it is centered about relevant physical experience, promotes intellectual growth.

Third, it is at times of conflict, of disequilibrium, that we can learn a great deal from children, and at which time they are susceptible to new ideas and able to absorb new experiences.

Fourth, it is the important role of the teacher to observe children and to provide them with the appropriate materials so that they can learn and, more important, learn how to learn.
CHAPTER III

RESEARCH DESIGN AND PROCEDURES

The purpose of this study was to investigate the effects of two methodologies, self-discovery and discovery-colloquium, on the science process achievement mean scores of a sample of third grade students.

Sample Selection

The subjects selected for the present study were fifty students in the third grade. Group I consisted of twenty-five students who experienced self-discovery and colloquium. Group II consisted of the remaining twenty-five students who experienced self-discovery only. In order to achieve equivalent groups a random sampling procedure was employed.

The subjects were attending an upper-middle class public elementary school in Simi Valley, California. The population of the school was homogeneous with respect to socioeconomic stratification. At the time of treatment the sample was characterized by a mean age of 8.0. Each had a measured I.Q. of 100 or above as determined by the Otis Intelligence Test administered in May of 1973. Because of failure to obtain proportionality in relation to sex
Research Design

A modified Pretest-Posttest Two Group Design was used. The organization of the experimental treatments are presented in Illustration 1. In order to allow the hypotheses of the present study to be tested appropriately, a pretest was administered to all prospective subjects during the second week of October, 1973. Following the four-month treatment period, a posttest was administered during the second week of February, 1974.

The treatment consisted of process-centered instruction with a combination of teacher-made materials and purchased science kits designed to teach science through materials children could manipulate and problems they could investigate. Both methods employed adaptations of Elementary Science Study (ESS) materials and methods. Although both Group I and Group II were exposed to the self-discovery method, only Group I worked under a discovery-colloquium procedure. Lessons of equivalent length for both groups were taught by the investigator. Both groups received ninety minutes of instruction four times a week for a period of fourteen weeks.
Illustration 1
Pretest-Posttest Two Group Design

<table>
<thead>
<tr>
<th>Activity</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Self-Discovery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discovery-Colloquium</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Posttest</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

Research Instrument

The Science Subtest of the Comprehensive Tests of Basic Skills Form S (CTBS/S), Level C and Level 1, was used for the pretest and posttest to assess the differences in science process achievement mean scores between Group I and Group II. The CTBS/S was selected because of: (1) unbiased sample for standardization, (2) excellent directions for administration of the test, (3) an appropriate science subtest, and (4) availability.

The thirty items in CTBS/S, Level C, assess the student's ability to investigate problems in science and, to a lesser degree, to recall scientific facts or concepts. Investigative skills measured are the abilities to classify objects or activities, to measure or quantify data, to recognize a trend in data, and to predict the outcome of a trend in data. The items are presented as oral problems read aloud by the examiner. In many cases the student
also examines pictures or numerals. Because of this for-
mat, the influence of reading ability on the science score
is eliminated. The items are distributed across the
various content areas of the physical and life sciences.

The thirty-seven items in CTBS/S, Level 1, assess
the student's ability to investigate problems in science,
and, to a lesser degree, to recall scientific facts or
concepts. Investigative skills measured are the abilities
to classify objects or phenomena, to measure or quantify
data, to recognize a trend in data, to predict the outcome
of a trend in data, to recognize a valid hypothesis drawn
from data presented, and to analyze an experimental
design. The student demonstrates these skills by interact-
ing with data presented in charts, diagrams, drawings,
graphs, and written passages. The items are distributed
across the various content areas of the physical and life
sciences.

The subtests comprise overlapping levels, for which
the designations and grade ranges are as follows: Level
C - Grades 1.5-2.9 and Level 1 - Grades 2.5-4.9. The com-
bination of subtests provides for maximum discrimination
among groups of children, as well as to provide for a wide
range of reading ability within the sample. During the
administration of the Level 1 pretest and posttest, indi-
vidual assistance was provided as needed to children in
both groups. This consisted of supplying the right word in
situations of reading difficulty.
Data Collection

All pretests and posttests were administered during the regular school day with the compliance of the student's classroom teachers. All test data were scored, analyzed, and interpreted by the investigator.

Statistical Analysis

The t test for correlated data was applied to test hypotheses 1 through 6. The t test for uncorrelated data was used for hypotheses 7 through 12. In each instance, the 0.05 level of confidence was set for rejection of the null hypotheses.
CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

This chapter presents the data and its analyses of the results of the study.

Treatment of the Data

The t test for correlated data was applied to test hypotheses 1 through 6. The t test for uncorrelated data was used for hypotheses 7 through 12. In each instance the level of confidence necessary to reject the null hypotheses was set at the 0.05 level. Each hypothesis was treated independently. Hypotheses 1 through 6 dealt with pretest and posttest science process achievement scores within the groups. Hypotheses 7 through 12 concerned comparison between groups. The statistical computations were made according to Downie and Heath (1965). All test data were scored, analyzed, and interpreted by the investigator.

Presentation of the Data

Hypothesis 1

The null hypothesis stated that there would be no significant difference in the Level C pretest and posttest science process achievement mean scores for Group I (Group
I was exposed to the discovery-colloquium treatment). The statistical data in Table 1 show the results of the \( t \) test.

**TABLE 1**

A COMPARISON OF PRETEST AND POSTTEST LEVEL C MEAN SCORES FOR GROUP I (\( N = 25 \))

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Mean</td>
<td>20.84</td>
<td>25.56</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>4.75</td>
<td>3.73</td>
</tr>
</tbody>
</table>

\[ t = 6.12* \]

\( *p < 0.05 \) (2.064)

\( 0.01 \) (2.797)

There was a significant difference in the Level C pretest and posttest science process achievement mean scores for Group I. Therefore, Hypothesis 1 was rejected beyond the 0.01 level of significance. Group I which was exposed to the discovery-colloquium treatment made significant gains on the Level C Science Subtest of the CTBS/S.

**Hypothesis 2**

The null hypothesis stated that there would be no significant difference in the Level I pretest and posttest science process achievement mean scores for Group I (Group I was exposed to the discovery-colloquium treatment). The statistical data in Table 2 show the results of the \( t \) test.
TABLE 2
A COMPARISON OF PRETEST AND POSTTEST LEVEL 1 MEAN SCORES FOR GROUP I (N = 25)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>25</td>
<td>17.28</td>
<td>6.37</td>
<td>24</td>
<td>3.98*</td>
</tr>
<tr>
<td>Posttest</td>
<td>25</td>
<td>22.48</td>
<td>6.96</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.05 (2.064)  
0.01 (2.797)

There was a significant difference in the Level 1 pretest and posttest science process achievement mean scores for Group I. Therefore, Hypothesis 2 was rejected beyond the 0.01 level of significance. Group I which was exposed to the discovery-colloquium treatment made significant gains on the Level 1 Science Subtest of the CTBS/S.

Hypothesis 3

The null hypothesis stated that there would be no significant difference in the Level C and Level 1 combined pretest and posttest science process achievement mean scores for Group I (Group I was exposed to the discovery-colloquium treatment). The statistical data in Table 3 show the results of the t test.
**TABLE 3**

A COMPARISON OF PRETEST AND POSTTEST LEVEL C AND LEVEL 1 COMBINED MEAN SCORES FOR GROUP I (N = 25)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>25</td>
<td>38.12</td>
<td>9.94</td>
<td>24</td>
<td>7.41*</td>
</tr>
<tr>
<td>Posttest</td>
<td>25</td>
<td>48.04</td>
<td>10.39</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p <0.05 (2.064)  
0.01 (2.797)

There was a significant difference in the Level C and Level 1 combined pretest and posttest science process achievement mean scores for Group I. Therefore, Hypothesis 3 was rejected beyond the 0.01 level of significance. Group I which was exposed to the discovery-colloquium treatment made significant gains on the Level C Science Subtest of the CTBS/S.

**Hypothesis 4**

The null hypothesis stated that there would be no significant difference in the Level C pretest and posttest science process achievement mean scores for Group II (Group II was exposed to the self-discovery treatment). The statistical data in Table show the results of the t test.
TABLE 4
A COMPARISON OF PRETEST AND POSTTEST LEVEL C MEAN SCORES FOR GROUP II (N = 25)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>25</td>
<td>20.32</td>
<td>3.86</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Posttest</td>
<td>25</td>
<td>24.92</td>
<td>2.66</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.05 (2.064)
0.01 (2.797)

There was a significant difference in the Level C pretest and posttest science process achievement mean scores for Group II. Therefore, Hypothesis 4 was rejected beyond the 0.01 level of significance. Group II which was exposed to the self-discovery treatment made significant gains on the Level C Science Subtest of the CTBS/S.

Hypothesis 5

The null hypothesis stated that there would be no significant difference in the Level 1 pretest and posttest science process achievement mean scores for Group II (Group II was exposed to the self-discovery treatment). The statistical data in Table 5 show the results of the t test.
TABLE 5
A COMPARISON OF PRETEST AND POSTTEST LEVEL 1 MEAN SCORES FOR GROUP II (N = 25)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>25</td>
<td>19.00</td>
<td>5.77</td>
<td>24</td>
<td>3.68*</td>
</tr>
<tr>
<td>Posttest</td>
<td>25</td>
<td>23.56</td>
<td>6.69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p <0.05 (2.064)
0.01 (2.797)

There was a significant difference in the Level 1 pretest and posttest science process achievement mean scores for Group II. Therefore, Hypothesis 5 was rejected beyond the 0.01 level of significance. Group II which was exposed to the self-discovery treatment made significant gains on the Level 1 Science Subtest of the CTBS/S.

Hypothesis 6

The null hypothesis stated that there would be no significant difference in the Level C and Level 1 combined pretest and posttest science process achievement mean scores for Group II (Group II was exposed to the self-discovery treatment). The statistical data in Table 6 show the results of the t test.
TABLE 6
A COMPARISON OF PRETEST AND POSTTEST LEVEL C AND LEVEL 1 COMBINED MEAN SCORES FOR GROUP II (N = 25)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>25</td>
<td>39.32</td>
<td>7.75</td>
<td>24</td>
<td>9.13*</td>
</tr>
<tr>
<td>Posttest</td>
<td>25</td>
<td>48.48</td>
<td>8.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p <0.05 (2.064)
  0.01 (2.797)

There was a significant difference in the Level C and Level 1 combined pretest and posttest science process achievement mean scores for Group II. Therefore, Hypothesis 6 was rejected beyond the 0.01 level of significance. Group II which was exposed to the self-discovery treatment made significant gains on the Level C Science Subtest of the CTBS/S.

**Hypothesis 7**

The null hypothesis stated that there would be no significant difference between Group I and Group II on the Level C science process achievement pretest mean scores. The statistical data in Table 7 show the results of the t-test.
TABLE 7

A COMPARISON OF GROUP I AND GROUP II ON THE LEVEL C PRETEST MEAN SCORES

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>25</td>
<td>20.84</td>
<td>4.75</td>
<td>48</td>
<td>.416</td>
</tr>
<tr>
<td>II</td>
<td>25</td>
<td>20.32</td>
<td>3.86</td>
<td>(n.s.)</td>
<td></td>
</tr>
</tbody>
</table>

There was no significant difference between Group I and Group II on the Level C science process achievement pretest mean scores. Therefore, the null hypothesis was sustained. Neither Group I nor Group II significantly outperformed each other on the Level C Science Subtest of the CTBS/S.

Hypothesis 8

The null hypothesis stated that there would be no significant difference between Group I and Group II on the Level 1 science process achievement pretest mean scores. The statistical data in Table 8 show the results of the t-test.
There was no significant difference between Group I and Group II on the Level C science process achievement pretest mean scores. Therefore, the null hypothesis was sustained. Neither Group I or Group II significantly outperformed each other on the Level C Science Subtest of the CTBS/S.

**Hypothesis 9**

The null hypothesis stated that there would be no significant difference between Group I and Group II on the Level C and Level 1 combined science process achievement pretest mean scores. The statistical data in Table 9 show the results of the $t$ test.
TABLE 9

A COMPARISON OF GROUP I AND GROUP II ON THE LEVEL C AND LEVEL 1 COMBINED PRETEST MEAN SCORES

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>25</td>
<td>38.12</td>
<td>9.94</td>
<td>48</td>
<td>.467</td>
</tr>
<tr>
<td>II</td>
<td>25</td>
<td>39.32</td>
<td>7.75</td>
<td>(n.s.)</td>
<td></td>
</tr>
</tbody>
</table>

There was no significant difference between Group I and Group II on the Level C and Level 1 combined science process achievement pretest mean scores. Therefore, the null hypothesis was sustained. Neither Group I nor Group II outperformed each other on the Level 1 and Level C combined Science Subtest of CTBS/S.

Hypothesis 10

The null hypothesis stated that there would be no significant difference between Group I and Group II on the Level C science process achievement posttest mean scores. The statistical data in Table 10 show the results of the t-test.
TABLE 10
A COMPARISON OF GROUP I AND GROUP II ON
THE LEVEL C POSTTEST MEAN SCORES

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>25</td>
<td>25.56</td>
<td>3.73</td>
<td></td>
<td>.681</td>
</tr>
<tr>
<td>II</td>
<td>25</td>
<td>24.92</td>
<td>2.66</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>

There was no significant difference between Group I and Group II on the Level C science process achievement posttest mean scores. Therefore, the null hypothesis was sustained. Neither Group I nor Group II significantly outperformed one another on the Level C Science Subtest of the CTBS/S.

Hypothesis 11

The null hypothesis stated that there would be no significant difference between Group I and Group II on the Level 1 science process achievement posttest mean scores. The statistical data in Table 11 show the results of the t-test.
TABLE 11

A COMPARISON OF GROUP I AND GROUP II ON THE LEVEL 1 POSTTEST MEAN SCORES

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>25</td>
<td>22.48</td>
<td>6.96</td>
<td>48</td>
<td>.548</td>
</tr>
<tr>
<td>II</td>
<td>25</td>
<td>23.56</td>
<td>6.69</td>
<td>(n.s.)</td>
<td></td>
</tr>
</tbody>
</table>

There was no significant difference between Group I and Group II on the Level 1 science process achievement posttest mean scores. Therefore, the null hypothesis was sustained. Neither Group I nor Group II significantly outperformed one another on the Level 1 Science Subtest of the CTBS/S.

Hypothesis 12

The null hypothesis stated that there would be no significant difference between Group I and Group II on the Level C and Level 1 combined science process achievement posttest mean scores. The statistical data in Table 12 show the results of the t-test.
TABLE 12
A COMPARISON OF GROUP I AND GROUP II ON THE LEVEL C AND LEVEL 1 COMBINED POSTTEST MEAN SCORES

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>25</td>
<td>48.04</td>
<td>10.39</td>
<td>48</td>
<td>.164</td>
</tr>
<tr>
<td>II</td>
<td>25</td>
<td>48.48</td>
<td>8.1</td>
<td></td>
<td>(n.s.)</td>
</tr>
</tbody>
</table>

There was no significant difference between Group I and Group II on the Level C and Level 1 combined science process achievement pretest mean scores. Therefore, the null hypothesis was sustained. Neither Group I nor Group II outperformed each other on the Level 1 and Level C combined Science Subtest CTBS/S.
CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

This study investigated the effects of two methodologies, self-discovery and discovery-colloquium, on the science process achievement mean scores of a sample of third grade students.

The general hypothesis for the present study was based on the assumption that there would be no significant difference in science process achievement between children who experienced the discovery-colloquium instruction and self-discovery instruction.

The subjects selected for the study were fifty third grade students who were randomly assigned to two groups. A modified Pretest-Posttest Two Group Design was used. The Science Subtest of the CTBS/S, Level C and Level 1, was used for the pretest and posttest to assess the difference in science process achievement mean scores between Group I and Group II. Following the pretests, Group I and Group II experienced process-centered instruction in science through the use of materials that children can manipulate and problems they can investigate. Although both Group I and Group II experienced the self-discovery
method, only Group I experienced the discovery-colloquium treatment. Both groups received ninety minutes of instruction four times a week for a period of fourteen weeks.

The t test for correlated data was applied to test hypotheses 1 through 6. The t test for uncorrelated data was used for hypotheses 7 through 12. In each instance the level of significance necessary to reject the null hypothesis was set at the 0.05 level. Each hypothesis was treated independently.

Hypotheses 1 through 6 were concerned with the comparison of pretest and posttest scores within each group. A significant t ratio was obtained at the 0.01 level for each hypothesis and each hypothesis was rejected. Hypotheses 7 through 12 were concerned with the comparison of pretest-posttest scores between Group I and Group II. In each case the null hypothesis was sustained.

Conclusions

The findings of this study indicate that both Group I and Group II made significant gains in process achievement as measured by the CTBS/S instrument. Process learning can take place in both self-discovery and discovery-colloquium contexts if meaningful concrete experiences in which the child can explore in his own way are provided; and if opportunities are given for listening to him tell of his own experiences, in his own language,
clarified through interchange with his peers.

Although each group's achievement was compared to itself on the pretest, the present study did not include a control group which received no exposure to any science instruction. Since it is possible that some gain in achievement could be related to maturation or to exposure to other school activities, and even to the practice gained from test taking, the inclusion of such a control group in the experimental design for within group and between group comparisons would have greatly strengthened this conclusion.

Since there was no significant difference between the groups on the pretest scores, it may be concluded that at the beginning of the study, groups were equivalent in process achievement. However, this study did not uncover any significant differences in the relative effectiveness of the two methods of process instruction. The inclusion of a colloquium in an attempt to increase social interaction in the classroom did not produce any measurable improvement in process achievement.

Levine (1973) expresses the opinion that "disciplined human judgement can do at least as effective job in many tasks as a reliance on pseudo-precise instruments and imperfect designs (p. 1)." Observations made by the investigator during the treatments suggest that the colloquium extended the children's learning gained from self-
discovery experiences. In addition to the spontaneous interaction of children sharing each other's discoveries as they happened, the colloquium experience brought preverbal thought which the exploration engendered to structured interaction with the words and thoughts of co-workers. The pooling of observations in social collaboration further provided opportunities for children to restructure their ideas and get clarification of concepts and generalizations they might not have understood. However, any differences in the effectiveness of the two methods went undetected by the CTBS/S instrument.

There are several limitations to testing in science which contradict the structure of process-centered instruction. A paper-pencil test instrument requires a different response mode than a performance task. In process-centered instruction, children exercise and demonstrate their knowledge and skill through manipulation with objects and interaction with their co-workers. A paper-pencil test instrument limits the child's response mode to reading, listening, and marking. In a study by Walbesser and Carter (1970), group and individual forms of a measure were developed to assess the acquisition of behaviors desired as outcomes of process instruction in science at the elementary school level. The individually administered competency measure required the learner to exhibit the desired behavior, whereas the group competency measure required the learner to select those illustrations which show what he
would do. Significant differences between the scores of individuals on the group and individual competency measures were observed. Students demonstrated higher competency on the items employing the individual format. The significance of these results indicate that the convenience of administering a group paper-pencil test over an individual process task underestimates the competency of the individuals being tested.

The paper-pencil test format is limited in that it requires the student to choose between a fixed set of alternatives. This does not model real-life problem solving. In process-centered instruction, children are encouraged to develop many possible explanations and then find ways to decide which of them make better choices. This kind of process is not reflected in a paper-pencil test format. In process-centered instruction, children share materials, discuss observations, and stimulate one another into further investigation. This social collaboration is discouraged in a paper-pencil testing situation.

It might be appropriate in the context of modern elementary science programs to present problems which require students to design and perform simple experiments as one means of evaluating their achievement in process-centered instruction. The limitations of a paper-pencil test instrument as an effective means of evaluation might have accounted for the differences which went undetected in the present study.
REFERENCES


Chittenden, E. What is learned and what is taught. Young Children, 1969, 25, 12-19.


