A STUDY OF VERBAL BEHAVIOR PATTERNS IN PRIMARY GRADE CLASSROOMS DURING SCIENCE ACTIVITIES

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

THOMAS CHARLES MOON

1969

This is to certify that the

thesis entitled

A STUDY OF VERBAL BEHAVIOR PATTERNS
IN PRIMARY GRADE CLASSROOMS
DURING SCIENCE ACTIVITIES

presented by

Thomas Charles Moon

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Science Education

Wayne Taylor
Major professor

Date 5/22/69

O-169

ABSTRACT

A STUDY OF VERBAL BEHAVIOR PATTERNS
IN PRIMARY GRADE CLASSROOMS
DURING SCIENCE ACTIVITIES

By

Thomas Charles Moon

Problem

This study was designed to analyze selected examples of verbal behavior patterns in primary grade classrooms during science activities. Thirty-two elementary school teachers within five mid-Michigan public school districts comprised the population under consideration. Sixteen of these teachers taught science in the manner suggested by their respective school districts. Each of the sixteen remaining teaching participants within the experimental population received an in-depth study of the Science Curriculum Improvement Study's teaching methods and materials, for they attended a three week workshop in these techniques during the summer of 1968. This study was designed as a quasi-experimental, time-series analysis and involved a series of science teaching observations that began in April, 1968 and were concluded in March, 1969.

Procedure

Each science lesson was recorded with easily portable, battery powered tape recorders, and two of the three instruments used in evaluating the study's data were exclusively concerned with information gathered from analyses of the taped lessons. These two instruments were the Flanders System of Interaction Analysis and the Science Teaching Observational Instrument. The third instrument, the Science Process Test for Elementary School Teachers, centered upon an evaluation of teachers' process skills and comprehension of selected science concepts. Statistical treatments used were a repeated measures design of a mixed model analysis of variance, the Friedman two-way analysis of variance by ranks, and t-tests for correlated data.

Findings

The following are among those findings obtained through analyses of the collected data:

1. those teachers who were exposed to the teaching methods and materials suggested by the Science Curriculum Improvement Study differed significantly from those teachers employing conventional science teaching methods and materials, by demonstrating an increase in the amount of direct teacher influence displayed in verbal behavior patterns during science activities. Apparently this was due to an increased percentage of teacher direction-giving to young children who were actively involved with science materials;

2. there was a pronounced shift in the question preferences displayed by the experimental teachers after the introduction of SCIS teaching methods and materials. The original observations demonstrated a heavy reliance upon low order question types. After the workshop's conclusion, the teachers demonstrated a much greater preference for higher level questions; and

3. although the SCIS summer workshop's activities seemed to have a definite influence upon the experimental teachers' science presentations during those fall months immediately following its conclusion, the types of science materials used by these teachers also might have contributed to this influence.

A STUDY OF VERBAL BEHAVIOR PATTERNS IN PRIMARY GRADE CLASSROOMS DURING SCIENCE ACTIVITIES

By

Thomas Charles Moon

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

College of Education

1969

ACKNOWLEDGEMENTS

The sincerest appreciation is expressed to those persons who have assisted so greatly in conducting this research and doctoral study.

First, to the thesis director and chairman of the doctoral committee, Dr. Wayne Taylor, whose interest, assistance, and guidance were essential to the development and completion of the study.

Second, to the other members of the doctoral committee, Drs. Glenn Berkheimer, George Myers, and Frank Peabody who made important contributions.

Third, to the thirty-two primary grade teachers who participated within the study.

Fourth, to Dr. Maryellen McSweeney who gave much guidance in the use of appropriate statistical formulae and to Dr. Julian Brandou, Director of Michigan State University's Science and Mathematics Teaching Center, for the use of the Center's tape recording facilities.

Fifth, to Mr. Steven Barnes and Mr. Larry Bruce, doctoral students who aided in the collection of data.

Finally, to friends, family, and my wife Marylyn for their support, encouragement, and patience throughout doctoral study, research, and the writing of this thesis.

TABLE OF CONTENTS

	Page
LIST OF TABLES	v
LIST OF FIGURES	viii
LIST OF APPENDICES	ix
Chapter	
I. PROBLEM AND ORGANIZATION OF THE STUDY	1
Introduction	1
Need for the Study	4
Definitions	8
Objectives of the Study	9
Hypotheses	10
Overview of Procedure and Analysis	10
Assumptions	12
Limitations	13
Organization of the Thesis	13
II. REVIEW OF THE LITERATURE	15
Introduction	15
Historical Implications of Elementary School Science Movement	15
Forces Redirecting Elementary Science Teaching	20
Desired Attributes of Contemporary Elementary School Science Programs	22
Role of the Teacher in Modern Elementary School Science	25
Pre-service and In-service Teacher Training in Elementary Science	28
Teacher Attitudes Toward Elementary School Science	34
Verbal Behavior Patterns Within the Classroom	38
Research on the Use of Questions during Science Activities	40
Summary	46
III. IMPLEMENTATION OF THE STUDY	48
Introduction	48
Design of the Study	48

Chapter | Page

Hypotheses 49
Selection of the Population 50
The In-service Experience 52
Teaching Methods and Materials 53
Description of Instruments Used and Collection of Data 60
Flanders System of Interaction Analysis 64
Reliability Estimates 68
Procedures for Analysis of Data 75
Summary 76

IV. ANALYSIS OF DATA AND FINDINGS 80

Introduction 80
Collection and Compilation of Data 80
Hypotheses 82
Comparisons Between the Two Teacher Groups 83
Teacher ID Ratios 84
Percentage of Teacher Talk Within SCIS Classrooms 87
Percentage of Student Talk Within SCIS Classrooms 89
Percentage of Continuous Student Comment Within SCIS Classrooms 91
Analyses of Teacher Preferences for Question Types . . . 93
Analyses of Science Process Skills 96
Discussion of the Study's Findings 100
Teacher ID Ratios 103
Percentage of Teacher Talk 104
Percentage of Student Talk 104
Percentage of Continuous Student Comment 106
Teacher Question Type Preferences 106
Teachers' Science Process Skills 108
Some Concerns and Attitudes of the Teachers Within the Study 109
Summary 110

V. SUMMARY AND CONCLUSIONS 111

Summary of Findings 112
Conclusions 114
Implications From the Study 114
Implications for Future Research 115

BIBLIOGRAPHY 117

APPENDICES 124

LIST OF TABLES

Table		Page
1.	Lesson Topics Presented by Pre-SCIS Teachers and Conventional Science Teachers	55
2.	Observation Dates of Teachers Using SCIS Teaching Methods and Materials	61
3.	Observation Dates of Teachers Using Conventional Science Teaching Methods and Materials	62
4.	Intra-observer Reliability for the Flanders System of Interaction Analysis	70
5.	Intra-observer Reliability for the Science Teaching Observational Instrument Categories	74
6.	Summary of Hypotheses and Models Used to Analyze Data . .	77
7.	Analysis of Variance Data for the ID Ratios of SCIS Teachers	85
8.	Mean Scores and Standard Deviations of SCIS Teachers' ID Ratios per Observation	86
9.	Mean Observation Dates for the Sixteen SCIS Teachers . .	86
10.	Analysis of Variance for Percentage of SCIS Teacher Talk	87
11.	Analysis of Variance Data for Percentage of Student Talk in SCIS Classrooms	91
12.	Analysis of Variance Data for Percentage of Continuous Student Comment in SCIS Classrooms	93
13.	Summary of Time by Type Interactions Using the Friedman Analysis of Variance by Ranks	96
14.	Pre-test and Post-test Data Concerning the SCIS Teachers on the Science Process Test	99

Table | Page

15. Summary of Data Analysis for Each Hypothesis Tested 101

16. SCIS Teachers' Percentage of Giving Directions (Flanders Category Six) Across Observations 105

17. A Statistical Comparison of Two Groups of In-Service Elementary Teachers on the Science Process Test 108

18. 1968 SCIS Summer Workshop 124

19. Interaction Analysis Categories 133

20. Observer Tally Sheet 135

21. Observation Matrix 136

22. Science Teaching Observational Instrument Categories . . . 137

23. Raw Score Frequencies of Two Groups of Elementary School Teachers on the Science Process Test for Elementary School Teachers 138

24. ID Ratios of Those Sixteen Teachers Using SCIS Teaching Methods and Materials 151

25. ID Ratios of Those Sixteen Teachers Using Conventional Science Teaching Methods and Materials 152

26. Percentage of Teacher Talk in Those Sixteen Classrooms Using SCIS Teaching Methods and Materials 153

27. Percentage of Teacher Talk in Those Sixteen Classrooms Using Conventional Science Teaching Methods and Materials 154

28. Percentage of Student Talk in Those Sixteen Classrooms Using SCIS Teaching Methods and Materials 155

29. Percentage of Student Talk in Those Sixteen Classrooms Using Conventional Science Teaching Methods and Materials 156

30. Percentage of Continuous Student Comment in Those Sixteen Classrooms Using SCIS Teaching Methods and Materials 157

Table | Page

31. Percentage of Continuous Student Comment in Those Classrooms Using Conventional Science Teaching Methods and Materials 158

32. Percentage of Question Type Preferences for Those Sixteen Teachers Using SCIS Teaching Methods and Materials 159

33. Percentage of Question Type Preferences for Those Sixteen Teachers Using Conventional Science Teaching Methods and Materials 162

LIST OF FIGURES

Figure		Page
1.	Subject Areas of the SCIS Program (1968)	58
2.	SCIS Teachers' Mean ID Ratios Per Mean Observations, N = 16	88
3.	SCIS Teachers' Mean Percentage of Teacher Talk Per Mean Observations, N = 16	90
4.	Mean Percentages of Student Talk per Mean Observations, N = 16 Classrooms	92
5.	Mean Percentages of Continuous Student Comment Per Mean Observations, N = 16 SCIS Classrooms	94
6.	Mean Percentages of Question Types by the Sixteen SCIS Teachers Per Mean Observations	97
7.	Mean Percentages of Question Type Preferences by Both SCIS Teachers and Conventional Science Teachers on Initial and Final Observations, N = 32	98

LIST OF APPENDICES

Appendix Page

A. The SCIS Summer Workshop and Instruments Used to Gather Data 124

B. Summary of Data Analyzed for Both the SCIS Teachers and Those Teachers Using Conventional Science Teaching Methods and Materials 151

C. Data Collected on Teacher Question Type Preference 159

D. Cover Letters 165

CHAPTER ONE

THE PROBLEM AND ORGANIZATION OF THE STUDY

In the past decade an increased interest in American elementary school science curricula has become evident. A wide spectrum of curriculum innovations has blossomed onto the educational scene that profess to focus upon the elementary school child and how he learns science. Many such programs stress the importance of the child within their published materials. And rightly so, for he represents the recipient of that wealth of scientific knowledge deemed important for him as a functioning member of his society. These new science materials also stress the importance of the elementary school teacher and how her teaching role is modified through the introduction of such programs. In actuality the actions of the individual teacher determine the curriculum within any respective classroom. The basis for this study stems from a consideration of such teacher actions in response to the introduction of a recent curriculum innovation, the Science Curriculum Improvement Study. This study's problem is to analyze selected examples of verbal behavior patterns in primary grade classrooms during science activities.

The teacher's role within educational endeavors is of utmost importance. This was made most evident by Hough when he stated:

> The central activity of any educational institution is teaching. Other activities such as those performed by administrative,

special services and curriculum development personnel gain sanction only when they function as to support teachers and their teaching.[1]

The following skills should be continually in evidence throughout the activities of any teacher charged with formulating the learning environments of others:

1. selecting and organizing the content of instruction and stating the objectives of instruction as observable student behavior;
2. making and implementing instructional decisions;
3. creating measuring devices and measuring student learning;
4. and evaluating the appropriateness of objectives, the effectiveness of instruction and the validity of measurement techniques.[2]

It is within the realm of science education that the above mentioned activities become most crucial to the elementary school teacher. Yet many such teachers feel uneasy when science is mentioned as an integral aspect of the total elementary curriculum.

One definition of science that seems quite appropriate states that science is a systematic and connected arrangement of knowledge within a logical structure of theory.[3] Tyler has also described science as a continuing process of inquiry.[4] Scientific endeavors have assumed ever-increasing importance within contemporary educational practices

---

[1] John B. Hough, "Ideas for the Development of Programs Relating to Interaction Analysis," Innovative Ideas in Search of Schools: Title III, PACE (Lansing: State Board of Education, 1966, p. 97.

[2] Ibid.

[3] Paul DeHart Hurd, Theory Into Action in Science Curriculum Development (Washington, D.C.: National Science Teachers Association, 1964), p. 11.

[4] Ralph W. Tyler, "The Behavioral Scientist Looks at the Purposes of Science-Teaching," Rethinking Science Education, Fifty-Ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1960), p. 31.

when one realizes that a principal goal of universal education should be the communication of the spirit of science and the development of people's capacities to use its values.[5] Cognizance of this goal should be demonstrated by the contemporary elementary school teacher.

Increasingly the teaching style demonstrated within the classroom is of critical importance in effective learning of scientific concepts.[6] Science in the elementary school can no longer be relegated exclusively to the incidental or chance-happening style of teaching. Jacobson indicated his conception of the type of elementary science instruction needed when he stated:

> Effective science teaching is not a step-by-step procedure; instead, it is an interaction between children, teacher, materials, equipment, and facilities. The teacher nurtures, stimulates, and guides these interactions.[7]

The importance of the teacher's role in the learning activities that occur within elementary school science becomes most evident when one realizes that the effectiveness of any science program depends ultimately on the competency and initiative of the individual teacher.[8]

It has been stated that the improvement of elementary school science:

> begins with the assignment of a teacher who has a good science background, has a knowledge of the objectives for teaching science,

---

[5]Educational Policies Commission, Education and the Spirit of Science (Washington, D.C.: National Educational Association, 1966), p. 27.

[6]Willard J. Jacobson, "Teacher Education and Elementary School Science--1980," Journal of Research in Science Teaching, 5, Issue I (1967), 76.

[7]Ibid., p. 77.

[8]Samuel W. Bloom, "How Effective is Science in the Elementary School?" School Science and Mathematics, 59 (February, 1959), 95-96.

> is interested in teaching, knows how children learn, and wants to be a good teacher. The teacher, then, is the key to the learning situation. His enthusiasm carries to the learner. His interests often become theirs. His concerns for them is reflected in his success as a teacher.
>
> The good teacher is a guide; but he is more than that. Because of his experience and understanding he not only guides but also directs the learning into profitable channels. He keeps the learning from being a narrow experience by broadening the interests of the learner and by opening up new avenues of learning.[9]

Thus the various concepts that a teacher of elementary school science conveys during these learning episodes will contribute much toward the effectiveness of her role in improving science education.

The purpose of this study is to determine whether selected examples of verbal behavior patterns demonstrated by primary grade teachers and their pupils change with instruction using the teaching methods and materials developed by the Science Curriculum Improvement Study.

The Need for the Study

The purpose of research in science education, according to some authors, is to advance the conceptual schemes which have developed to explain events that occur within man's environment.[10] An entire array of such conceptual schemes have been delineated concerning elementary school science and Mallinson has stated two such areas in dire need of educational research. She states that such research is needed to

---

[9]Glenn O. Blough, "Teaching and Evaluating Science in the Elementary School," Rethinking Science Education, Fifty-Ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1960), pp. 138-139.

[10]Joseph D. Novak, "A Preliminary Statement on Research in Science Education," Journal of Research in Science Teaching, I (1963), 3.

identify those things that science should help children do better, and that researchers must concentrate efforts upon determining how any given curricular method may be used more effectively.[11] Both of these examples are heavily dependent upon the teacher's effectiveness in communicating the goals of instruction to the children under her guidance.

The spoken discourse within the classroom has been studied profitably from many standpoints and for many purposes. It has been stated by Hough that:

> . . . a visit to a typical elementary or secondary school will reveal that 60 per cent of classroom time is taken up in verbal interaction, i.e., talk and that more than 70 per cent of such talk is done by teachers. Teachers use their verbal behavior for a variety of instructional purposes. They may manage activities by giving directions; they may present ideas or opinions by lecturing; they may elicit student involvement by asking questions; and, they may praise, clarify, accept or criticize student ideas or behavior. Clearly then, if only by virtue of its quantity, classroom verbal interaction and particularly teacher talk constitutes an important dimension of instruction.[12]

Hughes further attested to the importance of effective verbal communication when she stated that the measure of good teaching is the quality of the response the teacher makes to the child or group with whom he is interacting.[13]

One set of exemplars that are representative of such verbal interactions within the elementary school classroom focuses upon the effective use of questions. Questions can be used by the teacher to stimulate thinking, to initiate discussion, to appraise what children

---

[11] Jacqueline Buck Mallinson, "What Research in Science Education Is Needed to Strengthen the Elementary-School Science Program?" Science Education, 40 (December, 1956), p. 369.

[12] Hough, *op*. *cit*., p. 98.

[13] James Raths, John R. Pancella, and James S. Van Ness, Studying Teaching (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967), p. 21.

have learned, and to determine what they are thinking about.[14] Snyder also emphasized the importance of questions as a measure of verbal interaction when he stated that measuring question-asking behavior may serve as a means of evaluating new science curricula and as a means of determining the effects on inquiry of different science teaching methodologies.[15]

Those persons primarily responsible for the development of the Science Curriculum Improvement Study have stated that in order for learning to take place the child must be directly involved in the experience.[16] This pupil involvement focuses attention upon the teacher as an observer of children's learning activities. It is through these observations that the teacher will hopefully develop the insight and understanding necessary for making the choice of relevant further experiences for them. To guide learning in this way, an effective teacher of elementary school science should understand both the content and process aspects of that particular science topic for which she is formulating the classroom instruction.

The Science Curriculum Improvement Study heavily emphasizes child-to-child communication as an integral aspect in the operation of a science lesson. An effective teacher is one who is aware of such communication and structures the learning activity in such a way that

---

[14] Willard J. Jacobson and Allan Kondo, SCIS Elementary Science Sourcebook (Berkeley: University of California Regents, 1968), p. 44.

[15] William Ray Snyder, "The Question-Asking Behavior of Gifted Junior High School Science Students and their Teachers," Dissertation Abstracts, 27, No. 11 (1967), 3738-A.

[16] Robert Karplus and Herbert D. Thier, A New Look at Elementary School Science (Chicago: Rand, McNally and Company, 1967), p. 80.

this communication is enhanced. An ideal teacher does not take lightly the importance of question-asking and the purposes for which one asks questions, in formulating her role in elementary school science. A teacher familiar with SCIS teaching methods and materials would ideally have the ability to assume an indirect, passive role when the children are involved in a discovery lesson in which they are formulating and recording their own observations. Conversely, if the science lesson under consideration involves the introduction of new or complex concepts, she must be able to explicitly invent these concepts for the children and aid them in the use of these inventions.

Ideally, a teacher actively interested in promoting elementary school science would not place primary interest upon telling children about science or listening to them while they read about science, but rather observing and interacting with children while they are directly involved with science.

This study focuses upon selected aspects of teaching behavior during science lessons, and is designed to ascertain whether such a new curriculum effort does alter teaching modes. Primary attention is directed toward an analysis of verbal classroom interactions as exemplars of teaching procedures. It has been stated by Aschner that

> . . . verbal behavior in the classroom is, of course, the most continuous and pervasive of teacher behavior in the classroom. It is the language of responsible actions designed to influence the behavior of those under instruction.[17]

Such a study as this could be useful in structuring further in-service

---

[17]Marie Hughes, Development of the Means for the Assessment of the Quality of Teaching in Elementary Schools (Salt Lake City: University of Utah Press, 1959).

educational endeavors that profess interest in changing teachers' instructional activities.

Definitions

The following are definitions, statements, or assumptions as they are used in this dissertation.

Role, according to Good, is defined as those "behavior patterns of functions expected of or carried out by an individual in a given societal context."[18]

According to Bellack, verbal interaction means the communication of language and meaning in the classroom, which in turn tends to indicate the behavior of those involved in the classroom.[19]

Teacher behavior has been described by Ryans as the behavior or activities of persons as they go about doing whatever is required of teachers, especially the guidance and direction of the learning activities of others.[20]

Interaction analysis could be defined as the systematic quantification of behavioral acts or qualities of behavior acts as they occur in some sort of spontaneous interaction.[21] It is an observation procedure designed to permit a systematic record of spontaneous acts and

---

[18]Carter V. Good, Dictionary of Education (New York: McGraw-Hill Book Company, Inc., 1959), p. 471.

[19]John R. Verduin, Jr., Conceptual Models in Teacher Education (Washington, D.C.: American Association of Colleges for Teacher Education, 1967), p. 44.

[20]David G. Ryans, "Theory Development and the Study of Teacher Behavior," Journal of Educational Psychology, 47 (1956), 467.

[21]Verduin, op. cit., p. 32.

to scrutinize the process of instruction by taking into account each small bit of interaction.

The ID ratio has been defined by Amidon and Flanders as the amount of indirect teacher influence in verbal classroom behavior divided by the amount of direct teacher influence.[22]

Objectives of the Study

The purposes of this study were to determine whether there is a difference in:

1. the teachers' ID ratios during science activities, before and after the teachers have been exposed to the Science Curriculum Improvement Study's teaching methods and materials;

2. the percentage of time teachers spend talking during science activities, before and after the teachers have been exposed to the Science Curriculum Improvement Study's teaching methods and materials;

3. the percentage of time students talk during science activities, before and after the teachers have been exposed to the Science Curriculum Improvement Study's teaching methods and materials;

4. the percentage of continuous student comment during science activities within the classroom, before and after the teachers have been exposed to the Science Curriculum Improvement Study's teaching methods and materials;

5. the kinds of questions teachers ask during science activities, before and after the teachers have been exposed to the Science Curriculum Improvement Study's teaching methods and materials; and

6. the teachers' comprehension of the process aspects of science, before and after the teachers have been exposed to the Science Curriculum Improvement Study's teaching methods and materials.

---

[22]Edmund J. Amidon and Ned A. Flanders, The Role of the Teacher in the Classroom (Minneapolis: Amidon Associates, Inc., 1963), p. 29.

Hypotheses of the Study

Hypotheses:

H_{o1} There is no difference in the teachers' ID ratios during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o1}: $ID_1 = ID_2$).

H_{o2} There is no difference in the percentage of time teachers spend talking during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o2}: $TT_1 = TT_2$).

H_{o3} There is no difference in the percentage of time students talk during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o3}: $ST_1 = ST_2$).

H_{o4} There is no difference in the percentage of continuous student comment during science activities within the classroom, before and after the introduction of SCIS teaching methods and materials (H_{o4}: $CC_1 = CC_2$).

H_{o5} There is no difference in the kinds of questions teachers ask children, before and after the introduction of SCIS teaching methods and materials (H_{o5}: $KQ_1 = KQ_2$).

H_{o6} There is no difference in the teachers' comprehension of the process aspects of science, before and after the introduction of SCIS teaching methods and materials (H_{o6}: $PS_1 = PS_2$).

Overview of Procedure and Analysis

This study was designed as a quasi-experimental, time-series analysis and centered upon an assessment of teaching procedures during first and second grade science activities. Observations of verbal interactions were collected through taped recordings of science lessons and analyzed through the use of the Flanders System of Interaction Analysis.

Thirty-two elementary teachers within five mid-Michigan public school districts comprised the population under consideration. Sixteen of these teachers taught science in the conventional manner suggested by their respective school districts. Each of the sixteen remaining teachers were participants within the experimental population and received in-depth training in the Science Curriculum Improvement Study's teaching methods and materials, for they attended a three week workshop in these techniques during the summer of 1968. Eleven of the sixteen original teachers within the experimental population were observed twice prior to the workshop; the other five were observed once. All teachers within the experimental group were observed on four separate occasions after the workshop's conclusion. Each of the sixteen teachers using conventional science materials were also observed twice during the 1968-1969 school year. Taped recordings were analyzed for each lesson within the study.

The Flanders System of Interaction Analysis was used as the vehicle to gather data pertinent to hypothesis one. Flanders suggested several derived measures from this scale category and Fischler developed two such scales which were modified and used in the analysis of hypotheses two, three, and four.[23] Fischler also developed the Science Teaching Observational Instrument, which is designed to effectively code

[23]Abraham S. Fischler and N. J. Anastasiow, "In-Service Education in Science (A Pilot)," Journal of Research in Science Teaching, 3 (1965), 283.

teacher questions into five distinct categories.[24] This instrument organized data for the hypothesis five evaluation. Hypothesis six was tested from data collected via the following instrument: The Science Process Test for Elementary School Teachers (Revised Edition), devised by Dr. Evan A. Sweetser of Virginia Polytechnic Institute.

Correlations of ratings were produced to determine the intra-observer reliabilities of the two individuals engaged in the analysis of the taped lessons. Scott's coefficient of reliability was the statistic used to compute these data.

The first four stated hypotheses were tested statistically via a repeated measures design of a mixed model analysis of variance and a Friedman Test was used to evaluate hypothesis five. A t-test for correlated data was used to appraise hypothesis six.

Assumptions

In conducting this study it was assumed that: the verbal behavior of the teacher is an adequate sample of her total behavior; that is, her verbal statements are consistent with her nonverbal gestures; how much teachers talk and what they say determine to a large extent the reactions of the students; the kinds of questions teachers ask are an indication of the quality of teaching that is going on and the levels of thinking that are being stimulated; and the lessons observed and recorded are exemplars of the types of science lessons normally presented by those teachers within the study.

---

[24] Ibid.

Limitations

Although correlations of ratings were produced to determine the reliability of the two investigators in the use of the evaluation instruments previously described, there is an element of subjectivity in the judgments of these individuals in determining the classification of verbal classroom interaction. This subjectivity is a limitation to the study. In addition, the population under consideration was geographically limited to a selected sample of elementary school teachers within five mid-Michigan public school districts. Any inferences thus derived from this study are limited by the similarity of this population to the general population of elementary school teachers.

Organization of the Thesis

Presented in this chapter was the statement of the problem, the background of the study, the need for the study, and an overview of the procedures and analysis. Additionally the assumptions and limitations of the study were presented. Chapter two contains the derivation of the objectives of science education in the contemporary elementary school from a historical context, and the review of the literature concerning the changing role of the elementary school teacher in regard to the recent curricular developments within elementary school science.

The execution of the study is described in chapter three, which includes a discussion of the design used and the procedures demonstrated for selection of the population under consideration.

The analysis of data and findings are presented in chapter four; chapter five contains the conclusions and the implications of this study for future research.

CHAPTER TWO

REVIEW OF THE LITERATURE

Introduction

Before one can adequately consider the varied ramifications of this study's problem as stated in chapter one, some general aspects of elementary school science must be established.

Chapter two includes a review of the literature in regard to such germane topics as: the historical implications of the elementary science movement; forces redirecting contemporary elementary science; the teacher's role in elementary science at present and the implications this role demonstrates for pre-service and in-service science education. At its conclusion the literature review emphasizes the teacher's verbal behavior patterns as one exemplar of teaching style. The use of questions as a necessary component of these teaching techniques is also considered.

Historical Implications of the Elementary School Science Movement

Smith has written that there were two definite influences fostering the development of the modern American elementary school science program.[1] One focused upon the somewhat didactic literature imported from Great Britain at the time Sir Thomas Huxley was instigating seminars in science teaching for English grammar school teachers. The other influence developed from the famous "object teaching" movement of Pestalozzi in the latter half of the nineteenth century. Both approaches were sadly lacking, for they were highly formalized and attempted to impose a mature scientist's viewpoint upon young children. Neither contributed effectively to a sense of sequence and direction; the child often was considered in terms of his limitations rather than in terms of his capabilities.

Yet these two approaches held prominence within elementary school science until the nineteen twenties, when the nature study movement began to gain impetus within American grade schools. The Third Yearbook of the National Society for the Study of Education,[2] entitled Nature Study, had earlier advocated the importance of functional relationships between elementary instruction in science and the natural sciences in secondary schools. Bradley has written that science began to play a conspicuous role in elementary schools as a separate, autonomous subject[3] and that nature study was the basic theme within these

---

[1]Herbert A. Smith, "Educational Research Related to Science Instruction for the Elementary and Junior High School: A Review and Commentary," Journal of Research in Science Teaching, 1, Issue 3 (1963), 200.

[2]Nelson B. Henry, (Ed.), Rethinking Science Education, Fifty-Ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1960), XIII.

[3]R. C. Bradley, N. W. Earp, and T. Sullivan, "A Review of Fifty Years of Science Teaching and Its Implications," Science Education, 50 (March, 1966), 152.

programs. Even though science became stereotyped as a teaching of facts instead of a method of thinking scientifically, at least the nature study movement directed attention to the child and his need to be aware of, and to know more about, his environment.[4]

The publication of the Thirty-first Yearbook of the National Society for the Study of Education in 1932[5] gave further momentum to elementary school science when it recommended that:

1. all science instruction be organized about certain broad generalizations or principles;

2. the purpose of science teaching was the development of the understanding of major generalizations and associated scientific attitudes; and

3. a continuous science program is a necessity from kindergarten through the twelfth grade.

John Dewey also actively crusaded for a viable elementary science program when he contended that the methodology of science was at least of equal, or even greater, significance than the actual knowledge accumulated by young children.[6]

From the nineteen twenties to the mid-nineteen forties, science instruction in both the elementary and junior high schools was strongly influenced by "life adjustment education"[7] and the various curricula often revolved around technology in a somewhat fragmentary, unorganized

---

[4]Edward Victor, Science for the Elementary School (New York: Macmillan Company, 1965), p. 7.

[5]Nelson B. Henry, (ed.), Science Education in American Schools, Forty-Sixth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1947), p. 21.

[6]Smith, op. cit., p. 202.

[7]Robert H. Carleton, "Science Education in the Middle or Junior High School Grades," Science Teacher, 34, No. 9 (December, 1967), 26.

manner. From the close of the Second World War until the advance of the space age in late 1957, science education was primarily devoted to the preparation of individuals to live healthfully, successfully, and responsibly within a constantly changing society.[8] Those science experiments that were developed for elementary teachers during this period were more teacher directed than student directed, and the 1950s saw more audio-visual materials and aids, such as science kits and portable science laboratories, developed to encourage this trend.

Blough has written that the purposes of teaching science in the elementary schools of the nineteen sixties have bases in: the prevailing American culture, the nature of children, and science itself.[9] A review of the literature since 1960 demonstrates how influential these three points have been in the continued quest by society for scientific literacy within its members. For to escape the threat of obsolescence, education in the sciences must continually be based upon the kind of information that has survival value and upon strategies of inquiry that facilitate the adaptation of knowledge to new demands. A National Science Teachers Association publication fully advocated such an approach to contemporary science education when it stated that a person literate in science knows something of the role of science in society and appreciates the cultural conditions under which science thrives. Such a person also understands its conceptual inventions and

---

[8]Bradley, Earp, and Sullivan, op. cit., p. 153.

[9]Glenn O. Blough, "Teaching and Evaluating Science in the Elementary School," Rethinking Science Education, Fifty-Ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1960), p. 112.

its investigative procedures. Science teaching thus must result in scientifically literate citizens.[10]

Therefore it is not surprising to discover how many contemporary authors advocate such an approach to elementary science within their published materials. Mallinson and Mallinson have written that the prime objective of elementary science teaching is to help children acquire an understanding of, and an ability in, the topics and skills related to science.[11] Sears and Kessen have stated that the central task of science education is to awaken in children a sense of joy and excitement in science's intellectual power.[12] And Smith additionally recorded that the function of both elementary and junior high school science today is to provide knowledge, understanding, and concept development in basic science content. Such an approach should reveal the nature of science as a process of inquiry.[13]

But what circumstances have brought about this increased interest in elementary science curricula within the past decade, and the efforts by many authors to elucidate the objectives that such curricula should foster? The section that follows directs itself to this question.

---

[10] Paul DeHart Hurd, <u>Theory Into Action in Science Curriculum Development</u> (Washington, D.C.: National Science Teachers Association, 1964), p. 8.

[11] G. G. Mallinson and J. V. Mallinson, "Science in the Elementary Grades: Children's Learnings in Science," <u>Review of Educational Research</u>, 31 (June, 1961), 238.

[12] Paul B. Sears and W. Kesson, "Statement of Purposes and Objectives of Science Education in School," <u>Journal of Research in Science Teaching</u>, 2 (1964), 4.

[13] Smith, <u>op</u>. <u>cit</u>., p. 211.

Forces Redirecting Elementary Science Teaching

Tyler has clearly delineated four primary forces redirecting all levels of science teaching today.[14] These forces are:

1. the technological revolution that has resulted in public recognition of the importance of science's role in today's society;

2. the closer working relationship that has been fostered among university personnel, the research scientist, and the classroom teacher;

3. the nature of the knowledge explosion that has altered the conception of science itself--so that it is no longer considered to be the acquisition of basic principles and facts, but rather a process of continuing inquiry and reconstruction of knowledge; and

4. the wide range of pupil interests, abilities, backgrounds, and experiences that actively marshalls a science teaching methodology meeting the varied needs of all pupils.

This last point has led such authors as Gagné to conclude that any science teaching methodology must not have as its goal the accumulation of knowledge about any particular science domain, but rather inculcate competency in the use of processes basic to all the scientific disciplines.[15] By using such an avenue many science educators feel the needs of all pupils can best be achieved, for the development of such inquiry skills provide the learner with the tools so crucial for independent learning.

Through such forces redirecting elementary school science teaching has developed a theory of instruction actively supported by

---

[14] Ralph W. Tyler, "Forces Redirecting Science Teaching," Science Teacher, 29, No. 6 (October, 1962), 22.

[15] R. M. Gagné, "Elementary Science: A New Scheme of Instruction," 151, No. 3706 (January 7, 1966), 49.

a publication of the National Science Teachers Association.[16] The booklet states that such a theory of science education is crucial to modern curriculum development and should demonstrate the following aspects of instruction:[17]

1. the nature of science: its structure, its processes of inquiry and its conceptual schemes;

2. the nature of the learner: his motives, cognitive style, emotional background, and intellectual potential;

3. the nature of the teacher: his cognitive style, ability to communicate, control pattern, educational philosophy, and understanding of science;

4. the nature of learning: its processes, contexts, conditions, and purposes;

5. the nature of the curriculum: its organization, sequence, and its substantive, attitudinal, and procedural dimensions, and

6. the nature of the social structure: the social and cultural forces with their demands and incentives.

Although supporting such a theory of science instruction should be actively encouraged, one cannot easily dismiss Tyler's thoughts when he wrote that ". . . the one most important resource we have in improving science teaching and in solving the serious problems of this age is the science teacher."[18] With this quotation in mind, the following few sections are devoted to some desired components of modern elementary science programs and the unique roles teachers portray within them.

---

[16] DeH. Hurd, *op. cit.*, p. 13.

[17] *Ibid.*

[18] Tyler, *op. cit.*, p. 22.

Desired Attributes of Contemporary Elementary School Science Programs

Gagné has very capably described the functions of any science curriculum endeavor when he stated that ". . . Fundamentally, the purpose of a curriculum is to organize the educational situation in such a way that students, who are at one stage, or age, incapable of exhibiting certain kinds of behavior relevant to science, become capable of exhibiting certain kinds of behavior."[19] Bruner has also written that ". . . A curriculum, as it develops should revisit basic ideas repeatedly, building upon them until the student has grasped the full formal apparatus that goes with them."[20] Both authors certainly would agree with Hill when she stated that ". . . the idea of developing concepts related to topics chosen solely on some such opportunistic basis as children's interest or prominence in the news is being discarded in elementary science."[21]

Thus there is a conscientious effort being made to develop elementary school science activities that demonstrate scope, continuity, and sequence. Carin and Sund have endorsed such a planned program, for they feel that an integrated science curriculum minimizes boredom and repetition. An integrated science curriculum provides for the early introduction of the methods and systematic characteristics

---

[19] R. M. Gagné, "A Psychologist's Counsel on Curriculum Design," Journal of Research in Science Teaching, 1 (1963), 27.

[20] Jerome S. Bruner, The Process of Education (New York: Random House, 1960), p. 13.

[21] Katherine E. Hill, Helping Children Learn Science, ed. Anne B. Hopman (Washington, D.C.: National Science Teachers Association, 1966), p. 4.

of science inquiry.[22] Blough reinforced this concept when he delineated the following advantages of a structured elementary school science program.[23] Such a program:

1. presents a framework of science principles;
2. does not have to be rigid;
3. demonstrates uniqueness that is not lost--it allows for spontaneous topics;
4. arouses an interest in science within the school; and
5. allows children to acquire science concepts necessary for a complex world.

Craig has written that the content of any such structured elementary science program should be broad enough in scope to provide for growth in learning about all the major aspects of the environment--the sky, the atmosphere, the earth--conditions necessary to life, other living organisms, energy and forces (physical, chemical, biological), and the inventions and discoveries of mankind.[24] And Blackwood also has stated that:

> . . . attempts are being made to develop programs and courses that clearly follow the continuity and unity of science. Conceptual schemes, threads, themes and the like, are terms used for the strands of integrative ideas that give a continuity and pattern to the study of science. Conscious attention to the development of scientific methods by involving students in making scientific

---

[22]Arthur Carin and Robert Sund, Discovery Teaching in Science (Columbus, Ohio: Charles E. Merrill Books, Inc., 1966), p. 11.

[23]Blough, op. cit., p. 128.

[24]Gerald S. Craig, What Research Says to the Teacher: Science in the Elementary Schools (Washington, D.C.: National Education Association, 1957), p. 7.

inquiries is expected to give an integrity to the study of science and thereby to strengthen the curriculum.[25]

The teacher's role in presenting such desirable science activities for children becomes most evident when one realizes how much written material is devoted to the teacher and her relationships with children during a science lesson. Craig has stated emphatically that the elementary school teacher must be aware of how a child interprets the world about him, and parallels the similarities between children and scientific enterprises in that both are involved in the active process of interpreting the physical world.[26] Children's scientific curiosities are aroused by events in the home, mass communication, the school, and their own desires for answers about their environment. These questions could form the motivating force around which science teachers might devise teaching techniques.

Research, according to Cronbach, seems to reveal that leaving a child alone to discover is not nearly as good as providing him with a guided sequence to maximize the possibility of early discovery.[27] Atkin's studies have demonstrated that younger children rely more on emperical tests of hypotheses and tend to be less dependent on recourse to authority.[28] Thus most effective learning in science takes place through an active involvement of the learner. Subarsky would agree with this

---

[25] Paul E. Blackwood, Using Current Curriculum Developments, A Report of ASCD's Commission on Current Curriculum Developments (Washington, D.C.: Association for Supervision and Curriculum Development, NEA, 1963), p. 61.

[26] Craig, op. cit., p. 3.

[27] L. J. Cronbach, "Learning Research and Curriculum," Journal of Research in Science Teaching, 2 (1964), 206.

[28] Smith, op. cit., p. 213.

concept for he stated that ". . . teaching of science in the primary grades must center around experiences with concrete things to which the child does something."[29]

Renner and Ragan further attested to the crucial importance of the teacher within contemporary elementary science when they stated that:

> When we are teaching children, however, we must remember that they are not skilled scientists and do not think as such. Rather, pupils in the elementary schools are there to learn how to formulate possible solutions (hypotheses) to problems and this will be done only if the teacher leads them to develop correct procedures in hypothesis formation . . . This characteristic has been completely missing from science teaching in the elementary schools.[30]

With these last comments as a frame of reference, one becomes increasingly aware of the importance of the following statement attributed to the National Science Teachers Association's publication cited earlier:

> The success of a new curriculum greatly depends upon how it will be taught. A curriculum reform is as much a matter of improving instruction as it is a re-evaluation of course content.[31]

The next two sections of this literature review focus upon the elementary teacher's role in improving science curricula.

The Role of the Teacher in Modern Elementary School Science

If one agrees that a primary purpose in educating children must be to give them the kind of guidance which leads them to make adjustments

---

[29]Zachariah Subarsky, Helping Children Learn Science, ed. Anne B. Hopman (Washington, D.C.: National Science Teachers Association, 1966), p. 11.

[30]John W. Renner and William B. Ragan, Teaching Science In the Elementary School (New York: Harper and Row, 1968), p. 10.

[31]DeH. Hurd, *op. cit.*, p. 13.

to events occurring in the world around them, then a sound elementary science program can facilitate this goal by providing an adequate base for lifetime learning. Such science programs should be guided by teachers who are able both to distill from science its most basic concepts and to present them in meaningful and motivating ways to young children.[32] The teacher's role therefore becomes one of helping children achieve specific knowledge and skills which will serve both them and society in the present and in the future.[33] Victor further supported this concept of teacher role when he stated that the elementary teacher has two main objectives concerning science activities:

1. to help children learn basic scientific information; and
2. to develop desirable behavior within the children during the process.[34]

Suchman's studies on inquiry training have special merit for elementary science when one realizes that the various activities that a child undergoes during the process of inquiry are often identical to those that a child exhibits in contemplating science phenomena. Because a child during inquiry performs the following: 1.) searches for meaningful relationships within the problem under consideration; 2.) processes available data; 3.) discovers; and 4.) verifies his discoveries

---

[32]Joseph Zafforoni and Edith Selberg, New Developments in Elementary School Science (Washington, D.C.: National Science Teachers Association, 1963), p. 4.

[33]Harold Tannenbaum, N. Stillman, and Albert Piltz, Science Education for Elementary School Teachers, Second Edition (Boston: Allyn and Bacon, 1965), p. 12.

[34]Victor, *op. cit.*, p. 115.

through appropriate tests.[35] The classroom teacher should encourage this kind of student inquiry by:

1. creating a sense of freedom to have and express ideas and to test them with data;

2. providing a responsive environment so that each idea is heard and understood and so that each learner can get the data he requires; and

3. helping each learner to discover a direction to move in and a purpose for his intellectual pursuit.[36]

Increasingly it becomes important that elementary teachers understand the nature of scientific endeavors, the notion of inquiry, and the various cognitive processes that the young learner uses to develop conceptual structures. One of the most successful of the newer elementary science curricula, Science-A Process Approach, produced under the auspices of the American Association for the Advancement of Science,[37] heavily emphasizes such facets within both pre-service and in-service teacher training. Each teacher involved in such a program receives instruction in the process skills pertinent to scientific enterprises as well as needed instruction in science content. The implications that such newer science curricula have upon teacher training programs are discussed in the section that follows.

---

[35] D. P. Butts and H. L. Jones, "Development of the TAB Science Test," Science Education, 51 (December, 1967), 464.

[36] John R. Verduin, Jr., Conceptual Models in Teacher Education (Washington, D.C.: American Association of Colleges for Teacher Education, 1967), p. 98.

[37] A. H. Livermore, "The Process Approach of the AAAS Commission on Science Education," Journal of Research in Science Teaching, 2 (1964), 271-282.

Pre-Service and In-Service Teacher Training in Elementary Science

The literature in science education demonstrates that as early as 1947 there was a concerted effort to foster in-service education as well as pre-service education in elementary science; for the text Science Education In American Schools, published that year by the National Society for the Study of Education, stated that the professional education of an elementary school teacher must continue as long as that teacher is actively engaged in professional endeavors.[38] More recently, Jacobson stated that the future elementary school teacher should have completed fourteen years of science instruction before undertaking any professional work in teacher education.[39] He further advocated that these studies in science should include such items as the following:

1. an understanding of the scientific view of man and his world;
2. the conceptual structure of science;
3. a placing of emphasis upon the processes of science; and
4. systematic attention given to the interrelationships of science, technology, and society.

As if to give credence to these necessities, Eccles' research had earlier demonstrated that the following basic needs in a teacher's

---

[38] Nelson B. Henry, (ed.), Science Education in American Schools, p. 129.

[39] Willard J. Jacobson, "Teacher Education and Elementary School Science--1980," Journal of Research in Science Teaching, 5, Issue I (1967), 75.

preparation for science teaching must be met at some point in either their general education or professional training:[40]

1. an adequate background in science concepts;

2. an understanding of the nature of science, how scientists solve problems, and the methods and attitudes of scientists;

3. a clear view of the aims and objectives that should guide science teaching in the elementary grades;

4. some skill in various teaching techniques, including the ability to help children find answers to science questions; and

5. a knowledge of where to obtain materials, equipment, references, how to select appropriate supplies and how to effectively use them in the classroom.

Blough also stated that the various science discipline courses taught to both pre-service and in-service teachers of elementary science must serve two underlying purposes:[41]

1. to prepare teachers to be scientifically educated persons who know enough about their environment to interpret at least some of the common things they see; and

2. to give them experiences with subject matter that will somewhat resemble the kind which they will use in their own teaching.

Even though these above-mentioned qualities of pre-service science education were published in 1958, Uselton _et al_. conducted a study in 1963 that involved 78 college seniors in elementary education; it demonstrated that the knowledge of science concepts possessed by these teacher candidates was generally inadequate to enable them to

---

[40]Priscilla Jacobs Eccles, "An Evaluation of a Course in Teaching Science in the Elementary School," _Dissertation Abstracts_, 19, No. 11 (1959), 2862.

[41]Glenn O. Blough, "Preparing Teachers for Science Teaching in the Elementary School," _School Science and Mathematics_, 58 (October, 1958), 525.

teach science to elementary school pupils.[42] As if to verify these results, Gega reported that superficially learned science material decays very rapidly; therefore he proposed that science courses designed for pre-service and in-service elementary teachers reduce the scope of content instruction while retaining whatever degree of thoroughness is needed to insure some mastery.[43]

But what of in-service training in elementary school science, to which this study is primarily directed? Are there certain qualities of such training of which experienced practitioners should be aware? The next few paragraphs focus upon such questions.

Flanders has stated that the following questions must be asked of any in-service training program, whether it be designed for science or for social studies, for language arts or for music:[44]

1. Will the teachers be acting any differently while teaching as a direct result of the in-service training? and

2. If changes have occurred, has the quality of instruction actually improved or is it just different?

These questions will be presented again in chapter four's analysis of results, in reference to this study.

Yet research on in-service science training for experienced elementary teachers has produced some results worthy of consideration. Of the more recent studies, Hempel employed a questionnaire using a

---

[42] Horace W. Uselton, et al., "Factors Related to Competence in Science of Prospective Elementary Teachers," Science Education, 47 (December, 1963), 507.

[43] P. C. Gega, "Pre-Service Education of Elementary Teachers in Science and the Teaching of Science," School Science and Mathematics, 68 (January, 1968), 15.

[44] Ned A. Flanders, "Teacher Behavior and In-Service Programs," Educational Leadership, 21 (October, 1963), 25.

random sample of 1191 elementary teachers.[45] He reported that the following types of in-service training were considered most valuable, in order of preference:

1. graduate study leading to a degree;
2. workshops under the direction of university personnel;
3. individual study not connected with a college or university;
4. extension courses not leading to degrees;
5. local in-service activities other than workshops; and
6. workshops under local leadership.

Hempel also reported that those teachers responding felt their greatest needs in course work centered around the necessity for more science methodology.

Washton also conducted a recent study concerning in-service elementary science education and reported the following conclusions:[46]

1. most elementary teachers dislike science because they didn't achieve high scores on tests in high school or college;
2. to promote learning of science by elementary school teachers, it is essential that fears be minimized or removed;
3. elementary school teachers need confidence in manipulating materials for science demonstrations;
4. the more rigid teachers have greater difficulty in teaching others to develop scientific attitudes, or to learn how to master skills in problem solving; and
5. regardless of age, teachers are quite capable of learning science under suitable conditions.

---

[45] Carl H. Hempel, "Attitudes of a Selected Group of Elementary School Teachers Toward In-Service Education," Dissertation Abstracts, 21, No. 13 (1961), 3684.

[46] Nathon S. Washton, "Improving Elementary Teacher Education in Science," Science Education, 45 (February, 1961), 34.

Much of the research on in-service science offerings seems to concur with Flanders when he wrote that ". . . In-service training, to be effective, must involve teachers actively, and not as passive spectators."[47] Scott also reiterated this point when he stated that teachers must experience the philosophy and method of experimentation through active participation in science, in the same manner that it is hoped children will experience these attributes in their respective programs.[48]

Blosser and Howe also made determined pleas for sound, in-service education when they wrote that:

> In regards to elementary science instruction, attention should be given to such problems as finding methods for improving the science competencies of teachers, determining optimal content background and types of experiences in science for elementary teachers, building more positive attitudes toward science on the part of elementary teachers, as well as continuing the investigations into the area of science content and experiences that should be part of the elementary school curriculum.[49]

One must certainly agree with the crucial importance of in-service elementary science education when Hurd's statement is recalled concerning the development of the newer science project materials. He stated that:

> Each of the dozen or more new elementary studies in science maintain that the style of instruction is as important for achieving the purpose of the course as the instructional materials, that

---

[47]Flanders, op. cit., p. 26.

[48]LLoyd Scott, Helping Children Learn Science, ed. Anne B. Hopman (Washington, D.C.: National Science Teachers Association, 1966), p. 173.

[49]Patricia E. Blosser and Robert W. Howe, "An Analysis of Research on Elementary Teacher Education Related to the Teaching of Science," Science and Children, 6, No. 5 (January/February, 1969), 50.

> learning readiness is dependent on teaching methods as much as on subject matter.[50]

In reference to this last statement on subject matter, the elementary teacher generally has two avenues of approach. One such possibility focuses upon the more conventional method of teaching elementary science, generally employing traditional textbooks for use by the children. The other avenue is exemplified by those science project materials developed under the auspices of the National Science Foundation (NSF). Berkheimer concisely contrasted these two alternatives when he wrote that:

> In general, the NSF sponsored science project materials emphasize science concepts, the theoretical nature of science, contemporary science, scientific inquiry, the elements of the scientific methods, mathematics to study relations, and the investigative or laboratory approach to the learning of science. In contrast, the commercial science curriculum materials emphasize teacher demonstrations or group experiences, science content topics, facts and science principles, qualitative observations and explanations to study relations, and the practical nature of science or technology.[51]

But what have been some of the expressed attitudes of elementary school teachers, in reference to the types of science programs outlined in the paragraphs above? Do they feel at ease in conveying science concepts to children? What are their special areas of concern? The following sections address themselves to these questions.

---

[50]Paul DeH. Hurd, "New Directions in Science Teaching From Kindergarten through College," Educational Digest, 32 (March, 1967), 17.

[51]Glenn D. Berkheimer, "An Analysis of the Science Supervisors' Role in the Selection And Use of Science Curriculum Materials" (unpublished Ed.D. dissertation, College of Education, Michigan State University, 1966), p. 1.

Teacher Attitudes Toward Elementary School Science

In 1949 Lammers reported the results of an intensive interview study with one hundred elementary school teachers.[52] Among the more pertinent results are the following:

1. approximately fifty percent of the teachers interviewed relied upon a correlational or incidental approach for science instruction;

2. more than fifty percent stated that science in their classrooms evolved around "things brought in";

3. the majority of teachers had a nature study course as their only science background;

4. the approach used toward science was primarily that of reading and discussion; and

5. a lack of science equipment was mentioned as a basic problem by twenty eight percent of the teachers involved in the study.

Johnston reported a study involving a random sample of eighty-seven Minnesota fifty grade teachers conducted in 1954.[53] Her results indicated that:

1. the typical science lesson was thirty minutes long and the average time spent on science per week was under two hours;

2. the teachers emphasized more biological science topics than physical science topics in a ratio of 3:1; and

3. text reading and discussion was the most extensively used science teaching method, while field trips and laboratory work were the least in evidence.

---

[52]Theresa J. Lammers, "One Hundred Interviews with Elementary School Teachers Concerning Science Education," Science Education, 33 (October, 1949), 292.

[53]Jane Johnston, "The Relative Achievement of the Objectives of Elementary School Science in a Representative Sampling of Minnesota Schools," Dissertation Abstracts, 17 (1957), 2499.

In addition, Todd has emphatically written that the attitudes displayed by the woman teacher in regard to science will greatly determine her effectiveness in teaching science as an integral component of the entire elementary curriculum.[54] Bixler voiced support of the importance of effective teacher attitudes when his research demonstrated that favorable teacher attitudes toward science were contributing factors to significant changes in children's science attitude test scores.[55]

Brown,[56] Berryessa[57] and Alford[58] reported that elementary teachers have encountered many difficulties in science instruction such as lack of equipment and materials, a lack of texts and a lack of adequate room space. And Victor has written that a woeful lack of familiarity with science concepts and materials is a definite factor in the reluctance of many elementary school teachers to teach science.[59] Such teachers, unfamiliar with the objectives of science education, were more inclined to stress the technological aspects of science

---

[54] V. E. Todd, "Women Teachers' Attitudes Toward Science In the Classroom," Elementary School Journal, 58 (April, 1958), 385.

[55] James Edward Bixler, Jr., "The Effect of Teacher Attitude on Elementary Children's Science Information and Science Attitude," Dissertation Abstracts, 19 (1958), 2531.

[56] Clyde M. Brown, "A Workshop in Teaching Elementary Science: An In-Service Training Program for Teachers," Science Education, 42 (December, 1958), 405.

[57] Max Joseph Berryessa, "Factors Contributing to the Competency of Elementary Teachers in Teaching Science," Dissertation Abstracts, 20, No. 2 (1959), 558.

[58] Genevieve G. Alford, "An Analysis of Science Interests of Selected Children and An Identification of Problems Encountered by the Teachers of these Children in Science Instruction," Dissertation Abstracts, 20, No. 8 (1960), 2704.

[59] Edward Victor, "Why Are Our Elementary School Teachers Reluctant to Teach Science?" Science Education, 46 (March, 1962), 186.

rather than its underlying principles and philosophy. In 1965,[60] and again in 1967,[61] published studies concluded that the largest handicap to adequate science presentations in the elementary schools was the reluctance of teachers to teach science because of inadequate backgrounds. Such teachers felt their own science courses did not: provide assistance in planning and organizing; convey ideas of what should be presented at their respective grade levels; or present methods and techniques necessary for teaching science within the elementary school.[62]

One more recent study conducted by Ramsey and Wiandt[63] deserves consideration, for it focused upon alleviating some of the teachers' anxieties depicted in the preceding paragraphs. This study centered upon attempts to present science activities on an individual basis to a child at his particular level of science competency. One of the most revealing conclusions was that such an individualized science program offered considerable security to the teacher. Teachers appeared less reluctant or apprehensive in counseling with an individual child about an unfamiliar science topic than they would have been in discussing the same topic with the entire class.

The implications of those studies reviewed here become increasingly relevant when one considers Blackwood's survey of science

---

[60] Gladys S. Kleinman, "Needed: Elementary School Science Consultants," School Science and Mathematics, 65 (November, 1965), 745.

[61] Sallylee H. Hines, "A Study of Certain Factors Which Affect the Opinions of Elementary School Teachers in the Teaching of Science," Dissertation Abstracts, 27, No. 12 (June, 1967), p. 4153-A.

[62] Ibid.

[63] Irvin I. Ramsey and Sandra Lee Wiandt, "Individualizing Elementary School Science," School Science and Mathematics, 68, No. 5 (May, 1967), 427.

teaching practices within American elementary schools.[64] He strongly suggests the following points in reassessing their individual science programs:

1. the average class size in many of the larger schools should be reduced for more effective instruction in science;

2. the number of minutes per week that science is taught should be increased in a large percent of schools in order for children to have a science program of greater scope and depth;

3. the substantial percent of schools which teach science incidentally in the lower grades may wish to reassess the advantages and disadvantages of that approach in comparison with a program based on a systematically planned curriculum;

4. the need of many elementary schools to acquire more adequate supplies of science teaching materials and equipment is clear. Small schools and schools in small administrative units particularly need to put more effort into obtaining and using science equipment and supplies;

5. schools need to develop or participate in effective in-service programs that enable teachers to update their knowledge and to learn better methods of teaching; and

6. a lack of consultant service was indicated by schools as a most important barrier to good science teaching. This suggests the need of schools to identify consultant resources, particularly for the classroom teachers who most often teach science in elementary classrooms.

The literature review thus far has focused upon such topics as: the historical implications of the American elementary science movement; the varied forces redirecting elementary science teaching today; some desirable attributes of modern elementary science programs; the role of the teacher in elementary science; and pre-service and in-service teacher training to adequately meet the needs of an evolving elementary science curriculum. Also included was a consideration of

---

[64]Paul E. Blackwood, "Science Teaching in the Elementary School: A Survey of Practices," Journal of Research in Science Teaching, 3 (September, 1965), 197.

prevailing teacher attitudes toward science and possible guidelines to be used in reassessing the science programs within individual school systems. All these topics were presented so that one might be aware of some of the problems engendered in teaching elementary science and the present status of such curricular offerings. The remaining portions of this chapter will focus upon selected aspects of teacher activities during science lessons--namely, the verbal behavior patterns demonstrated by both the teacher and pupils during learning experiences. Additionally, studies involving the use of questions as a necessary component of verbal behavior will be reviewed.

Verbal Behavior Patterns Within the Classroom

Flanders has written that:

> In our society the authority to direct the learning activities of the student is given to the teacher. Both the teacher and the students expect the teacher to take charge, to initiate learning activities, and to contribute information as needed in the problem solving process.[65]

Although no one would seriously refute this statement, one must not negate the importance of the child in classroom verbal interaction, for what the pupil does determines in some measure what the teacher does, for both pupil and teacher are influenced by the texture of the teaching and learning environment.[66]

Hughes likewise stated the importance of a teacher's verbal behavior patterns when she wrote that:

---

[65]Ned A. Flanders, Teacher Influence, Pupil Attitudes and Achievement (Minneapolis: University of Minnesota, 1960), p. 6.

[66]DeH. Hurd, Theory Into Action In Science Curriculum Development, p. 13.

> If teaching may be described as decision-making in interaction, then the product of the teacher's decision is the response he makes to the child or group with whom he is interacting. The measure, then, of good teaching is the quality of the response the teacher makes to the child or group with whom he is interacting.[67]

In addition, Kleinman reported that:

> . . . observation of what goes on in elementary and secondary schools indicates that the major classroom activity is verbal interaction between students and teachers. Flanders reports that the asking of questions and the giving of information accounts for 70% to 90% of teacher talk. Bellack, _et al_. found that the teacher-pupil ratio of verbal activity in terms of lines spoken is three to one, indicating that teachers are considerably more active than pupils in the amount of verbal activity.[68]

B. Othanel Smith has also suggested that there are three types of verbal behavior used in teaching.[69] One type, such as instructing, eliciting responses, and causing the topic to be remembered, is intended to have a specific effect. This kind of discourse involves such intellectual operations as explaining and defining so that the topic can be understood and restated. The second kind of verbal behavior, simply telling the student how to perform an operation, can be checked if the student is able to perform the skill or operation required of him. Once the skill is acquired, then nothing more is required. The third kind of verbal behavior, such as praising, advising, and commending the student, has an emotional rather than a cognitive influence on the

---

[67] Marie M. Hughes, "The Model of Good Teaching," _Studying Teaching_, ed. James Raths, John R. Pancella, and James S. Van Ness (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967), p. 21.

[68] Gladys S. Kleinman, "Teachers' Questions and Student Understanding of Science," _Journal of Research in Science Teaching_, 3, Issue 4 (1965), 307.

[69] Verduin, _op_. _cit_., p. 7.

student. These kinds of utterances are not usually of an intellectual nature, but are used for affective purposes.

Anderson has found that the verbal behavior of the teacher, more than any other influence, sets the climate of the class in question.[70] And Flanders has written that such verbal behavior can be categorized into the dichotomy described below:[71]

1. direct influence by a teacher restricts the freedom of action of a student by setting restraints or focusing his attention on an idea; and

2. indirect influence by a teacher increases the freedom of action of a student by reducing restraints or encouraging participation.

Very few researchers would disagree with Ryans' statement that teacher behavior and pupil behavior demonstrate substantially more interdependence within the elementary school as compared with the secondary classroom.[72] This certainly becomes evident when one ponders the use of questions as one ingredient in dialogue patterns during elementary science activities.

Research on the Use of Questions during Science Activities

Science educators have long acknowledged the importance of the method of inquiry--of asking the right question of nature--for Kleinman stated that as early as 1867, Youmans deplored the lack of study of

---

[70] Flanders, Teacher Influence, Pupil Attitudes and Achievement, p. 6.

[71] Ibid., p. 12.

[72] David G. Ryans, "Some Relationships Between Pupil Behavior and Certain Teacher Characteristics," Journal of Educational Psychology, 52 (1961), 89.

nature and the emphasis on verbal acquisition and mechanical recitation rather than "thinking about things" and the "cultivation of independent judgment."[73] The very nature of the inquiry processes dictates the tasks of the teacher: to help the child formulate questions that are important and meaningful to him and to aid him in his quest for answers.[74] Thus the teacher's questioning is the basic technique for guiding the very young child through the inquiry process.

Many references are made in the literature to basic question types and their appropriate definitions. A few such definitions will suffice here. Kleinman has written of two fundamental question categories:[75] lower type questions, including those questions that require simple recall and the memorization of limiting responses; and higher type questions, which clarify students' concepts and call for comparison, the drawing of inferences, and the supporting of conclusions.

R. L. Carner has categorized question types into the three fundamental categories described below.[76]

> Level 1--Concrete Questions
>
> The type of question used at this level usually elicits responses which are characteristic of concrete thinking where there is a primary concern for observable, tangible, or obtainable details. In this kind of thinking one is dealing with relatively simple ideas, objects, processes, or concepts which

---

[73] Kleinman, Journal of Research in Science Teaching, p. 308.

[74] Frank J. Estvan, "Teaching the Very Young: Procedures for Developing Inquiry Skills," Phi Delta Kappan, 50, No. 7 (March, 1969), 391.

[75] Kleinman, op. cit., p. 310.

[76] R. L. Carner, "Levels of Questioning," Studying Teaching, ed. James Raths, John R. Pancella, and James S. Van Ness (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967), pp. 182-186.

most often do not require evaluation, judgment, or drawing conclusions.

Level 2--Abstract Questions

The kind of question asked at this level aids in the development of abstract thinking skills and requires pupils to go beyond the specific or detail level to comprehension in order to generalize, classify, or relate these specifics into meaningful patterns.

Level 3--Creative Questions

Questions which are asked at this level require answers which are more creative by nature and may demand both concrete and abstract thinking.

Carner also has stated that within the hierarchy of questions outlined above, teachers have been most reluctant to probe the creative realms where answers <u>are</u> <u>not</u> comfortingly right or wrong.[77] Such open-ended questions could be used in scientific endeavors to enable pupils to hypothesize new or different applications of principles learned, for it does not restrict the pupil to a specific context.

Jacobson and Kondo have labeled such open-ended questions as divergent questions and have written that these types of questions asked of children serve to enlarge the scope of the materials being studied, and to deepen the interest in the topic under study.[78] Some exemplars of such divergent questions are: "How are these objects alike?" and "How can we find out?"

In addition, Taba has written that concerning strategies of teaching, teachers need to change their role from the customary answer-giving to question-asking. Cognitive operations are stimulated

---

[77] <u>Ibid</u>., p. 185.

[78] Willard J. Jacobson and Allan Kondo, <u>SCIS Elementary Science Sourcebook</u>, (Berkeley: University of California Regents, 1968), p. 44.

only as the students are required to search for answers and to invent and discover processes by which to deal with the tasks proposed by the questions.[79] Taba also suggests that questions should be viewed as serving specific pedagogical functions.[80] One function would be that of focusing. The questions should set the stage for both the kind of mental operation to be performed and the topic or the content on which this question is to be performed. Another pedagogical function might be that of extending a series of thought patterns on the same level. A third function would involve making a transition from one level of thought to another. Taba described this activity as a form of changing the focus, or "lifting thought processes to another level."[81]

The fact that teachers often do not possess adequate skills in question asking techniques has been mentioned often in the literature. Craig has written that in many instances a type of instruction consists of ferreting the answers from the children.[82] In this procedure the teacher asks a question, expecting the children to give the response she seeks. This response is then followed by another question to which another correct response is sought. For Craig such teaching assumes an absolute concept of knowledge which is contrary to the nature of modern science. And Renner and Ragan likewise deplore such teaching practices. They have noted that . . .

---

[79]Hilda Taba, Helping Children Learn Science, ed. Anne B. Hopman (Washington, D.C.: National Science Teachers Association, 1966), p. 14.

[80]Verduin, *op. cit.*, p. 21.

[81]*Ibid.*, p. 22.

[82]Craig, *op. cit.*, p. 25.

> Teachers usually ask a question . . . to get an answer already formulated in their own minds or to make a point of their own choosing. Teachers rarely ask a question because they are really curious to know what the pupils think or believed or have observed.[83]

But skill in questioning is, of course, valueless unless it is accompanied by a willingness to listen.[84] Jacobson and Kondo have even stated that if questions have no useful purpose in advancing the lesson, they should not be asked.[85]

Some recent studies seem to confirm the opinions brought forth in these past few paragraphs. Moyer conducted a study focusing upon the types of questions asked during instructional processes in selected elementary schools.[86] He analyzed over 2500 questions and his conclusions demonstrated that:

1. teachers tend to be consistent in the types of questions they ask, and display distinguishable patterns of questioning in terms of structure, language, function, and utilization;

2. over fifty percent of the total questions analyzed were initiated with WHAT, HOW, WHY, WHO, WHERE, WHICH, and WHEN;

3. no evidence was found of any question that required students to evaluate;

4. the number of questions asked and percentage of responses received are not accurate signals that pupils are being challenged to think;

5. teachers' questions and questioning practices do not effectively involve pupils in critical thinking activities; and

---

[83] Renner and Ragan, op. cit., p. 220.

[84] Jacobson and Kondo, op. cit., p. 33.

[85] Ibid., p. 45.

[86] John R. Moyer, "An Exploratory Study of Questioning in the Instructional Processes In Selected Elementary Schools," Dissertation Abstracts, (1965), p. 147-A.

6. it appears that teachers are not prepared to develop and utilize the questioning process effectively.

Three studies have been reported in the past four years that have direct implications for the research under consideration. All have some bearing upon the implementation of one of the newer science programs, the Science Curriculum Improvement Study (SCIS), in elementary school classrooms. This science curricular approach will be described in depth within chapter three.

Fischler and Anastasiow reported the results of a summer workshop employing SCIS teaching methods and materials, where emphasis was placed upon generating question-asking techniques most conducive to sound elementary school science activities.[87] Among their conclusions were the following:

1. there was a clear trend for the teachers to reduce their own participation in the class situation by asking fewer questions;

2. most teachers asked more indirect questions and allowed the students to answer at greater length;

3. there was a marked reduction in the number of questions which "ask children to relate facts but do not go beyond"; and

4. there was a noticeable increase in the teachers' use of observational questions after instruction in SCIS teaching methods and materials.

Wilson conducted a study reported in 1967 that included thirty teachers --fifteen of whom employed SCIS teaching methods and materials in grades one through six plus fifteen additional teachers who used the

---

[87]Abraham S. Fischler and N. J. Anastasiow, "In-Service Education in Science (A Pilot)," Journal of Research in Science Teaching, 3 (1965), 283-284.

more conventional science materials described in previous sections of this chapter.[88] The following results were among his conclusions:

1. those teachers educated in SCIS teaching methods and materials asked approximately one and one-half times as many questions as those teachers employing traditional science methods;

2. the traditional science teachers heavily relied upon question categories which elicit lower levels of thinking whereas the SCIS educated teachers asked questions which evoke higher levels of thinking to a significant degree; and

3. the SCIS-educated teachers used significantly more demonstration-of-skill type questions. This suggests that these teachers are probably treating science more like a skill subject than as a content subject.

Kondo also reported results of a study focusing upon the questioning behavior of teachers employing a specified unit within the Science Curriculum Improvement Study.[89] This research demonstrated that when individual lessons were largely presented through demonstrations, the percentages of routine questions were relatively low and the percentages of cognitive-memory questions were relatively high. In addition, approximately fifty percent of all questions asked were of a convergent type.

Summary

The current literature on the role of the teacher in modern elementary school science programs indicates that the success of such

---

[88]John H. Wilson, "Differences Between the Inquiry-Discovery and the Traditional Approaches to Teaching Science in Elementary Schools" (unpublished Ed.D. dissertation, University of Oklahoma, 1967), pp. 67-69.

[89]Allan K. Kondo, "A Study of the Questioning Behavior of Teachers in the Science Curriculum Improvement Study Teaching the Unit on Material Objects" (unpublished Ph.D. Dissertation, University of California at Berkeley, 1968), p. 2.

efforts greatly depends upon the attitudes that teachers demonstrate toward science and upon the methods used in pre-service and in-service science training to foster desirable teaching styles. The chapter that follows describes the execution of this study that had its origins in an analysis of teacher role and in-service training, in response to the introduction of teaching methods and materials advocated within the Science Curriculum Improvement Study.

CHAPTER THREE

IMPLEMENTATION OF THE STUDY

Introduction

This chapter describes the organizational plan of the study, the science methods and materials employed by the two groups of teachers under consideration, and the approaches used in gathering research data. Additionally, the evaluation instruments are discussed and a summary table outlines the hypotheses tested and the statistical models used in analyzing the data.

Design of the Study

In December, 1967 Dr. Glenn D. Berkheimer, Coordinator of the Science Curriculum Improvement Study's Trial Center at Michigan State University, invited the writer to generate a possible study that would focus upon selected aspects of teacher classroom behavior. As a result of this initial suggestion, a study evolved that centered upon verbal behavior patterns in primary grade classrooms during science activities. This research was designed as a quasi-experimental, time-series analysis[1] and involved a series of observations during science

---

[1]Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research (Chicago: Rand, McNally and Company, 1963), p. 34.

lessons that extended over an eleven month period, from April, 1968 through March, 1969. A three-week workshop employing the Science Curriculum Improvement Study's teaching methods and materials was the primary experimental variable, and sixteen of the thirty-two teachers included within this study's population attended the workshop from August 5 through August 23, 1968. These sixteen teachers used the teaching methods and science materials advocated by SCIS in their classrooms during the 1968-69 school year.

Portable tape recorders were used to gather data from each science lesson observed, and two individuals were trained to analyze the verbal comments during these activities. The data thus gleaned from the taped lessons were used to consider the following hypotheses, which set the major structure for this study.

Hypotheses

Stated in null form, the hypotheses were:

H_{o1} There is no difference in the teachers' ID ratios during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o1}: $ID_1 = ID_2$);

H_{o2} There is no difference in the percentage of time teachers spend talking during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o2}: $TT_1 = TT_2$);

H_{o3} There is no difference in the percentage of time students talk during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o3}: $ST_1 = ST_2$);

H_{o4} There is no difference in the percentage of continuous student comment during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o4}: $CC_1 = CC_2$);

H_{o5} There is no difference in the kinds of questions teachers ask children, before and after the introduction of SCIS teaching methods and materials (H_{o5}: $KQ_1 = KQ_2$);

H_{o6} There is no difference in the teachers' comprehension of the process aspects of science, before and after the introduction of SCIS teaching methods and materials (H_{o6}: $PS_1 = PS_2$).

Stated in symbolic form, the alternate hypotheses to those stated above would be:

$$H_1 : ID_1 \neq ID_2$$

$$H_2 : TT_1 \neq TT_2$$

$$H_3 : ST_1 \neq ST_2$$

$$H_4 : CC_1 \neq CC_2$$

$$H_5 : KQ_1 \neq KQ_2$$

$$H_6 : PS_1 \neq PS_2$$

Selection of the Population

The population considered within this study was composed of thirty-two primary grade teachers employed within the following five mid-Michigan public school districts: DeWitt, East Lansing, Grand Ledge, Laingsburg, and Williamston. These teachers were all females and displayed a spectrum of teaching experiences that ranged from new teachers with no formal teaching background to some with over twenty years' experience in the primary grades. The teachers taught primary grade children in nine separate school buildings scattered throughout these districts. Although the great majority of the classes contained first and second grade children, the East Lansing district had two classrooms composed of students who normally would have been placed in the more traditional second, third, and fourth grade classes. These two groups of children were labeled the transitional classes by the East Lansing district.

Of the five districts employing these teachers, two are considered primarily rural--DeWitt and Laingsburg. Both East Lansing and Grand Ledge are suburban. In addition, East Lansing is a university-oriented community. The parents of school children within these five districts are primarily farmers, industrial workers, and professional people.

When it was formally determined that an in-service workshop would be conducted using SCIS teaching methods and materials during August, 1968, the writer contacted those teachers who were sent invitations to attend. Sixteen of these teachers agreed to allow the writer to visit and record their classroom science activities during April and May, 1968. Eleven of these teachers were observed on two separate occasions prior to the workshop and the other five teachers were observed once during this period. In September, 1968 sixteen additional teachers who had no experience in the newer elementary science programs agreed to visits by the writer during their science presentations. Each of these sixteen teachers were observed twice between November, 1968 and March, 1969.

The following two sections describe the in-service science workshop attended by sixteen of the teachers, and the basic methods and materials employed by both groups of teachers in their science lessons during the course of the study.

The In-Service Experience

As previously mentioned, during August, 1968 the Science and Mathematics Teaching Center of Michigan State University (in cooperation with the National Science Foundation) offered an in-service workshop using the Science Curriculum Improvement Study's teaching methods and materials. The workshop was designed basically to acquaint primary grade teachers and their elementary school principals with the newer approaches to elementary school science as stated in chapter two. Attention was placed upon preparing these teachers to use effectively SCIS teaching methods and materials in their respective classrooms during the 1968-69 school year. Lectures were presented describing the scope and sequence of science units offered by the Science Curriculum Improvement Study and films were previewed demonstrating the implications Piaget's studies in developmental psychology have for some of the modern elementary science curricula. Inquiry laboratories were an integral aspect of the three-week workshop and the teachers were directly involved in using science equipment and preparing lessons. Certainly one highlight of the workshop was attained when each participant had opportunities to present SCIS lessons to individual children on a one-to-one basis. Within such micro-teaching situations, portable television cameras and tape recorders were employed to produce instant feedback for lesson analysis. Additionally, the teachers were able to converse with guest lecturers on the nature of scientific activities and to observe demonstration lessons conducted by experienced SCIS teachers with primary grade children. Teaching participants also engaged in field trips to observe examples of different types of ecosystems. In Appendix A, Table eighteen presents a synopsis of the summer workshop.

In addition, the participants were given two other opportunities to observe different examples of living organisms within varied environments, for two week-end conferences were conducted during the school year (September 28-29, 1968 and May 17-18, 1969) at the Kellogg Biological Station, Hickory Corners, Michigan. Lectures on ecology and field studies were presented by university personnel at the biological station, and the teachers collected and studied representative specimens from both aquatic and terrestrial habitats.

The SCIS Trial Center at Michigan State University also employed three half-time science consultants who actively advised the in-service teachers throughout the 1968-69 school year. These consultants visited each teacher approximately once every two weeks during science lessons, and periodically conducted feedback meetings with the teachers in an effort to assist them with any problems encountered. Occasionally, these consultants would teach selected science lessons if requested by the teachers.

The following paragraphs describe some representative science activities that were presented by these thirty-two teachers during the eleven months this study was in progress.

Teaching Methods and Materials

Of the science lessons recorded during April and May, 1968, there is close similarity observed among the topics included by the sixteen pre-SCIS teachers[2] and those presented by the second group of sixteen teachers using conventional science materials after the workshop's conclusion. Both groups relied heavily upon traditional textbooks for guidance. If science materials were included as part of the lessons, they were used primarily by the teacher in demonstration fashion. There was very little children involvement in these science activities, for the lessons were essentially teacher-oriented. Table one outlines lessons topics and the basic methods of instruction used by both groups for the time periods indicated.

The following section describes some particular aspects of the Science Curriculum Improvement Study and some representative units that were used by the sixteen experimental teachers during the 1968-69 school year.

Stendler has stated that in constructing any science series, whether it be elementary, secondary, or college oriented, there must be a rationale put forth for the selection and grade placement of subject matter.[3] Such a rationale could cooperatively evolve from mature scientists' analyses of what is important in science, plus the contributions of science educators and psychologists concerning what is known about human learning. Some of the newer science programs have attempted to emulate this; the Science Curriculum Improvement Study is but one example.

---

[2]The pre-SCIS teachers are those sixteen teachers originally observed prior to the SCIS summer workshop. They represent the experimental group that participated in the workshop activities and who used SCIS materials throughout the 1968-69 school year.

[3]Celia Stendler, "The Developmental Approach of Piaget and its Implications for Science in the Elementary School," The Macmillan Science Series (Chicago: Macmillan Company, 1966), p. 14.

TABLE 1

LESSON TOPICS PRESENTED BY PRE-SCIS TEACHERS* AND CONVENTIONAL SCIENCE TEACHERS

Lesson Topics and Number of each Type of Lesson	Pre-SCIS Teachers* (Spring, 1968)		Conventional Science Teachers (Fall, Winter, 1968-69)	
	1. Classification of Animals	(7 lessons)	1. Classification of Animals	(5 lessons)
	2. The Solar System	(3 lessons)	2. Properties of Air	(5 lessons)
	3. Seed Germination, Plants	(3 lessons)	3. Weather, Temperature	(5 lessons)
	4. Classification of Trees	(2 lessons)	4. The Solar System	(3 lessons)
	5. Properties of Sound	(2 lessons)	5. Using Senses	(3 lessons)
	6. Using Senses of Taste, Touch, Hearing	(2 lessons)	6. Electric Circuits	(2 lessons)
	7. Grouping Objects by Similarities	(2 lessons)	7. Measurement	(2 lessons)
	8. Properties of Magnets	(1 lesson)	8. Properties of Magnets	(2 lessons)
	9. Use of Magnifiers	(1 lesson)	9. Physical States of Water	(1 lesson)
	10. Good Health Habits	(1 lesson)	10. Crystals	(1 lesson)
	11. Review of Student Experiments	(1 lesson)	11. Simple Machines	(1 lesson)
			12. Good Health	(1 lesson)
			13. Colors	(1 lesson)
Primary Methods of Presentation	1. textbooks 2. teacher demonstrations 3. little direct student involvement		1. textbooks 2. teacher demonstrations 3. little direct student involvement	

*Pre-SCIS teachers are those teachers observed prior to the SCIS summer workshop.

One individual whose research has contributed significantly to the development of the Science Curriculum Improvement Study is the behavioral psychologist, Piaget. Piaget's contributions to cognition theory have influenced such personalities as Almy, Bruner, Hunt, Inhelder, and Stendler. Simply stated, Piaget's theories have two related, central themes: 1.) children's intellectual capacities pass through a number of qualitatively contrasting stages before adulthood; and 2.) a child's interaction with his environment plays a very significant role in his transition from one stage to the next.[4] Inherent within Piaget's writings is the underlying premise of actively involving the child with concrete objects from his environment. Duckworth has interpreted Piaget as stating that good instruction must involve presenting the child with situations in which he himself experiments in the broadest sense of that term--such as trying things out and manipulating symbols.[5] Likewise, Flavell added his support to active involvement when he stated that ". . . the child should first work with the principle in the most concrete and action-oriented context possible; he should be allowed to 'see' the principle in his own actions."[6]

Karplus, one of the primary forces behind the development of the Science Curriculum Improvement Study during this decade, seems to have paraphrased these thoughts when he wrote that:

---

[4]Robert Karplus and Herbert D. Thier, A New Look at Elementary School Science (Chicago: Rand, McNally and Company, 1967), p. 21.

[5]Eleanor Duckworth, "Piaget Rediscovered," Journal of Research in Science Teaching, 2 (1964), 173.

[6]John Flavell, Studies in Cognitive Growth, ed. Jerome Bruner, et al. (New York: John Wiley and Sons, Inc., 1966), pp. 208-209.

> The function of education is to guide the children's development by providing them with particularly informative, suggestive experiences as a base for their abstractions. At the same time, children must be led to form a conceptual framework that permits them to perceive the phenomena in a more meaningful way and to integrate their inferences into generalizations of greater value than they would form if left to their own desires.[7]

Karplus further contends that the essence of the SCIS program rests in the effort to attempt to develop in children's thinking about natural phenomena a hierarchial structure of concepts that later become increasingly more sophisticated. Each topic within the entire program represents an application of previous elements of study and at the same time presents a foundation for subsequent elements of study.[8] Figure one depicts an outline of such topics within the overall SCIS program.

Within all these subject areas outlined in figure one, special care is given to acquaint the children with specific examples of objects and living organisms, to let them examine natural phenomena, and to help them develop skills in manipulating equipment and recording data. Instead of being supplied with correct answers, children are encouraged to think for themselves, to respond creatively to problems presented to them, and to arrive at conclusions on the basis of their own observation and interpretation of evidence.

As was mentioned in chapter one, a teacher ideally trained in the SCIS approach to elementary school science would be one whose position is not primarily telling children about science or listening

---

[7] Robert Karplus, "The Science Curriculum Improvement Study," _Journal of Research in Science Teaching_ (October, 1965), 8.

[8] Robert Karplus, "The Science Curriculum Improvement Study--Report to the Piaget Conference," _Journal of Research in Science Teaching_, 2 (1964), 237.

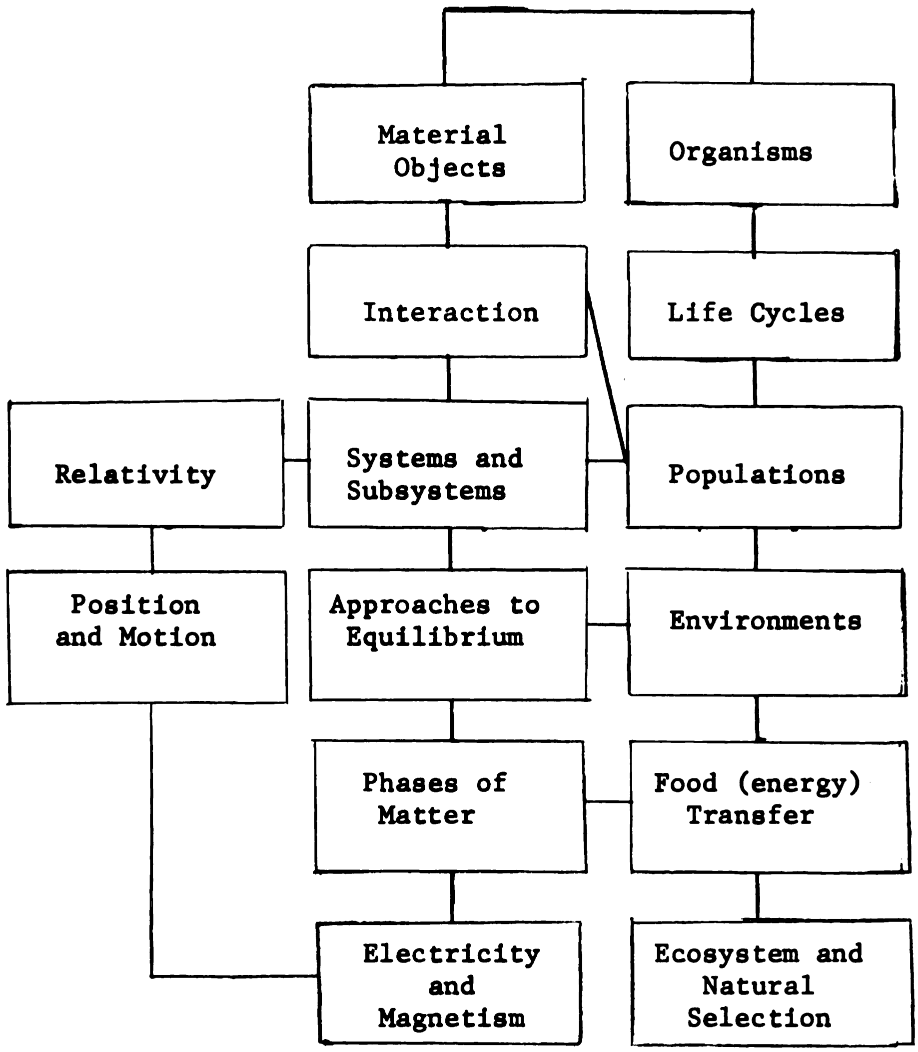


Figure 1

Subject Areas of the SCIS Program (1968) to them while they read about science, but rather observing and interacting with children while they are directly involved with science.

The sixteen teachers within the experimental population used four SCIS units in their classrooms during the 1968-69 school year. The four first grade teachers used the Material Objects and Organisms units, representing subject areas in the physical sciences and life sciences respectively. The remaining second grade and transitional grade teachers employed the Interactions and Life Cycles units. Figure one outlines these units. All four units stress basically two kinds of lessons. One type, denoted as an "invention lesson," involves activities of defining new concepts for the children. The second kind of lesson has been labeled a "discovery lesson," and is designed to aid a child in manipulating materials, broaden his background of experience, and apply new ideas.[9] Each lesson within these four units has essentially the following types of information present:

1. objectives of the learning experience, which state the intended goals of the lesson in behavioral terms;

2. background information for the teacher, which stresses relationships among the present activity, past lessons, and succeeding activities;

3. teaching materials--a list of all materials to be distributed to the children for that specific lesson; and

4. teaching suggestions--a general plan for carrying out the particular exercise and what to look for in the way of children's behaviors.

Thus far this chapter has been primarily concerned with delineating the design of the study, the hypotheses tested and the

---

[9] Donald B. Neuman, "The Influence of Selected Science Experiences on the Attainment of Concrete Operations by First Grade Children" (unpublished Ph.D. dissertation, Michigan State University, 1968), p. 65.

selection of the population. The in-service science experience and the teaching methods and materials used by the teachers have also been reviewed. The sections that follow center upon a description of the instruments used to collect data and procedures used for their analyses.

Description of Instruments Used and Collection of Data

The act of teaching is a highly complex phenomenon that involves simultaneously a number of complex, interacting forces. Unless one has some way to capture the essence of an instructional act at the moment it occurs, it is lost forever. Once lost it cannot be analyzed and evaluated in any meaningful way. The use of tape recordings and more recently video tapes, captures and holds the moment of teaching for further analysis. Such a technique was used in this study, for three individuals working as a coordinated team were engaged in collecting taped recordings of the science lessons observed. Originally, easily portable, battery powered tape recorders with accompanying tape cassettes were used to record verbal classroom interaction. But when many of the SCIS teachers increased their mobility during science activities, a wireless microphone was placed around each teacher's neck so that her comments could easily be recorded as she moved freely about the classroom. An FM tuner was used to feed the microphone output into the tape recorder. At no time, however, were tapes analyzed in which either the teacher's or the children's voices could not be heard. Tables two and three list the observation dates of science lessons for both the sixteen SCIS teachers and the sixteen teachers using more conventional science materials.

TABLE 2

OBSERVATION DATES OF TEACHERS USING SCIS TEACHING METHODS AND MATERIALS

Teacher Number	Dates of Observation					
	O_1	O_2	O_3	O_4	O_5	O_6
1.	5/3/68	5/20/68	11/3/68	12/2/68	1/29/69	2/19/69
2.	5/21/68	5/22/68	9/25/68	10/9/68	11/6/68	12/5/68
3.	5/15/68	. .	10/29/68	11/18/68	1/14/69	2/25/69
4.	5/16/68	5/23/68	10/24/68	11/7/68	1/23/69	3/13/69
5.	5/24/68	5/25/68	10/9/68	10/23/68	11/6/68	12/5/68
6.	5/15/68	5/16/68	10/24/68	11/7/68	1/23/69	3/13/69
7.	5/8/68	. .	10/10/68	10/24/68	11/14/68	12/5/68
8.	4/29/68	5/3/68	1/8/69	1/20/69	2/19/69	3/5/69
9.	5/11/68	5/24/68	10/9/68	10/23/68	11/6/68	12/4/68
10.	5/15/68	5/16/68	10/24/68	3/13/69	3/18/69	3/27/69
11.	5/23/68	. .	12/5/68	1/16/69	1/30/69	3/6/69
12.	5/8/68	. .	10/10/68	11/14/68	1/30/69	2/27/69
13.	4/22/68	. .	10/22/68	11/5/68	12/3/68	2/18/69
14.	5/3/68	5/20/68	1/20/69	1/29/69	2/5/69	2/19/69
15.	5/21/68	5/22/68	10/16/68	10/30/68	3/12/69	3/25/69
16.	5/21/68	5/22/68	9/25/68	10/9/68	10/23/68	12/5/68

TABLE 3

OBSERVATION DATES OF TEACHERS USING CONVENTIONAL SCIENCE TEACHING METHODS AND MATERIALS

Teacher Number	Dates of Observation	
	O_1	O_2
1.	11/20/68	2/26/69
2.	11/25/68	2/26/69
3.	11/20/68	2/26/69
4.	2/6/69	2/27/69
5.	2/4/69	2/18/69
6.	2/5/69	2/12/69
7.	2/5/69	2/12/69
8.	2/4/69	2/18/69
9.	2/4/69	2/18/69
10.	2/4/69	2/18/69
11.	2/18/69	2/18/69
12.	2/6/69	3/4/69
13.	2/4/69	2/27/69
14.	2/4/69	2/18/69
15.	2/6/69	2/27/69
16.	2/4/69	2/18/69

Ryans has reported that teacher behaviors are classifiable, both qualitatively and quantitatively.[10] Both Aschner and Gallagher have also written that the spoken discourse within a classroom can be studied profitably from many standpoints and for many purposes.[11] One such purpose might be in gathering evidence to aid in the development of instructional theories. Flanders has stated that . . .

> A theory of instruction can be distinguished from a theory of learning because the former incorporates concepts and principles about the teacher's behavior while the latter places greater emphasis on the student's behavior. The development of a theory of instruction will require some emperical verification of hypotheses. Many of these hypotheses will be concerned with patterns of teacher influence. Interaction analysis techniques are helpful tools in this research.[12]

Three instruments were used in evaluating the study's data. Two of these measurements were exclusively concerned with information gathered from analyses of the taped science lessons--the Flanders System of Interaction Analysis and the Science Teaching Observational Instrument. The third instrument, the Science Process Test for Elementary School Teachers, is a written test designed to evaluate process skills and science concepts. Each of these measurements will be thoroughly described in the following paragraphs.

Two individuals were trained to analyze the taped lessons; each lesson, therefore, was reviewed twice--once to gather data using the Flanders System of Interaction Analysis and a second time using the

---

[10]David G. Ryans, "Theory Development and the Study of Teacher Behavior," Journal of Educational Psychology, 47 (1956), 472.

[11]Mary Jane Aschner, James J. Gallagher, et al., A System for Classifying Thought Processes in the Context of Classroom Verbal Interaction (Urbana: University of Illinois, 1962), 1.

[12]Ned A. Flanders, Teacher Influence, Pupil Attitudes and Achievement (Minneapolis: University of Minnesota, 1960), p. 10.

Science Teaching Observational Instrument. The training period began in September, 1968 with a literature review concerning these measurements and a memorization of the various categories within each instrument. Taped lessons gathered the previous spring months in the sixteen pre-SCIS classrooms were used for study during an intensive one week training session. The formal data analysis began in early October, 1968. The writer analyzed all tapes using the Flanders System of Interaction Analysis and an experienced elementary school teacher was employed to categorize question types. Throughout the course of the study, random samples of tapes analyzed previously were selected and recoded by both individuals as an indication of intra-observer reliability. This process will be described more fully in later paragraphs of this chapter.

The Flanders System of Interaction Analysis

The Flanders System of Interaction Analysis developed from extensive studies conducted by Flanders[13] and his associates, and focuses upon student-teacher verbal interaction in classrooms. The system could be defined as the systematic quantification of behavioral acts or qualities of behavior acts as they occur in some sort of spontaneous interaction. Emphasis is placed upon verbal behavior primarily because it can be observed with higher reliability than can nonverbal behavior, with the assumption that the verbal behavior of an individual is an adequate sample of his total behavior. Flanders has identified the following ten categories within the system: 1. accepting student

---

[13]Dr. Ned A. Flanders is Professor Education at the University of Michigan, Ann Arbor.

feelings, 2. giving praise, 3. accepting, clarifying, or making use of a student's ideas, 4. asking a question, 5. lecturing, giving facts, or opinions, 6. giving directions, 7. giving criticism, 8. student response, 9. student initiation, and 10. confusion or silence. The first seven categories are assigned to teacher talk and categories eight and nine are assigned to student comment. Table nineteen in Appendix A summarizes these various aspects of Interaction Analysis.

To use this system for analysis purposes requires an observer who has had some training and an adequate knowledge of the categories. The observer can either tally the appropriate category of behavior as the teacher instructs or mark each category while listening to previously taped lessons. To obtain an adequate sample of interaction, Flanders suggests that a mark for recording a number should be made approximately every three seconds, which would record twenty instances in a minute. During a recorded period of a class session there would be several columns of numbers. The tempo should be kept as steady as possible and the observer should be as accurate as possible. Some ground rules that may assist the recorder of interaction are as follows:

GROUND RULES

Rule 1: When not certain in which of two or more categories a statement belongs, choose the category that is numerically farthest from Category five, <u>except</u> ten.

Rule 2: If the primary tone of the teacher's behavior has been consistently direct or consistently indirect, do not shift into the opposite classification unless a clear indication of shift is given by the teacher.

Rule 3: The observer must not be overly concerned with his own biases or with the teacher's intent.

Rule 4: If more than one category occurs during the three-second interval, then all categories used in the interval are recorded; therefore, record each change in category. If no change occurs within three seconds, repeat that category number.

Rule 5: If a silence is long enough for a break in the interaction to be discernible, and if it occurs at a three-second recording time, it is recorded as a ten.[14]

Perhaps a small example might be appropriate.[15] A verbal interaction pattern during a science lesson might develop something like this:

> First of all silence (10); then a directive of, "Take out your books" (6); "Open them to page 27" (6); some confusion (10); then the teacher asks, "What did you think about this chapter?" (4); a student responds, "It was interesting" (8); another student states, however, "I don't understand the first part" (9); silence or confusion (10).

The recorder of such a series of verbal interaction would have written the following numbers in a column arrangement:

10
6
6
10
4
8
9
10

In Appendix A, Table twenty demonstrates the Observer Tally Sheet used to record such data.

As suggested above, the recording of interaction data in sequence is important for the analysis process. Once it has been recorded, an

---

[14]Edmund J. Amidon and Ned A. Flanders, The Role of the Teacher in the Classroom (Minneapolis: Amidon Associates, Inc., 1963), p. 26.

[15]John R. Verduin, Jr., Conceptual Models in Teacher Education (Washington, D.C.: American Association of Colleges for Teacher Education, 1967), p. 36.

interpretation may begin. The process for analyzing the sequence of events can be accomplished by placing the numbers on a matrix. For placing the data on the matrix, the numbers must be paired. The first number of the pair is concerned with the row and the second number is concerned with the column. The second number of the first pair becomes the first number of the new pair. Each pair of numbers overlaps with the previous pair and each number is used twice, with the exception of the first and last. The first and last numbers should always be ten to make analysis easier and because it can be assumed that any session starts with silence and ends the same way. Using the previous example of verbal comment, the sequencing of numbers would be:

10		10
6		6
6		6
10	The pairing would thus be	10
4		4
8		8
9		9
10		10

The pairing of numbers, then, assists the recorder in placing the pairs in the appropriate cell of the matrix. The first number dictates the row; the second the column. Included in Table twenty-one is the type of matrix used in this study.

Once the matrix is completed with the verbal interaction data, the analysis process can begin for that particular lesson. One step the analyst could take before any other activity would be to determine the percentage of time spent in each cell. This is done by dividing 100 by the total marks on the matrix and using the quotient to multiply the total for each column. For this study, teacher talk (columns 1-7) and student talk (columns 8 and 9) were determined by adding the appropriate column percentages. Additionally, the ID ratios, defined in chapter one as the ratio of indirect influence of teacher talk (columns 1-4) to the direct influence of teacher talk (columns 5, 6, 7) were calculated by dividing the first total by the second. The percentage of continuous student comment was determined by totaling all entries in the 8-8, 8-9, 9-8, and 9-9 matrix cells and dividing by the total number of matrix entries. This number was then converted to the appropriate percentage.

The following section summarizes the reliability estimates for the two instruments used to determine verbal behavior patterns.

Reliability Estimates

Although only one observer was used to analyze the taped lessons via the Flanders technique, it was considered important to maintain frequent checks of the observer's stability--i.e., the ability of the observer to obtain the same information from the same observation. This estimate of stability will be referred to as intra-observer reliability.

Flanders advocates the use of Scott's coefficient of reliability for estimating such intra-observer reliability.[16] Scott calls his coefficient "pi" and it is determined by the two formulae below:

$$1. \quad \pi = \frac{P_o - P_e}{1 - P_e}$$

P_o is the proportion of agreement, and P_e is the proportion of agreement expected by chance which is found by squaring the proportion of

---

[16]Flanders, loc. cit., p. 10.

tallies in each category and summing these over all categories.

$$2.\quad P_e = \sum_{i=1}^{K} P_i^2$$

In formula two there are k categories and P_i is the proportion of tallies falling into each category. π, in formula one, can be expressed in words as the amount that two observers exceeded chance agreement divided by the amount that perfect agreement exceeds chance.

Commenting on Scott's coefficient of reliability, Flanders states that the coefficient is . . . "unaffected by low frequencies, can be adapted to per cent figures, can be estimated more rapidly in the field, and is more sensitive at higher levels of reliability."[17]

As was mentioned previously, random samples were selected at periodic intervals of tapes done previously, and these random samples were analyzed again in their entirety. This procedure was followed in determining checks using both the Flanders System of Interaction Analysis and the Science Teaching Observational Instrument. Table four outlines the results of such reliability checks for the Flanders System.

Borg has written concerning reliability coefficients that correlations ranging from .65 to .85 make possible group predictions that are accurate enough for most purposes.[18] With the exception of reliability check number eight, the reliability coefficients listed in table four are adequate. A close inspection of this reliability check will denote the greatest discrepancies occurring within categories

---

[17] Ibid.

[18] Walter R. Borg, Educational Research, An Introduction (New York: David McKay Company, Inc., 1963), p. 283.

TABLE 4

INTRA-OBSERVER RELIABILITY FOR THE FLANDERS SYSTEM OF INTERACTION ANALYSIS

Reliability Check Number	1	2	3	4	5	6	7	8	9	10	Reliability
	Percent of Tallies in Each Category										
1											
Original tallies (229)	3.1	0	4.8	25.3	1.7	1.3	.4	54.6	8.2	.4	.79
Recoded tallies (244)	3.7	.4	3.7	29.5	.4	2.9	.4	54.9	3.7	.4	
Difference	.6	.4	1.1	4.2	.3	1.6	0	.3	4.5	0	
2											
Original tallies (223)	.4	.4	1.8	17.5	14.8	32.3	.8	12.6	12.1	7.3	.74
Recoded tallies (252)	1.2	1.2	2.5	16.7	11.1	38.5	0	11.1	14.3	3.6	
Difference	.8	.8	.7	.8	3.7	6.2	.8	1.5	2.2	3.7	
3											
Original tallies (344)	1.8	1.2	1.8	23.2	15.4	21.5	.9	21.2	1.5	11.3	.77
Recoded tallies (329)	2.7	.9	2.1	24.6	11.5	20	.9	27.7	1.8	7.6	
Difference	.9	.3	.3	1.4	3.9	1.5	0	6.5	.3	3.7	

4											
Original tallies (312)	.4	0	.6	12.8	4.0	14.4	0	18.3	47.8	1.6	.72
Recoded tallies (328)	.6	.6	1.7	10.8	1.7	17.3	0	17.1	56.7	1.4	
Difference	.2	.6	1.1	2.0	2.3	2.9	0	1.2	8.9	.2	
5											
Original tallies (227)	0	.9	1.3	22	9	21.1	.9	24.7	18.5	1.8	.83
Recoded tallies (220)	0	.9	1.8	23.2	7.7	22.7	.5	27.7	14.1	1.4	
Difference	0	0	.5	1.2	1.3	1.6	.4	3	4.4	.4	
6											
Original tallies (231)	.4	1.3	1.7	16.5	13.4	24.2	.4	22.1	14.7	5.2	.72
Recoded tallies (223)	.5	.9	1.8	21.1	7.6	26.9	1.3	25.1	10.8	4.0	
Difference	.1	.4	.1	4.6	5.8	2.7	.9	3	3.9	1.2	
7											
Original tallies (259)	1.2	1.6	1.2	5.4	0	37.4	1.2	2.7	48.2	.8	.74
Recoded tallied (224)	0	1.3	0	6.3	0	43.3	0	5.9	42.9	.4	
Difference	1.2	.3	1.2	.9	0	5.9	1.2	3.2	5.3	.4	

TABLE 4--Continued

Reliability Check Number	1	2	3	4	5	6	7	8	9	10	Reliability
	Percent of Tallies in Each Category										
8											
Original tallies (335)	2.7	.3	.3	22.9	0	22.1	.6	14.6	35.2	.9	.64
Recoded tallies (328)	2.7	1.2	0	25.3	0	23.8	.6	23.2	22.6	.6	
Difference	0	.9	.3	2.4	0	1.7	0	8.6	12.6	.3	
9											
Original tallies (287)	.3	.7	4.2	27.2	19.5	8.4	2.8	28.6	7.7	.7	.86
Recoded tallies (302)	0	1.0	4.3	26.1	16.2	11.9	2.6	30.1	7.6	.3	
Difference	.3	.3	.1	1.1	3.3	3.5	.2	1.5	.1	.4	
10											
Original tallies (198)	0	0	3.5	31.8	5.1	7.6	0	39.4	10.6	2.0	.88
Recoded tallies (219)	0	.9	5.5	32.0	3.2	8.2	0	40.2	8.7	1.4	
Difference	0	.9	2.0	.2	1.9	.6	0	.8	1.9	.6	

eight and nine. It is extremely difficult to reproduce consistently reliable data on these two categories of student verbal behavior, for many times one cannot determine whether the student talked in response to another person, or initiated the comment himself. Flanders attests to this dilemma by stating that his research has yet to discover a simple ground rule for distinguishing between categories eight and nine.[19] McLeod also has noted that very small percentage differences in each of the ten Flanders categories will result in a disturbing decrease in reliability.[20] This is an example of Flanders' reference to sensitivity of the Scott coefficient at higher reliabilities.

The second observer engaged in analyzing the taped science lessons for question types also used the identical pattern of periodically selecting random samples of all tapes previously completed, and recoded them for reliability checks. Scott's coefficient was also used with these data and the results are demonstrated in Table five. No previous study using this instrument has published reliability coefficients.

Fischler and Anastasiow devised the Science Teaching Observational Instrument to effectively code teacher questions into five distinct categories.[21] Table twenty-two describes these five categories.

---

[19]Flanders, op. cit., Appendix F, p. 9.

[20]Richard J. McLeod, "Changes in the Verbal Interaction Patterns of Secondary Science Student Teachers Who Have Had Training in Interaction Analysis and the Relationship of These Changes to the Verbal Interaction of their Cooperating Teachers" (unpublished Ph.D. dissertation, Cornell University, 1967), p. 39.

[21]Abraham S. Fischler and N. J. Anastasiow, "In-Service Education in Science (A Pilot)," Journal of Research in Science Teaching 3 (1965), 283.

TABLE 5

INTRA-OBSERVER RELIABILITY FOR THE SCIENCE TEACHING OBSERVATIONAL INSTRUMENT CATEGORIES

Reliability Check Number	1	2	3	4	5	Reliability
	Percent of Tallies in Each Category					
1						
Original tallies (44)	56.8	4.5	38.6	0	0	.72
Recoded tallies (67)	58.2	10.4	31.3	0	0	
Difference	1.4	5.9	7.3	0	0	
2						
Original tallies (61)	6.5	0	88.5	1.6	3.3	.91
Recoded tallies (50)	6.0	0	88.0	2.0	4.0	
Difference	.0	0	.5	.4	.7	
3						
Original tallies (20)	30.0	0	45.0	20.0	5.0	.70
Recoded tallies (20)	30.0	10.0	40.0	20.0	0.0	
Difference	0	10.0	5.0	0	5.0	
4						
Original tallies (45)	86.7	6.7	2.2	4.4	0	.78
Recoded tallies (47)	89.4	4.3	2.1	4.3	0	
Difference	2.7	2.4	.1	.1	0	
5						
Original tallies (28)	57.1	3.6	35.7	3.6	0	.66
Recoded tallies (33)	63.6	0	30.3	6.1	0	
Difference						
6						
Original tallies (79)	24.0	0	73.2	2.5	0	.76
Recoded tallies (80)	20	5	72.5	2.5	0	
Difference	4	5	.9	0	0	

The first two categories represent low level question types that demand little student comprehension. Categories three, four, and five include questions of a higher level, where the child must observe, reason, or validate data in order to respond effectively.

The third evaluation instrument was given to only the experimental group--those sixteen teachers who attended the summer workshop and who employed SCIS teaching methods and materials in their classrooms during the 1968-69 school year. Entitled the Science Process Test for Elementary School Teachers, it is designed to evaluate science process skills and associated concepts deemed important for in-service teachers in the elementary grades. A pre-test was given to these teachers early in August, 1968, prior to the summer workshop's activities. A post-test using the same instrument was given to these teachers on April 19, 1969, at the conclusion of the study. Descriptive data concerning this test and a sample test specimen are located in Appendix A.

Procedures for Analyses of Data

The first four hypotheses stated at the beginning of this chapter, concerning ID ratios, percentage of teacher talk, percentage of student talk, and percentage of continuous student comment during science activities, were tested statistically via a repeated measures design of mixed model analysis of variance.[22] Some critics might question the use of parametric statistics with the population under

---

[22] B. J. Winer, Statistical Principles in Experimental Design (New York: McGraw-Hill Book Company, Inc., 1962), pp. 105-124.

consideration. Yet the following quotation by Medley and Mitzel lends support to such use:

> Two widespread misconceptions about complex designs should be noted here. One is that a nonparametric method must be used in analyzing behavior data because the assumption of normality does not hold. The minor role this assumption plays has already been pointed out; it has been shown that much information can be extracted from behavior data without making any assumptions about the form of their sampling distribution. Besides, in the experience of the authors it is quite unusual to find behavior data about which the assumption cannot reasonably be made. Finally, the consequences of making this assumption when it is not true are much less serious than many research workers fear.[23]

The Friedman two-way analysis of variance by ranks was used to analyze hypothesis five, concerning the kinds of questions teachers asked of children during science activities.[24] Hypothesis six, focusing upon teacher process skills in elementary science, was tested statistically via use of a t-test for correlated data. Table six summarizes the hypotheses tested and the models used to analyze the data. A complete description of the results obtained and their accompanying statistical analyses will be discussed in chapter four.

Summary

Included within this chapter was a discussion of the following topics: the general design of the study; the hypotheses under consideration; the selection of the population; and a review of the science methods and materials used by each group of teachers. A description of the evaluation instruments used for the collection of data was also

---

[23]Donald M. Medley and Harold E. Mitzel, "Measuring Classroom Behavior by Systematic Observation," Handbook of Research on Teaching, ed. N. L. Gage (Chicago: Rand, McNally and Company, 1963), pp. 325-326.

[24]Sidney Siegel, Nonparametric Statistics (Chicago: McGraw-Hill Book Company, Inc., 1956), pp. 166-172.

TABLE 6

SUMMARY OF HYPOTHESES AND MODELS USED TO ANALYZE DATA

	Statement of Hypotheses	Models Used for Analyzing Data
H_{o1}	There is no difference in the teachers' ID ratios during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o1}: $ID_1 = ID_2$).	Analysis of variance $\alpha = .05$
H_{o2}	There is no difference in the percentage of time teachers spend talking during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o2}: $TT_1 = TT_2$).	Analysis of variance $\alpha = .05$
H_{o3}	There is no difference in the percentage of time students talk during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o3}: $ST_1 = ST_2$).	Analysis of variance $\alpha = .05$
H_{o4}	There is no difference in the percentage of continuous student comment during science activities within the classroom, before and after the introduction of SCIS teaching methods and materials (H_{o4}: $CC_1 = CC_2$).	Analysis of variance $\alpha = .05$

H_{o5}	There is no difference in the kinds of questions teachers ask children, before and after the introduction of SCIS teaching methods and materials (H_{o5}: $KQ_1 = KQ_2$).	Friedman two-way analysis of variance by ranks $\alpha = .05$
H_{o6}	There is no difference in the teachers' comprehension of the process aspects of science, before and after the introduction of SCIS teaching methods and materials (H_{o6}: $PS_1 = PS_2$).	t-test for correlated data $\alpha = .05$

reviewed, in addition to the various statistical procedures selected for testing each hypothesis. Chapter four will center upon an analysis of the results gleaned from this study.

CHAPTER FOUR

ANALYSIS OF DATA AND FINDINGS

Introduction

Included within this chapter is a restatement of the six null hypotheses that were tested in this study, a presentation of collected data, and a summary of findings. Each hypothesis is discussed individually and pertinent results are presented in tables throughout the chapter. Additional data are located in the appendices.

Collection and Compilation of Data

This study focused upon an analysis of verbal behavior patterns during science activities in thirty-two mid-Michigan primary grade classrooms. Sixteen of the teachers within these classrooms used the teaching methods and materials suggested by the Science Curriculum Improvement Study (SCIS), and the remaining sixteen teachers presented more conventional science activities as advocated by their respective school systems. These teachers were employed within the DeWitt, East Lansing, Grand Ledge, Laingsburg, and Williamston public schools and taught in nine separate buildings scattered throughout these districts. A three-week workshop (August 5-August 23, 1968) employing the Science Curriculum Improvement Study's teaching methods and materials was the primary experimental variable, and those sixteen teachers who taught science using the SCIS approach during the 1968-69 school year were active participants within the workshop.

Portable tape recorders were used to gather data during each science lesson observed for the thirty-two teachers. Formal observations of the sixteen SCIS teachers began prior to the summer workshop on April 22, 1968, and both the SCIS teachers and those teachers using more conventional science activities received periodic visitations throughout the 1968-69 school year. The final lesson was recorded on March 27, 1969.

Three instruments were used in evaluating the study's data. Two of these measurements were exclusively concerned with information gathered from analyses of the taped lessons--the Flanders System of Interaction Analysis and the Science Teaching Observational Instrument. The third instrument, the Science Process Test for Elementary School Teachers, was a written test designed to evaluate process skills and science concepts.

Two individuals were trained to analyze the taped lessons; each lesson, therefore, was reviewed twice--once to gather data using the Flanders System of Interaction Analysis and a second time using the Science Teaching Observational Instrument. The third evaluation instrument, the Science Process Test for Elementary School Teachers, was given to only the experimental group--those teachers who attended the summer workshop and who employed SCIS teaching methods and materials in their classrooms during the 1968-69 school year. A pre-test using this instrument was given to the teachers on August 6, 1968, prior to the summer workshop's formal activities. On April 19, 1969 these teachers were tested again with the same instrument and under similar conditions, at the study's conclusion.

Of the null hypotheses stated in the section that follows, the Flanders System of Interaction Analysis was used in obtaining data to test hypotheses one through four. The Science Teaching Observational Instrument evaluated data gathered for hypothesis five. Hypothesis six was analyzed using the results of pre-test and post-test administrations of the Science Process Test for Elementary School Teachers.

Hypotheses

Stated in null form, the hypotheses tested were:

H_{o1} There is no difference in the teachers' ID ratios during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o1}: $ID_1 = ID_2$);

H_{o2} There is no difference in the percentage of time teachers spend talking during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o2}: $TT_1 = TT_2$);

H_{o3} There is no difference in the percentage of time students talk during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o3}: $ST_1 = ST_2$);

H_{o4} There is no difference in the percentage of continuous student comment during science activities within the classroom, before and after the introduction of SCIS teaching methods and materials (H_{o4}: $CC_1 = CC_2$);

H_{o5} There is no difference in the kinds of questions teachers ask children, before and after the introduction of SCIS teaching methods and materials (H_{o5}: $KQ_1 = KQ_2$); and

H_{o6} There is no difference in the teachers' comprehension of the process aspects of science, before and after the introduction of SCIS teaching methods and materials (H_{o6}: $PS_1 = PS_2$).

Although these hypotheses were primarily concerned with those sixteen teachers using the Science Curriculum Improvement Study's teaching methods and materials, additional statistical tests using both the SCIS teachers and the teachers employing more traditional science methods were conducted. The following section delineates the results of these tests.

Comparisons Between the Two Teacher Groups

Analyses were conducted to determine whether there were any significant differences between the SCIS teachers and those teachers using conventional science materials for hypotheses one through four. To obtain necessary statistical data, four separate t-tests were computed on the initial observations of both the sixteen SCIS teachers and the sixteen teachers using more conventional approaches to elementary school science.[1] The results demonstrated that there were no significant differences between these two groups of teachers on their initial observations, in regards to ID ratios, percentage of teacher talk, percentage of student talk, and percentage of continuous student comment during science activities.

In addition, the investigator determined whether any significant differences had occurred, for hypotheses one through four, between the initial observations and the final observations of those teachers employing conventional science activities. Therefore four separate t-tests for correlated data were calculated between the initial and final observations for this group.[2] The results demonstrated that there were no significant differences between these two observations

---

[1] N. M. Downie and R. W. Heath, Basic Statistical Methods, Second Edition (New York: Harper and Row, 1965), pp. 132-143.

[2] Ibid.

in regards to ID ratios, percentage of teacher talk, percentage of student talk, and percentage of continuous student comment during science activities. The original data germane to these analyses are included in Appendix B.

The following paragraphs report the results of data analysis for each of the six hypotheses within this study. Because five of the sixteen SCIS teachers could be observed only once, rather than twice, prior to the summer workshop, mean scores for the remaining eleven teachers on observations one and two were used in pertinent calculations. Both the original and adjusted data for these teachers are included within the appendices.

Teacher ID Ratios

Within the spoken discourse of the classroom, Amidon and Flanders have defined the ID ratio as the amount of indirect teacher influence in verbal classroom behavior divided by the amount of direct teacher influence.[3] Flanders has also written that direct influence by a teacher restricts the freedom of action of a student by setting restraints or focusing his attention on an idea; and indirect influence by a teacher increases the freedom of action of a student by reducing restraints or encouraging participation.[4] It was hypothesized that exposure to one of the newer elementary science curricula might have a noticeable effect on teachers' ID ratios during science activities.

---

[3]Edmund J. Amidon and Ned A. Flanders, The Role of the Teacher in the Classroom (Minneapolis: Amidon Associates, Inc., 1963), p. 29.

[4]Ned A. Flanders, Teacher Influence, Pupil Attitudes and Achievement (Minneapolis: University of Minnesota, 1960), p. 6.

A repeated measures design of a mixed model analysis of variance was employed to test this hypothesis and the results are summarized in Table seven, in the manner suggested by Winer.[5]

TABLE 7

ANALYSIS OF VARIANCE DATA FOR THE ID RATIOS OF SCIS TEACHERS

Source of Variation	SS	df	MS	F
Between Subjects	29.1385	15	. .	. .
Within Subjects				
Treatment	8.2556	4	2.0639	40.7080** S
Error	3.0479	60	0.0507	
Total	40.4420	79		

$^{*}F_{.95,\ (4,60)} = 2.53$

$^{*}F_{.99,\ (4,60)} = 3.65$

The resulting F statistic demonstrated significance at both the .05 and .01 α levels. Therefore the null hypothesis that there is no difference in the teachers' ID ratios during science activities before and after the introduction of SCIS teaching methods and materials (H_{o1}: $ID_1 = ID_2$) is rejected. Table eight supplies the mean scores and standard deviations for the significant ID ratio analysis.

In an effort to determine more precisely where the greatest changes might have occurred, an additional test contrasting the teachers' initial ID ratios with those obtained during observations two and five was conducted after the significant F statistic was

[5]B. J. Winer, Statistical Principles in Experimental Design (New York: McGraw-Hill Book Company, Inc., 1962), pp. 105-124.

reached. No significant results were obtained from this particular analysis.

TABLE 8

MEAN SCORES AND STANDARD DEVIATIONS OF SCIS TEACHERS' ID RATIOS PER OBSERVATION

	O_1	O_2	O_3	O_4	O_5
Mean	1.6687	2.0681	1.2606	1.1650	1.4931
S.D.	0.7821	1.7368	1.1228	1.0780	1.2234

Throughout the remaining sections of this chapter, tables are presented which graphically illustrate the data gathered from the taped lessons. Because it was virtually impossible to record every teacher during a science lesson on the same observation day, mean observation dates for the sixteen SCIS teachers were obtained and are illustrated in Table nine. These mean observation dates are used in many of the following figures.

TABLE 9

MEAN OBSERVATION DATES FOR THE SIXTEEN SCIS TEACHERS

Number	Mean Date
T_1	5/16/68
T_2	10/22/68
T_3	11/7/68
T_4	1/23/69
T_5	2/19/69

The SCIS teachers' mean ID ratios per mean observation times are portrayed in Figure two. The interrupted portion of this graph demonstrates the summer vacation period.

Percentage of Teacher Talk within SCIS Classrooms

A literature review concerning the newer elementary science curricula might lead one to ponder whether or not the percentage of time teachers spend talking during science activities would differ, in response to the introduction of SCIS teaching methods and materials. A repeated measures design of a mixed model analysis of variance was used to test hypothesis H_{o2}, and the results are summarized in Table ten.

TABLE 10

ANALYSIS OF VARIANCE FOR PERCENTAGE OF SCIS TEACHER TALK

Source of Variation	SS	df	MS	F
Between Subjects	2183.5548	15	. .	. .
Within Subjects				
Treatment	17.3356	4	4.4339	0.0326 NS
Error	8151.3644	60	135.8560	. .
Total	10352.2548	79		

$F_{.95, (4,60)} = 2.53$

The analysis failed to produce an F statistic that reached the assigned level of significance. Therefore one fails to reject the null hypothesis that there is no difference in the percentage of time teachers spend talking during science activities, before and after the

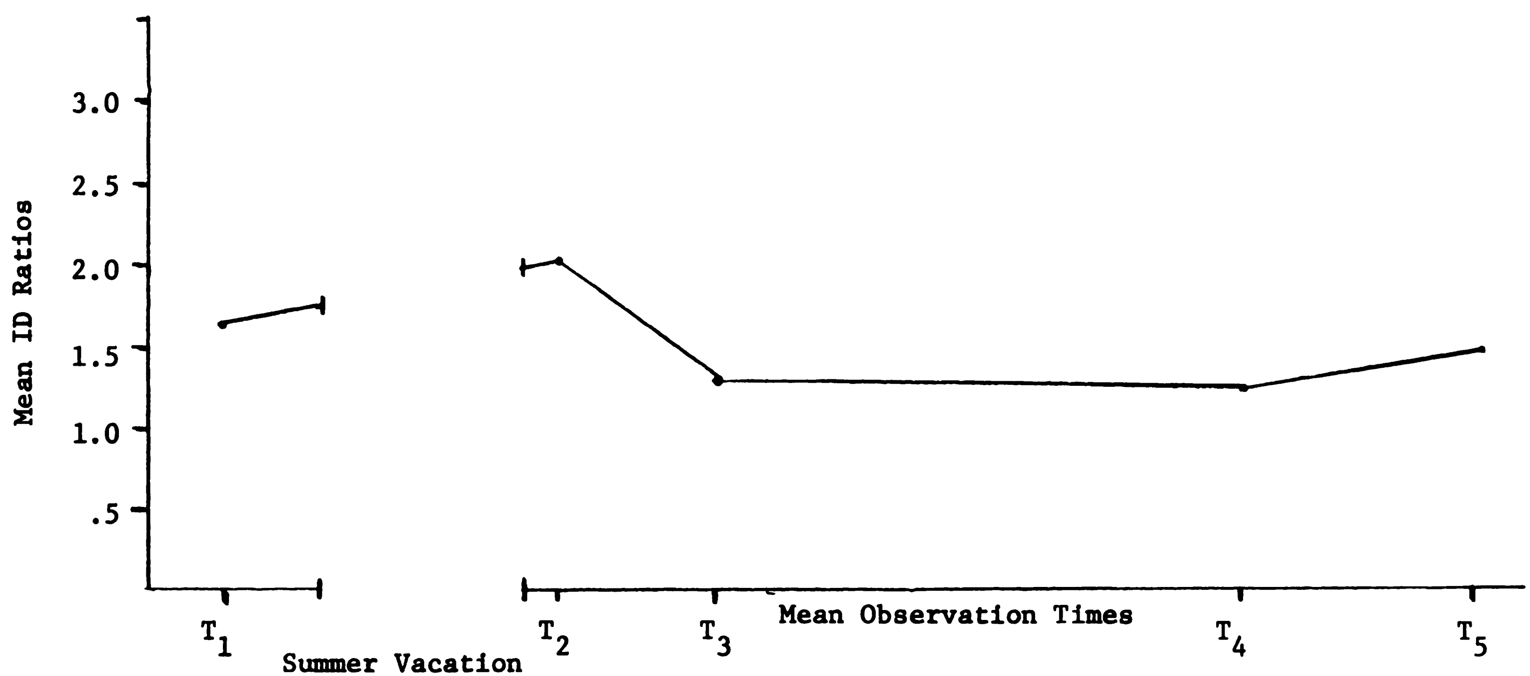


Figure 2

SCIS Teachers' Mean ID Ratios Per Mean Observations, N = 16 introduction of SCIS teaching methods and materials (H_{o2}: $TT_1 = TT_2$). Figure three graphically displays these data across mean observation times.

Percentage of Student Talk within SCIS Classrooms

Those persons primarily responsible for the development of the Science Curriculum Improvement Study have stated that in order for effective learning to take place the child must be directly involved in the experience.[6] One indication of such direct involvement during science activities might be a measure of how much student talk takes place within a classroom's verbal behavior patterns. Data measuring the percentage of student talk within the sixteen SCIS classrooms were gathered to test hypothesis H_{o3}: there is no difference in the percentage of time students talk during science activities, before and after the introduction of SCIS teaching methods and materials (H_{o3}: $ST_1 = ST_2$). A repeated measures design of a mixed model analysis of variance was used to test hypothesis H_{o3}, and Table eleven summarizes the results.

The analysis failed to produce an F statistic that reached the assigned level of significance. Yet the test statistic certainly approached significance, for it missed the .05 significance level by .1754. Based upon the statistical evidence, one fails to reject the null hypothesis that there is no difference in the percentage of time students talk during science activities, before and after the

---

[6] Robert Karplus and Herbert D. Thier, A New Look at Elementary School Science (Chicago: Rand, McNally and Company, 1967), p. 80.

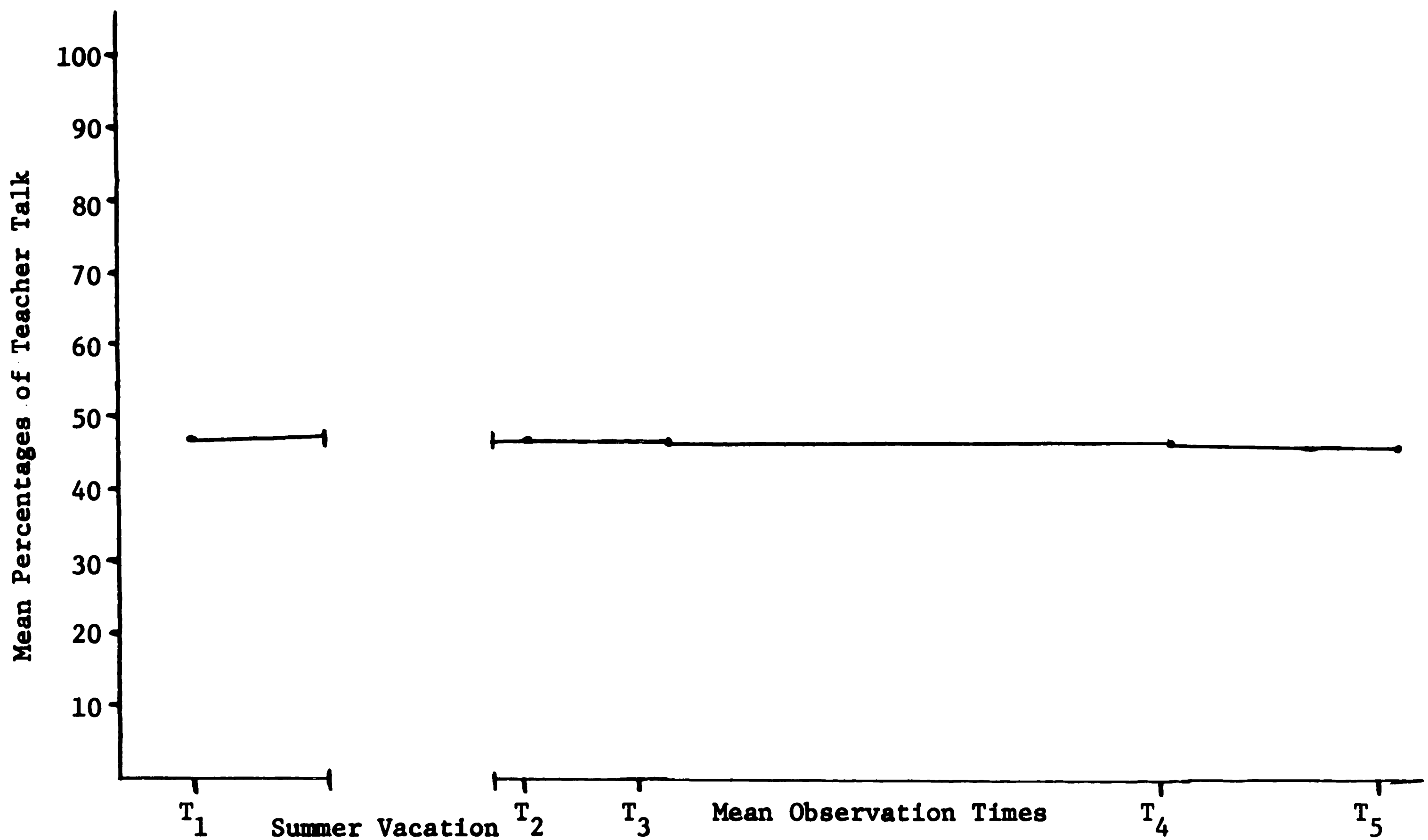


Figure 3

SCIS Teachers' Mean Percentage of Teacher Talk Per Mean Observations, N = 16 introduction of SCIS teaching methods and materials (H_{o3}: $ST_1 = ST_2$). Figure four presents the data in graphic form.

TABLE 11

ANALYSIS OF VARIANCE DATA FOR PERCENTAGE OF STUDENT TALK IN SCIS CLASSROOMS

Source of Variation	SS	df	MS	F
Between Subjects	3910.0785	15	. .	. .
Within Subjects				
Treatment	1329.8562	4	332.4640	2.3546 NS
Error	8471.7878	60	141.1964	. .
Total	13711.7225	79		

$F_{.95,\ (4,60)} = 2.53$

Percentage of Continuous Student Comment Within SCIS Classrooms

The Science Curriculum Improvement Study heavily emphasizes child-to-child communication as an integral aspect in the operation of a science lesson. Such an emphasis led the investigator to hypothesize whether or not the introduction of SCIS teaching methods and materials into primary grade science activities would enhance this communication. Thus the following hypothesis was analyzed via a repeated measures design of a mixed model analysis of variance:

H_{o4}: There is no difference in the percentage of continuous student comment during science activities within the classroom, before and after the introduction of SCIS teaching methods and materials (H_{o4}: $CC_1 = CC_2$).

Table twelve summarizes the results.

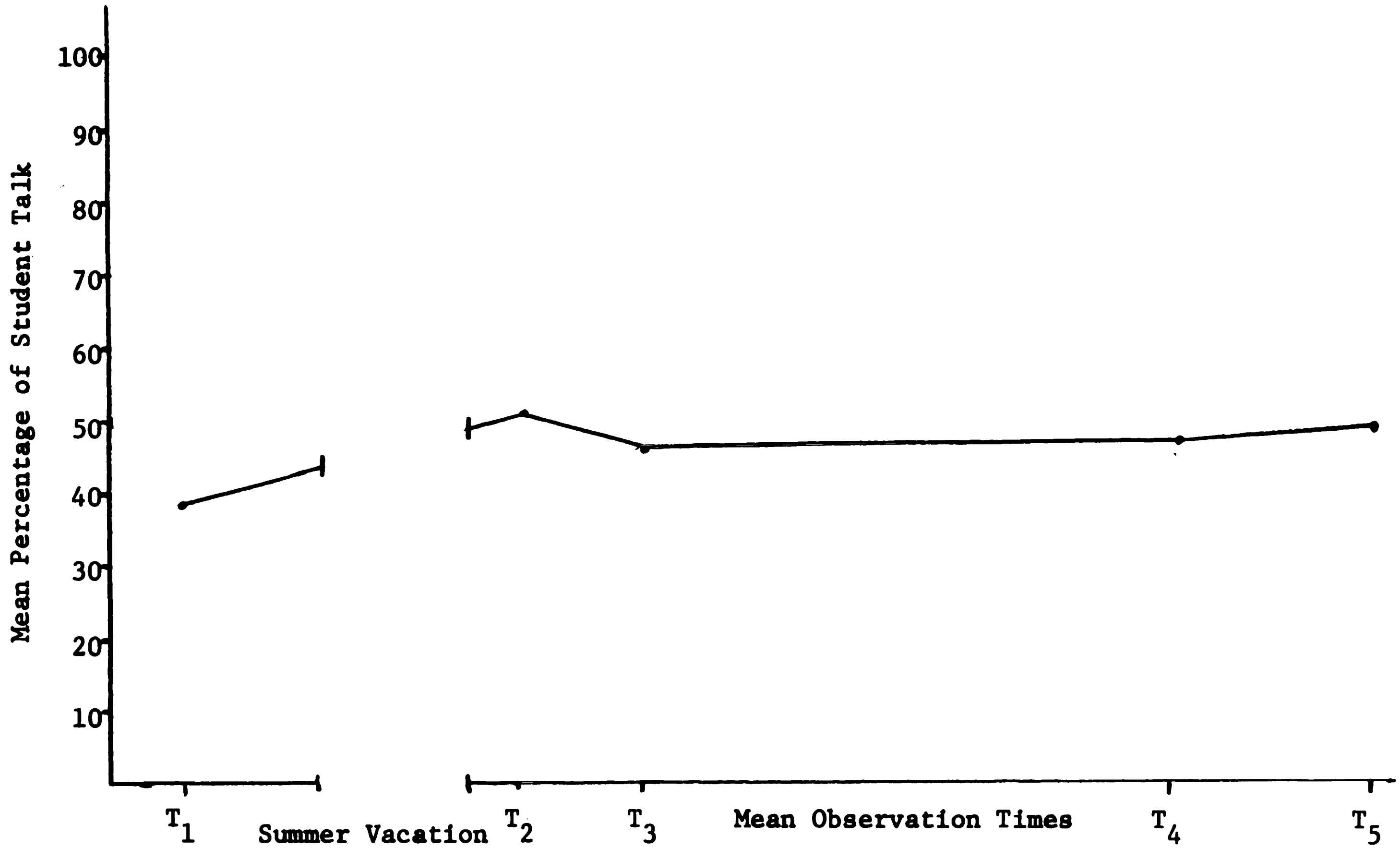


Figure 4

Mean Percentages of Student Talk per Mean Observations, N = 16 Classrooms

TABLE 12

ANALYSIS OF VARIANCE DATA FOR PERCENTAGE OF CONTINUOUS STUDENT COMMENT IN SCIS CLASSROOMS

Source of Variation	SS	df	MS	F
Between Subjects	3822.3729	15	. .	. .
Within Subjects				
Treatment	526.9882	4	131.7470	0.7230 NS
Error	10933.1878	60	182.2197	
Total	15282.5489	79		

$F_{.95, (4,60)} = 2.53$

The analysis failed to produce an F statistic that reached the assigned level of significance. Therefore null hypothesis H_{o4} fails to be rejected. Figure five displays these mean percentages of continuous student comment across mean observation times.

The original data for these above mentioned hypotheses are located in Appendix B.

The following section describes the results gathered from analyses of teacher preferences for question types displayed during science activities.

Analyses of Teacher Preferences for Question Types

The literature review described in chapter two underscores the importance of effective questioning strategies that should be used by elementary school teachers during science activities. In essence, good questions can be employed by the teacher to stimulate thinking,

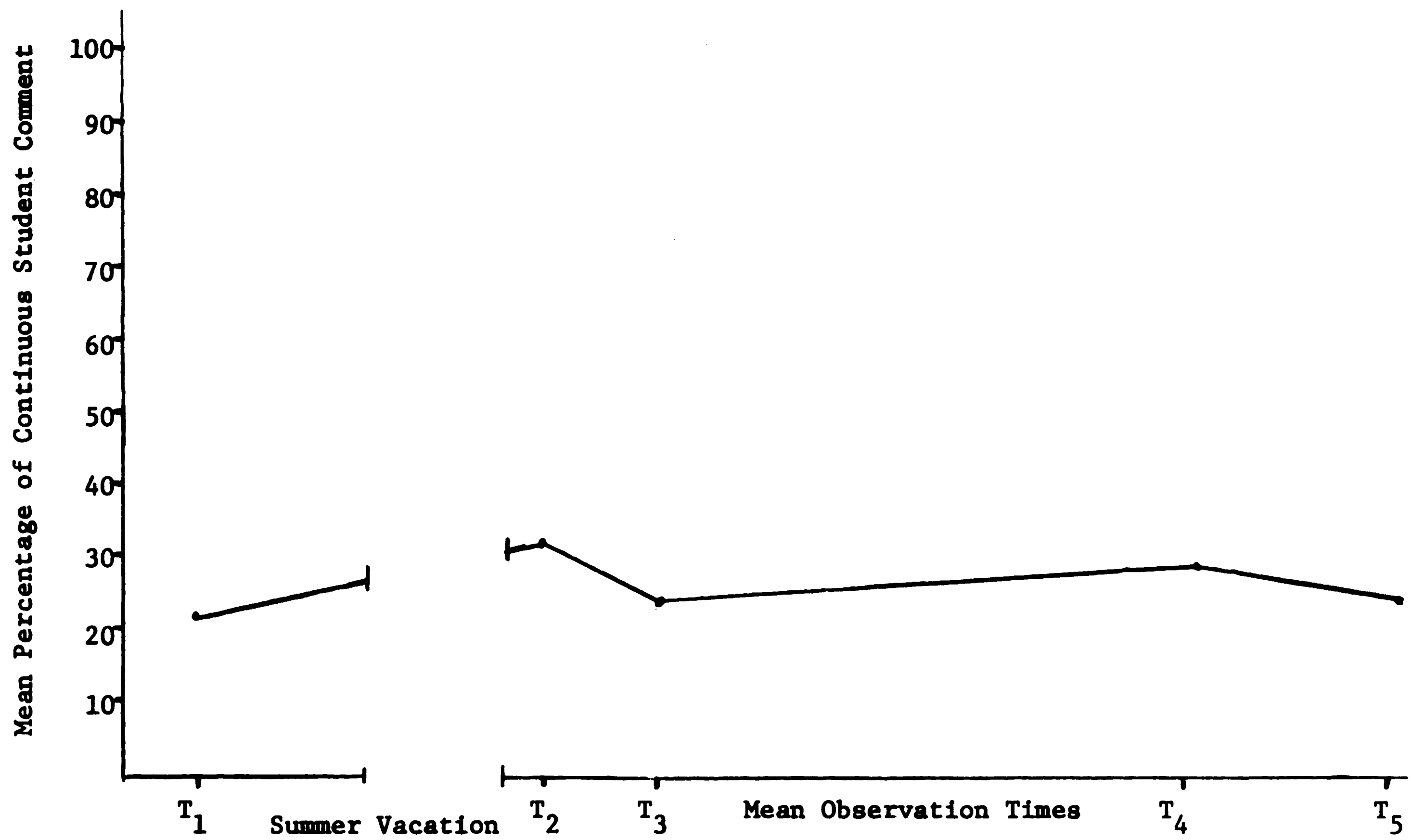


Figure 5

Mean Percentages of Continuous Student Comment Per Mean Observations, N = 16 SCIS Classrooms to initiate discussion, to appraise what children have learned, and to determine what they are thinking about.[7] The Science Teaching Observational Instrument effectively codes teacher questions into five distinct categories and was used to determine whether or not there was a difference in the kinds of questions teachers ask children, before and after the introduction of SCIS teaching methods and materials (H_{o5}: $KQ_1 = KQ_2$).

The Friedman two-way analysis of variance by ranks was used to analyze hypothesis H_{o5}.[8] After the percentage of questions asked in each of the five categories per teacher observation was determined, these percentages were ranked across all five observations for the sixteen SCIS teachers. The Friedman statistic was calculated to analyze whether there was a difference in the kinds of questions teachers asked of children during science activities. This statistic was significant ($X_r^2 = 57.7 > 9.48$ at the .05 level of significance). After this original Friedman test produced statistically significant results, additional tests for time by type interactions were performed by making orthogonal tests within the subtables.[9] Table thirteen displays these test results.

Based upon these statistical results concerning teacher preferences for question types, the null hypothesis that there is no difference

---

[7] Willard J. Jacobson and Allan Kondo, SCIS Elementary Science Sourcebook (Berkeley: University of California Regents, 1968), p. 44.

[8] Sidney Siegel, Nonparametric Statistics (Chicago: McGraw-Hill Book Company, Inc., 1956), pp. 166-173.

[9] James V. Bradley, Distribution-Free Statistical Tests (Wright-Patterson Air Force Base, Ohio: Wadd Technical Report 60-661, 1960), pp. 292-296.

in the kinds of questions teachers ask children, before and after the introduction of SCIS teaching methods and materials (H_{o5}: $KQ_1 = KQ_2$) is rejected. Figure six demonstrates a graphic presentation of the data gathered for each question type. In addition, Figure seven illustrates the plots of question preferences for the SCIS teachers and the teachers using more conventional science methods and materials on both the initial and the final observations for each group.

TABLE 13

SUMMARY OF TIME BY TYPE INTERACTIONS USING THE FRIEDMAN ANALYSIS OF VARIANCE BY RANKS

Time by Type Interaction	Friedman Statistic (X_r^2)
$T_1 - T_2$	22.11 * S
$T_1 + T_2 - 2T_3$	23.61 * S
$T_1 + T_2 + T_3 - 3T_4$	10.94 * S
$T_1 + T_2 + T_3 + T_4 - 4T_5$	4.35 NS

*X_r^2,.95, 4 df = 9.49

All pertinent data used in the Friedman calculations are located in Appendix C. In the following section the data gathered on the sixteen SCIS teachers using pre- and post-tests of the Science Process Test for Elementary School Teachers are analyzed.

Analyses of Science Process Skills

As was previously mentioned in chapter two, many of the newer elementary science programs developed within the past decade place

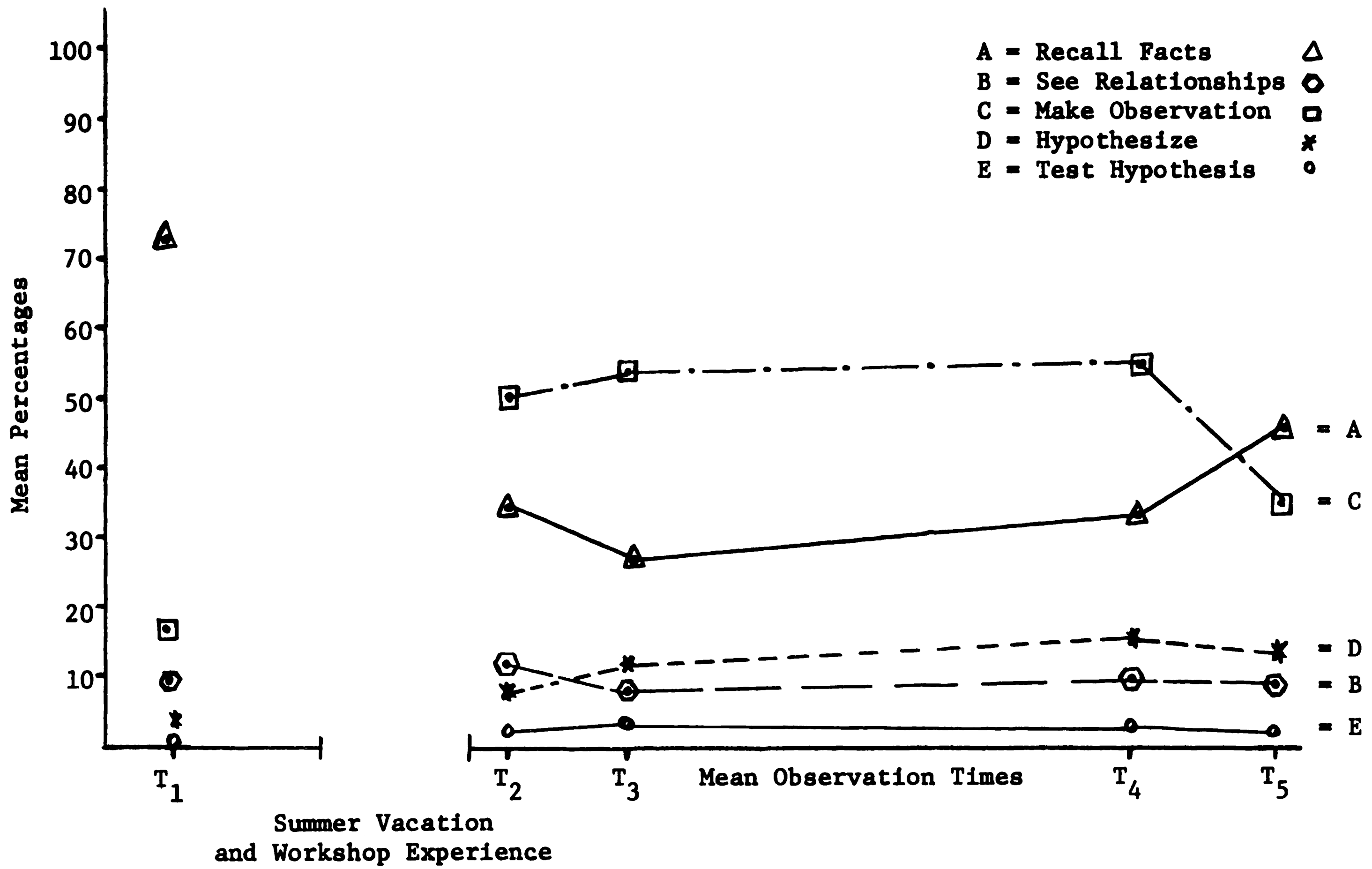


Figure 6

Mean Percentages of Question Types by the Sixteen SCIS Teachers Per Mean Observations

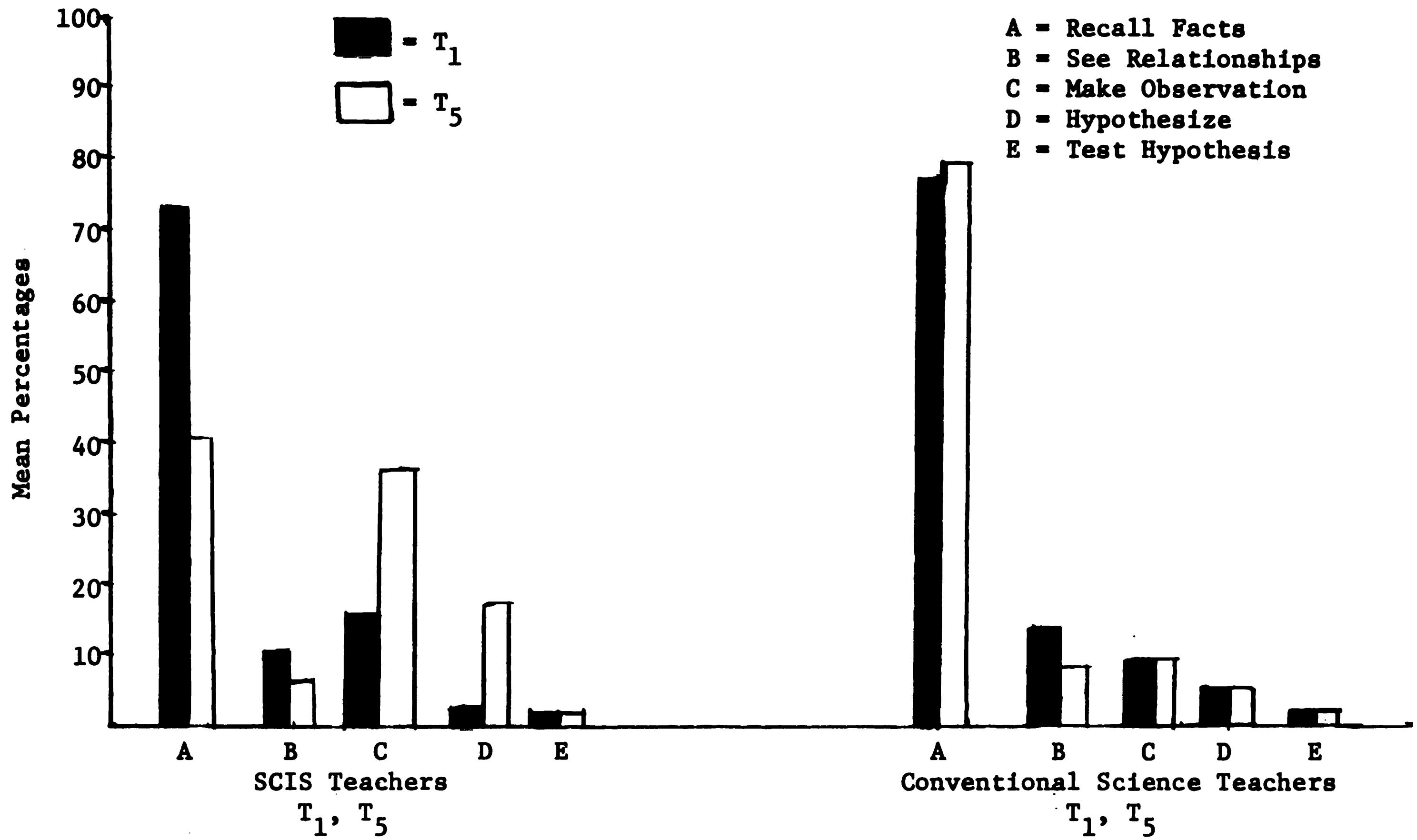


Figure 7

Mean Percentages of Question Type Preferences by Both SCIS Teachers and Conventional Science Teachers on Initial and Final Observations emphasis upon teacher comprehension of the basic process skills that good science teaching should foster within children. From such an emphasis, the investigator wished to determine whether or not there would be a difference in the teachers' comprehension of the process aspects of science, before and after the introduction of SCIS teaching methods and materials (H_{o6}: $PS_1 = PS_2$). A pre-test using the Science Process Test for Elementary School Teachers was administered to all sixteen SCIS teachers on August 6, 1968, prior to the summer workshop's formal activities. A post-test using this same instrument was given to these sixteen teachers on April 19, 1969. Using a t-test for correlated data,[10] the test scores were analyzed. Table fourteen summarizes the results.

TABLE 14

PRE-TEST AND POST-TEST DATA CONCERNING THE SCIS TEACHERS ON THE SCIENCE PROCESS TEST

	Pre-test	Post-test	T-test
Number of teachers	16	16	
Mean score	20.94	20.00	1.29 NS
Standard deviation	5.40	4.98	

$t_{.95,(15\ df)} = 2.131$

Based upon the statistical results outlined above, the null hypothesis that there is no difference in the teachers' comprehension

[10]Downie and Heath, op. cit., pp. 132-143.

of the process aspects of science before and after the introduction of SCIS teaching methods and materials (H_{o6}: $PS_1 = PS_2$) fails to be rejected. Descriptive data concerning the use of this instrument with other populations of in-service elementary school science teachers have been obtained from the test's author, and are located in Appendix A in addition to a specimen test copy.

Table fifteen summarizes the data analysis for each of the six hypotheses tested within this study. A more detailed consideration of each hypothesis, plus a synthesis of informal conversations with the thirty-two teachers involved in the study, are found within the following sections.

Discussion of the Study's Findings

This research indirectly evolved from the results of a pilot study published in 1965 under the joint authorship of Fischler and Anastasiow.[11] Using ten teachers who were employed in fourth, fifth, and sixth grade classrooms, these authors gathered two taped recordings on six of the teachers prior to their participation in a summer workshop using the Science Curriculum Improvement Study's teaching methods and materials. At the workshop's conclusion, one additional science lesson was taped for each participating teacher. Among the results were the following points of interest:

1. there was a significant decrease in the teachers' indirect-direct ratios (ID ratios);

---

[11] Abraham S. Fischler and N. J. Anastasiow, "In-Service Education in Science (A Pilot)," Journal of Research in Science Teaching, 3 (1965), pp. 280-285.

TABLE 15

SUMMARY OF DATA ANALYSES FOR EACH HYPOTHESIS TESTED

Statement of Hypotheses	Models Used for Analyzing Data	Results Based Upon α = .05
H_{o1} There is no difference in the teachers' ID ratios during science activities, before and after the introduction of SCIS teaching methods and materials.	analysis of variance	a significant difference
H_{o2} There is no difference in the percentage of time teachers spend talking during science activities, before and after the introduction of SCIS teaching methods and materials.	analysis of variance	no significant difference
H_{o3} There is no difference in the percentage of time students talk during science activities, before and after the introduction of SCIS teaching methods and materials.	analysis of variance	no significant difference
H_{o4} There is no difference in the percentage of continuous student comment during science activities within the classroom, before and after the introduction of SCIS teaching methods and materials.	analysis of variance	no significant difference
H_{o5} There is no difference in the kinds of questions teachers ask children, before and after the introduction of SCIS teaching methods and materials.	Friedman two-way analysis of variance by ranks	a significant difference

H_{o6}	There is no difference in the teachers' comprehension of the process aspects of science, before and after the introduction of SCIS teaching methods and materials.	t-test for correlated data	no significant difference

2. at least seven teachers demonstrated decreases in time talking and the use of fewer relationship questions;

3. significantly more teachers allowed more continuous, uninterrupted student comment; and

4. there was a greater percentage of observational questions after the summer experience.

Fischler and Anastasiow also state that with only ten teachers it is extremely difficult to obtain significant results. Thus, any interpretation must be based on data trends.

With these comments as a reference, implications of the findings for each hypothesis within this study are described in the following paragraphs.

Teacher ID Ratios

Although the data displayed in Table seven clearly demonstrates a significant F statistic concerning teacher ID ratios, figure two more vividly conveys the true implications of this analysis. This graph demonstrates a very high ID ratio at the time two interval (T_2), yet across the remaining observation times there has been a significant decrease. It would appear that the sixteen SCIS teachers attempted a more indirect approach to verbal behavior patterns during the fall months immediately after the workshop's conclusion, then assumed a more direct stance as the school year progressed. Perhaps one explanation for this phenomenon centers upon the fact that the SCIS science program is heavily materials-centered, for the children are actively involved in manipulating such objects as wood samples, pieces of lead, wire, and rubber balloons. The summer workshop greatly emphasized the importance of carefully giving directions to young children before allowing them to handle objects. Table sixteen demonstrates that most teachers increased their percentages of direction giving (Flanders category six) across observation times. Such an increase within this category has the effect of depressing the teachers' ID ratios across these same observation times. Fischler and Anastasiow's data trends concerning ID ratios confirm the results mentioned here.

Percentage of Teacher Talk

Both Table ten and Figure three demonstrate that there was no significant difference in the percentage of teacher talk before and after the introduction of the Science Curriculum Improvement Study's teaching methods and materials. Yet one point needs further consideration. Both Flanders[12] and Hough[13] have written that a visit to an elementary or secondary school classroom will typically demonstrate that between fifty and eighty percent of verbal interaction is conducted by the teacher. But at no time did the mean percentage of SCIS teacher talk rise above 47.9 percent. Perhaps this is an indication of more student verbal participation in primary grades than was once thought. This possibility might be worthy of further study.

Percentage of Student Talk

Although data focusing upon this hypothesis yielded no significant F statistic at the .05 level of significance, Table eleven demonstrates

---

[12] Flanders, _op. cit._, p. 17.

[13] John B. Hough, "Ideas for the Development of Programs Relating to Interaction Analysis," _Innovative Ideas in Search of Schools: Title III, PACE_ (Lansing: State Board of Education, 1966), p. 98.

TABLE 16

SCIS TEACHERS' PERCENTAGE OF GIVING DIRECTIONS
(FLANDERS CATEGORY SIX) ACROSS OBSERVATIONS

Teacher Number	Observation Times					
	O_1	O_2	O_3	O_4	O_5	O_6
1	9.7	3.0	5.0	24.0	27.8	37.8
2	5.4	9.7	3.9	6.0	14.6	7.4
3	3.7	. .	5.6	15.7	12.9	19.9
4	15.0	8.9	27.9	39.0	20.3	33.2
5	11.0	20.2	15.0	19.3	13.7	18.9
6	16.3	28.6	24.2	20.4	20.1	32.3
7	0.0	. .	13.4	17.7	16.0	15.0
8	3.0	5.7	21.4	27.6	30.5	37.4
9	.3	2.3	9.4	1.4	17.2	15.7
10	6.3	8.3	7.7	21.0	25.3	17.4
11	6.1	. .	19.0	21.2	17.7	12.2
12	9.9	. .	8.4	16.9	25.0	14.6
13	3.5	. .	22.3	13.0	16.7	22.1
14	9.7	3.0	41.9	34.0	22.1	21.4
15	2.5	4.6	20.8	13.4	24.1	29.7
16	13.5	28.5	11.9	20.5	22.6	15.2

that it missed by merely .1754. Furthermore, the graph illustrated in figure four shows that there was a definite increase in mean percentage of student talk across observation times, with the greatest amount occurring during those months immediately after the workshop's conclusion. It seems that the use of SCIS teaching methods and materials during science lessons contributed toward this trend, with most student verbal activity occurring at the period when there was an increase in teachers' ID ratios (Figure two).

Percentage of Continuous Student Comment

In similar fashion, Figure five depicts the greatest increase in continuous student comment occurring in those months immediately following the workshop's conclusion. During this same period the teachers demonstrated tendencies toward an indirect approach in verbal behavior patterns, as shown by their momentary rise in ID ratios. In essence, careful review of the data for hypotheses one through four demonstrates two important implications:

1. the ten categories composing the Flanders System of Interaction Analysis are not mutually independent--for an increase or decrease in one category's tallies during a specified time period results in a corresponding increase or decrease in the other categories; and

2. the overall effects of the summer workshop in regard to hypotheses one through four seem most noticeable in the time period between September, 1968 and November, 1968.

Teacher Question Type Preferences

Certainly one set of data that deserves further comment centers upon the sixteen SCIS teachers' preferences for question types across the various observation times. As previously described in chapter three, the Science Teaching Observational Instrument contains five categories of questions. Two of these question types, "recall facts" and "see relationships," are of a low order classification and elicit little cognitive skill from the children to effectively answer. The other three question types (make observation, hypothesize, and test hypothesis) are of a higher order and demand more effort to answer correctly.

Figure six graphically depicts the pronounced decrease in the teachers' simple recall questions over time and a slight decrease in their preference for question type B (see relationships). Likewise, this same graph portrays the teachers' noticeable increases in higher level questions that ask the children to use data from their observations (type C) and to hypothesize (type D). There is very little difference displayed in the teachers' use of question type E (test hypothesis) possibly because this category demands too much sophistication for primary grade children to answer effectively. The data contained within Table thirteen also depicts these changes in teacher question preferences across time. Perhaps one reason why there was an increase in question category A and a corresponding decrease in question category C at observation time four (T_4) might be that during this period the teachers completed the physical science units of the SCIS program and began using the life science units within their classrooms. This phenomenon might be worthy of further study. One should also note that while there was a definite shift in question preferences between the SCIS teachers' initial and final observations, no such pronounced shift occurred between the conventional science teachers' question preferences on initial and final observations (Figure seven).

Teachers' Science Process Skills

Based upon the test results reported in Table fourteen, it appears that instruction in the teaching methods and materials suggested by the Science Curriculum Improvement Study made little difference in these teachers' science process skills. Yet this group of experienced teachers did not differ markedly from a similar group of experienced elementary school teachers in Maryland and Michigan, who were evaluated using the same instrument during science workshops conducted in the summer of 1968. The following table summarizes pertinent test data on these two groups.

TABLE 17

A STATISTICAL COMPARISON OF TWO GROUPS OF IN-SERVICE ELEMENTARY TEACHERS ON THE SCIENCE PROCESS TEST*

	Michigan-Maryland Teachers	SCIS Teachers	
	Summer-1968	Summer-1968	Spring-1969
Number	103	16	16
Mean	21.34	20.94	20.00
S.D.	5.60	5.40	4.98
Variance	31.38	29.16	24.80

*Descriptive data was furnished by the test's author, Dr. Evan A. Sweetser.

Although the null hypothesis concerning science process skills for these sixteen SCIS teachers failed to be rejected, at least their test results compare favorably with a much larger number of experienced elementary school teachers who were evaluated in a similar fashion.

Whenever one is concerned with the same group of teachers for the duration of a study such as this, inevitably some major concerns and attitudes can be distilled from their various conversations. The following few paragraphs represent an effort to crystallize some of their comments.

Some Concerns and Attitudes of the Teachers Within the Study

Of the sixteen teachers who used the more traditional teaching methods and materials as outlined in chapter three, the most pressing concern was the lack of sufficient materials that could be used by the children during science activities. Whenever science equipment was available, it was often used by the teacher in demonstration fashion, stationed at the front of the room. Many teachers also felt uncomfortable with some of the science concepts presented in the childrens' textbooks, and seemed somewhat reticent about expanding upon them. Thus either a narrow reliance upon the textbooks was in evidence, or a feeling was expressed that science occupied a secondary position in the overall elementary school curriculum. Some of these sixteen teachers appeared to want guidance in presenting their science activities.

Those sixteen teachers who used the teaching methods and materials advocated by the Science Curriculum Improvement Study likewise conveyed certain attitudes shared in common. Although there were some problems that developed in effectively shipping and caring for living organisms in the classrooms, most teachers were quite pleased that there was an abundance of objects, both physical and biological, that could be manipulated and observed by each individual child. Many commented on the enthusiasm displayed by the children during science activities, and seemed pleased that close personal attention was given to their science needs by various SCIS Trial Center personnel throughout the school year.

Summary

Included within the opening paragraphs of this chapter were statements describing how the necessary data were collected and analyzed. Each hypothesis was then restated, the data related to that hypothesis were reported, and a statement was given concerning whether or not the null hypothesis was rejected. Of the six hypotheses considered within the study, only two--those focusing upon teacher ID ratios and upon teacher question preferences--attained statistical significance. All other findings failed to reach the necessary level of significance established for this study.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

The purpose of this study was to analyze selected examples of verbal behavior patterns in primary grade classrooms during science activities. Thirty-two elementary teachers within five mid-Michigan public school districts comprised the population under consideration. Sixteen of these teachers taught science in the conventional manner suggested by their respective school districts. Each of the sixteen remaining teaching participants within the experimental population received an in-depth study of the Science Curriculum Improvement Study's teaching methods and materials, for they attended a three week workshop in these techniques during the summer of 1968. This study was designed as a quasi-experimental, time-series analysis and involved a series of science teaching observations that began in April, 1968 and were concluded in March, 1969.

Each science lesson was recorded with easily portable, battery powered tape recorders, and two of the three instruments used in evaluating the study's data were exclusively concerned with information gathered from analyses of the taped lessons. Two individuals were trained to analyze these taped observations. Each lesson was therefore reviewed twice--once to gather data using the Flanders System of Interaction Analysis and a second time using the Science Teaching Observational

Instrument. The third instrument centered upon an evaluation of teachers' process skills and comprehension of selected science concepts. A pre-test and post-test administration of the Science Process Test for Elementary School Teachers provided data for this analysis. The following statistical tests were performed to evaluate the study's six null hypotheses: a repeated measures design of a mixed model analysis of variance; the Friedman two way analysis of variance by ranks; and the t-test for correlated data. The alpha level used for these tests was .05. The summary of findings described below outlines the pertinent results of the data analyzed for this study.

Summary of Findings

The following findings were evident from the data:

1. there were no significant differences between the SCIS teachers and those teachers using conventional science materials on initial observations, in regards to ID ratios, percentage of teacher talk, percentage of student talk, and percentage of continuous student comment during science activities;

2. no significant differences occurred between the initial and final observations of those teachers using conventional science methods and materials, in regards to ID ratios, percentage of teacher talk, percentage of student talk, and percentage of continuous student comment during science activities;

3. there was a significant difference in the experimental teachers' ID ratios during science activities, before and after the introduction of SCIS teaching methods and materials;

4. there was no significant difference in the percentage of time the experimental teachers spent talking during science activities, before and after the introduction of SCIS teaching methods and materials;

5. there was no significant difference in the percentage of time students talked in the experimental classrooms during

science activities, before and after the introduction of SCIS teaching methods and materials;

6. there was no significant difference in the percentage of continuous student comment in the experimental classrooms during science activities, before and after the introduction of SCIS teaching methods and materials;

7. there was a significant difference in the kinds of questions the experimental teachers asked children, before and after the introduction of SCIS teaching methods and materials; and

8. there was no significant difference in the experimental teachers' comprehension of the process aspects of science, before and after the introduction of SCIS teaching methods and materials.

In addition, informal conversations with both groups of teachers brought forth the points summarized below.

A. of those teachers using conventional science methods and materials, many :

   1. expressed concern over the lack of sufficient materials that could be used by all children during science activities;

   2. often seemed uncomfortable with some of the science concepts presented in the childrens' textbooks;

   3. seemed somewhat reticent about expanding beyond the textbooks' content and methods of presentation; and

   4. appeared to want guidance in presenting science activities.

B. of those teachers using the teaching methods and materials suggested by the Science Curriculum Improvement Study, many:

   1. seemed pleased that enough science objects were furnished so that each child could be actively involved in manipulating and observing during science lessons; and

   2. seemed satisfied with the personal attention given to their needs by various SCIS Trial Center personnel throughout the school year.

Conclusions

Based upon these findings, the following conclusions described below seem justified.

A. Those teachers who were exposed to the teaching methods and materials suggested by the Science Curriculum Improvement Study differed significantly from those teachers employing conventional science teaching methods and materials, by demonstrating an increase in the amount of direct teacher influence displayed in verbal behavior patterns during science activities. Apparently this was due to an increased percentage of teacher direction-giving to young children who were actively involved with science materials;

B. There was a pronounced shift in the question preferences displayed by the experimental teachers after the introduction of SCIS teaching methods and materials. The original observations demonstrated a heavy reliance upon low order question types, demanding little cognitive skill from the children to effectively answer. After the workshop's conclusion, the teachers demonstrated a much greater percentage of high level questions, which included asking the children to make observations of some on-going sense activity or to reason out (or guess) an answer which is not given as an immediate fact.

C. Although the SCIS summer workshop's activities seemed to have a pronounced influence upon the experimental teachers' science presentations during those fall months immediately following its conclusion, the possibility cannot be discounted that the types of science materials used by these teachers might also have contributed to this influence.

Implications From the Study

Based upon the data gathered during observations of science lessons, the implications listed below are worthy of consideration.

1. The Science Curriculum Improvement Study is heavily materials-centered, for the children are actively involved in manipulating various science equipment during science lessons. Because of such a diverse array of activities occurring simultaneously, it was often difficult to differentiate categories eight and nine (student talk-response and student talk-initiation) using the Flanders System of Interaction Analysis.

Perhaps a modification of this system will be necessary for future studies involving laboratory-oriented classroom activities.

2. Results from data analysis demonstrated that the SCIS teachers used fewer low order questions and a greater percentage of high order questions immediately after the summer workshop. Yet as the school year progressed, the teachers' preferences for question types began to closely parallel their question patterns demonstrated during those months before participation in the summer workshop. Possibly more effort should be placed upon continual supervision and in-service consultation throughout the school year in future implementation projects, in an effort to sustain any gains made during a summer workshop experience.

3. Some SCIS teachers seemed to expend an unreasonable amount of class time in the distribution and retreval of science materials. It appears that such elementary school teachers could benefit from systematic instruction in the handling and distribution of science equipment.

Implications for Future Research

Many unanswered questions could be composed regarding the various ramifications of this study in relation to the elementary school teacher's role in fostering optimum science learning experiences for children. Some of these questions appear in the comments that follow, and should provide direction for continued research in elementary school science instruction.

1. The use of instruments that only focus upon verbal classroom behavior patterns limit somewhat the researcher's abilities to record the actual teaching-learning experience. More recently, television cameras have been employed, but the expense involved restricts its practicality. Might not an instrument be developed that could analyze data taken from both tape recorders and more conventional photographic techniques in synchronization with each other? Such an analysis could be effectively used to record all types of learning activities across all curricular presentations. Dr. Wayne Taylor of Michigan State University is currently involved in developing such an instrument employing time-lapse photographic techniques.

2. What are some effective strategies that elementary teachers can employ in organizing, handling, and distributing science objects to young children? Such information would greatly aid those teachers who might be involved with one of the newer elementary science programs.

3. Can some usable teaching techniques be delineated that would enable teachers to determine when and how to guide children into more sophisticated cognitive processes through effective use of questions? Is there a relationship between the types of questions asked by teachers and the advancement of children into more sophisticated cognitive styles?

4. The literature concerning the Science Curriculum Improvement Study states the importance that Piaget's studies in developmental psychology have for the formulation of its own conceptual scheme approach to elementary school science. Can a diagnostic instrument be developed to effectively aid classroom teachers in determining when primary grade children have attained the various developmental stages as described by Piaget? Such a tool would greatly aid teachers in determining the most advantageous times to introduce certain science concepts and process skills.

5. Among this study's findings was the indication of a possible shift in question preferences that paralleled the introduction of the SCIS life science units. A further study might consider whether teachers trained to use SCIS teaching methods and materials do elicit different question patterns when using the life science units as opposed to the physical science units within their classrooms.

BIBLIOGRAPHY

BIBLIOGRAPHY

Books

Amidon, Edmund J., and Flanders, Ned A. The Role of the Teacher in the Classroom. Minneapolis: Amidon Associates, Inc., 1963.

Association for Supervision and Curriculum Development. Using Current Curriculum Developments. A Report of ASCD's Commission on Current Curriculum Developments. Washington, D.C.: ASCD, 1963.

Borg, Walter R. Educational Research, An Introduction. New York: David McKay Company, Inc., 1963.

Bradley, James V. Distribution-Free Statistical Tests. Wright-Patterson Air Force Base, Ohio: Wadd Technical Report 60-661, 1960.

Bruner, Jerome S. The Process of Education. New York: Random House, 1960.

Bruner, Jerome S., et al. Studies in Cognitive Growth. New York: John Wiley and Sons, Inc., 1966.

Campbell, Donald T., and Stanley, Julian C. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand, McNally and Company, 1963.

Carin, Arthur, and Sund, Robert. Discovery Teaching in Science. Columbus, Ohio: Charles E. Merrill Books, Inc., 1966.

Craig, Gerald S. What Research Says to the Teacher: Science in the Elementary Schools. Washington, D.C.: National Educational Association, 1957.

Downie, N. M., and Heath, R. W. Basic Statistical Methods, Second Edition. New York: Harper and Row, 1965.

Flanders, Ned A. Teacher Influence, Pupil Attitudes and Achievement. Minneapolis: University of Minnesota, 1960.

Gage, N. L. (ed.). Handbook of Research on Teaching. Chicago: Rand, McNally and Company, 1963.

Gega, Peter C. Science in Elementary Education. New York: John Wiley and Sons, Inc., 1966.

Good, Carter V. Dictionary of Education. New York: McGraw-Hill Book Company, Inc., 1959.

Hopman, Anne B. (ed.). Helping Children Learn Science. Washington, D.C.: National Science Teachers Association, 1966.

Hughes, Marie. Development of the Means for the Assessment of the Quality of Teaching in Elementary Schools. Salt Lake City: University of Utah Press, 1959.

Hurd, Paul DeHart. Theory Into Action in Science Curriculum Development. Washington, D.C.: National Science Teachers Association, 1964.

Jacobson, Willard J., and Kondo, Allan. SCIS Elementary Science Sourcebook. Berkeley: University of California Regents, 1968.

Karplus, Robert, and Thier, Herbert D. A New Look at Elementary School Science. Chicago: Rand, McNally and Company, 1967.

National Society for the Study of Education. Rethinking Science Education. Fifty-Ninth Yearbook of the Society, Part I. Chicago: University of Chicago Press, 1960.

National Society for the Study of Education. Science Education in American Schools. Forty-Sixth Yearbook of the Society, Part I. Chicago: University of Chicago Press, 1947.

Raths, James, Pancella, John R., and Van Ness, James S. Studying Teaching. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967.

Renner, John W., and Ragan, William B. Teaching Science in the Elementary School. New York: Harper and Row, 1968.

Siegel, Sidney. Nonparametric Statistics. Chicago: McGraw-Hill Book Company, Inc., 1956.

Tannenbaum, Harold, Stillman, N., and Piltz, Albert. Science Education for Elementary School Teachers, Second Edition. Boston: Allyn and Bacon, Inc., 1965.

Verduin, John R. Jr. Conceptual Models in Teacher Education. Washington, D.C.: American Association of Colleges for Teacher Education, 1967.

Victor, Edward. Science for the Elementary School. New York: Macmillian Company, 1965.

Winer, B. J. Statistical Principals in Experimental Design. New York: McGraw-Hill Book Company, Inc., 1962.

Zafforoni, Joseph, and Selberg, Edith. New Developments in Elementary School Science. Washington, D.C.: National Science Teachers Association, 1963.

Articles and Pamphlets

Alford, Genevieve G. "An Analysis of Science Interests of Selected Children and An Identification of Problems Encountered by the Teachers of these Children in Science Instruction," Dissertation Abstracts, 20, No. 8 (1960), 2704.

Aschner, Mary Jane, and Gallagher, James J., et al. A System for Classifying Thought Processes in the Context of Classroom Verbal Interaction (Urbana: University of Illinois, 1962), 1.

Berryessa, Max Joseph. "Factors Contributing to the Competency of Elementary Teachers in Teaching Science," Dissertation Abstracts, 20, No. 2 (1959), 558.

Bixler, James Edward Jr. "The Effect of Teacher Attitude on Elementary Children's Science Information and Science Attitude," Dissertation Abstracts, 19 (1958), 2531.

Blackwood, Paul E. "Science Teaching in the Elementary School: A Survey of Practices," Journal of Research in Science Teaching, 3 (September, 1965), 177-197.

Bloom, Samuel W. "How Effective is Science in the Elementary School?" School Science and Mathematics, 59 (February, 1959), 95-96.

Blosser, Patricia E., and Howe, Robert W. "An Analysis of Research on Elementary Teacher Education Related to the Teaching of Science," Science and Children, 6, No. 5 (January/February, 1969), 50-60.

Blough, Glenn O. "Preparing Teachers for Science Teaching in the Elementary School," School Science and Mathematics, 58 (October, 1958), 524-525.

Bradley, R. C., Earp, N. W., and Sullivan, T. "A Review of Fifty Years of Science Teaching and its Implications," Science Education, 50 (March, 1966), 152-156.

Brown, Clyde M. "A Workshop in Teaching Elementary Science: An In-Service Training Program for Teachers," Science Education, 42 (December, 1958), 401-405.

Butts, D. P., and Jones, H. L. "Development of the TAB Science Test," Science Education, 51 (December, 1967), 463-473.

Carleton, Robert H. "Science Education in the Middle or Junior High School Grades," Science Teacher, 34, No. 9 (December, 1967), 25-28.

Cronbach, L. J. "Learning Research and Curriculum," Journal of Research in Science Teaching, 2 (1964), 204-207.

Duckworth, Eleanor. "Piaget Rediscovered," Journal of Research in Science Teaching, 2 (1964), 172-175.

Eccles, Priscilla Jacobs. "An Evaluation of a Course in Teaching Science in the Elementary School," Dissertation Abstracts, 19, No. 11 (1959), 2862.

Educational Policies Commission. Education and the Spirit of Science Washington, D.C.: National Educational Association, 1966), 27.

Estvan, Frank J. "Teaching the Very Young: Procedures for Developing Inquiry Skills," Phi Delta Kappan, 50, No. 7 (March, 1969), 389-393.

Fischler, Abraham S., and Anastasiow, N. J. "In-Service Education in Science (A Pilot)," Journal of Research in Science Teaching, 3 (1965), 280-285.

Flanders, Ned A. "Teacher Behavior and In-Service Programs," Educational Leadership, 21 (October, 1963), 25-29.

Gagné, R. M. "Elementary Science: A New Scheme of Instruction," Science, 151, No. 3706 (January 7, 1966), 49-53.

Gagné, R. M. "A Psychologist's Counsel on Curriculum Design," Journal of Research in Science Teaching, 1 (1963), 27-32.

Gega, P. C. "Pre-Service Education of Elementary Teachers in Science and the Teaching of Science," School Science and Mathematics, 68 (January, 1968), 11-20.

Hempel, Carl H. "Attitudes of a Selected Group of Elementary School Teachers Toward In-Service Education," Dissertation Abstracts, 21, No. 13 (1961), 3684.

Hines, Sallylee H. "A Study of Certain Factors Which Affect the Opinions of Elementary School Teachers in the Teaching of Science," Dissertation Abstracts, 27, No. 12 (June, 1967), 4153-A.

Hough, John B. "Ideas for the Development of Programs Relating to Interaction Analysis," Innovative Ideas in Search of Schools: Title III, PACE (Lansing: State Board of Education, 1966), 97.

Hurd, Paul DeH. "New Directions in Science Teaching from Kindergarten through College," Educational Digest, 32 (March, 1967), 16-19.

Jacobson, Willard J. "Teacher Education and Elementary School Science--1980," Journal of Research in Science Teaching, 5, Issue 1 (1967), 73-80.

Johnston, Jane. "The Relative Achievement of the Objectives of Elementary School Science in a Representative Sampling of Minnesota Schools," Dissertation Abstracts, 17 (1957), 2499.

Karplus, Robert. "The Science Curriculum Improvement Study," Journal of Research in Science Teaching, 8 (October, 1965), 237-238.

Karplus, Robert. "The Science Curriculum Improvement Study-Report to the Piaget Conference," Journal of Research in Science Teaching, 2 (1964), 237.

Kleinman, Gladys S. "Needed: Elementary School Science Consultants," School Science and Mathematics, 65 (November, 1965), 743-745.

Kleinman, Gladys S. "Teachers' Questions and Student Understanding of Science," Journal of Research in Science Teaching, 3, Issue 4 (1965), 307-317.

Lammers, Theresa J. "One Hundred Interviews with Elementary School Teachers Concerning Science Education," Science Education, 33 (October, 1949), 292-295.

Livermore, A. H. "The Process Approach of the AAAS Commission on Science Education," Journal of Research in Science Teaching, 2 (1964), 271-282.

Mallinson, G. G., and Mallinson, J. V. "Science in the Elementary Grades: Children's Learnings in Science," Review of Educational Research, 31 (June, 1961), 238-241.

Mallinson, Jacqueline Buck. "What Research in Science Education is Needed to Strengthen the Elementary-School Science Program?" Science Education, 40 (December, 1956), 369.

Moyer, John R. "An Exploratory Study of Questioning in the Instructional Processes in Selected Elementary Schools," Dissertation Abstracts, (1965), 147-A.

Novak, Joseph D. "A Preliminary Statement on Research in Science Education," Journal of Research in Science Teaching, 1 (1963), 3.

Ramsey, Irvin I., and Wiandt, Sandra Lee. "Individualizing Elementary School Science," School Science and Mathematics, 68, No. 5 (May, 1967), 419-427.

Ryans, David G. "Some Relationships Between Pupil Behavior and Certain Teacher Characteristics," Journal of Educational Psychology, 52 (1961), 82-89.

Ryans, David G. "Theory Development and the Study of Teacher Behavior," Journal of Educational Psychology, 47 (1956), 467-472.

Sears, Paul B., and Kessen, W. "Statement of Purposes and Objectives of Science Education in School," Journal of Research in Science Teaching, 2 (1964), 3-6.

Smith, Herbert A. "Educational Research Related to Science Instruction for the Elementary and Junior High School: A Review and Commentary," Journal of Research in Science Teaching, 1, Issue 3 (1963), 199-225.

Snyder, William Ray. "The Question-Asking Behavior of Gifted Junior High School Science Students and their Teachers," Dissertation Abstracts, 27, No. 11 (1967), 3738-A.

Stendler, Celia. "The Developmental Approach of Piaget and its Implications for Science in the Elementary School," The Macmillan Science Series (Chicago: Macmillan Company, 1966), 14.

Todd, V. E. "Women Teachers' Attitudes Toward Science in the Classroom," Elementary School Journal, 58 (April, 1958), 385-388.

Tyler, Ralph W. "Forces Redirecting Science Teaching," Science Teacher, 29, No. 6 (October, 1962), 22-25.

Uselton, Horace W., et al. "Factors Related to Competence in Science of Prospective Elementary Teachers," Science Education, 47 (December, 1963), 506-507.

Victor, Edward. "Why Are Our Elementary School Teachers Reluctant to Teach Science?" Science Education, 46 (March, 1962), 185-192.

Washton, Nathon S. "Improving Elementary Teacher Education in Science," Science Education, 45 (February, 1961), 33-34.

Unpublished Materials

Berkheimer, Glenn D. "An Analysis of the Science Supervisors' Role in the Selection and Use of Science Curriculum Materials." Unpublished Ed.D. dissertation, College of Education, Michigan State University, 1966.

Kondo, Allan K. "A Study of the Questioning Behavior of Teachers in the Science Curriculum Improvement Study Teaching the Unit on Material Objects." Unpublished Ph.D. dissertation, University of California at Berkeley, 1968.

McLeod, Richard J. "Changes in the Verbal Interaction Patterns of Secondary Science Student Teachers Who Have Had Training in Interaction Analysis and the Relationship of These Changes to the Verbal Interaction of their Cooperating Teachers." Unpublished Ph.D. dissertation, Cornell University, 1967.

Neuman, Donald B. "The Influence of Selected Science Experiences on the Attainment of Concrete Operations by First Grade Children." Unpublished Ph.D. dissertation, Michigan State University, 1968.

Wilson, John H. "Differences Between the Inquiry-Discovery and the Traditional Approaches to Teaching Science in Elementary Schools." Unpublished Ed.D. dissertation, University of Oklahoma, 1967.

APPENDICES

APPENDIX A

THE SCIS SUMMER WORKSHOP AND INSTRUMENTS USED TO GATHER DATA

APPENDIX A

THE SCIS SUMMER WORKSHOP AND INSTRUMENTS
USED TO GATHER DATA

TABLE 18

SCIS SUMMER WORKSHOP SCHEDULE

Week 1

Monday, August 5

9:00 - 10:00 a.m.	"Demonstration Lesson" Christina Kageyama Discussion McDonel Hall Kiva
10:00 - 10:45 a.m.	"Orientation to the 1968 SCIS Summer Workshop" Berkheimer
	Break
11:00 - 11:45 a.m.	"Overview of Interaction and Material Objects Kits" Berkheimer
	Lunch
12:45 - 2:00 p.m.	"The Role of the Teacher in Teaching SCIS" "Reactions and Experiences of the SCIS Teacher" Christina Kageyama
	Break
2:00 - 4:00 p.m.	Introduction to the SCIS Kits Grade 1 teachers, Organisms Grade 2 teachers, Interaction

TABLE 18--*Continued*

Tuesday, August 6	
9:00 - 10:15 a.m.	"What are the Purposes of the Elementary School?" Berkheimer, Bruce, Moon
	Break
10:30 - 11:45 a.m.	Laboratory: Grade 1 teachers, *Material Objects* Grade 2 teachers, *Life Cycles*
	Lunch
12:45 - 1:45 p.m.	*The Science Process Test* Moon
	Break
2:00 - 4:00 p.m.	Inquiry Laboratory (Observed by College Science Educators)
Wednesday, August 7	
9:00 - 10:00 a.m.	"SCIS Scope and Sequence", Slides Berkheimer
	Break
10:15 - 11:15 a.m.	"Role of the SCIS Teacher" Berkheimer
11:15 - 11:45 a.m.	"Operating Procedures for the 1968-69 School Year" Berkheimer
	Lunch
12:45 - 1:30 p.m.	*Minnesota Teacher Attitude Inventory* Bruce
	Break
1:45 - 2:30 p.m.	"Introduction to Micro-Teaching" Berkheimer
2:30 - 4:00 p.m.	Laboratory: Grade 1, *Organisms* Grade 2, *Interaction*

TABLE 18--Continued

Thursday, August 8	
9:00 - 10:15 a.m.	"The Nature of Science" Dr. Sherwood Haynes
	Break
10:30 - 10:45 a.m.	Study SCIS Sourcebook, pp. 18-24 Discussion Berkheimer
10:45 - 11:45 a.m.	Preparation for Micro-Teaching Lessons
	Lunch
12:45 - 2:45 p.m.	Micro-Teaching by SCIS Teachers
	Break
3:00 - 4:00 p.m.	Laboratory: Grade 1, _Material Objects_ Grade 2, _Life Cycles_
Friday, August 9	
9:00 - 9:45 a.m.	"Objectives of Science Education and SCIS" Berkheimer
	Break
10:00 - 10:45 a.m.	Study SCIS Sourcebook, pp. 25-33
10:45 - 11:45 a.m.	Preparation for Micro-Teaching Lessons
	Lunch
12:45 - 2:45 p.m.	Micro-Teaching by SCIS Teachers
	Break
3:00 - 4:00 p.m.	Laboratory: Grade 1, _Organisms_ Grade 2, _Interaction_
	SCIS Workshop Reaction, _Form 1_ Barnes

TABLE 18--Continued

Week II

Monday, August 12

9:00 - 9:45 a.m.	"The SCIS Life Science Program" Dr. Chester A. Lawson
9:45 - 10:15 a.m.	"The Role of the Teacher in SCIS Life Science" Dr. Chester A. Lawson
	Break
10:30 - 11:00 a.m.	"The Organisms Unit" Dr. Chester A. Lawson
11:00 - 11:45 a.m.	"The Life Cycles Unit" Dr. Chester A. Lawson
	Lunch
12:45 - 2:15 p.m.	Demonstration Teaching: Grade 1, Material Objects film, Activity 6, "Grandma's Button Box" Grade 2, Life Cycles
	Break
2:30 - 4:00	Demonstration Teaching: Grade 1, Organisms Grade 2, Interaction

Tuesday, August 13

9:00 - 10:30 a.m.	"Principles of Learning" Berkheimer
	Break
11:00 - 11:45 a.m.	Study: SCIS Sourcebook, pp. 34-39 (Grade 2 teachers) Micro-Teaching Preparation (Grade 1 teachers)
	Lunch
12:45 - 2:45 p.m.	Micro-Teaching: T_3, T_1 (T_3 - College Educator, T_1 - SCIS Teachers)
	Break

TABLE 18--Continued

3:00 - 4:00 p.m.	Demonstration Teaching: Grade 1, Organisms Grade 2, Interaction
Wednesday, August 14	
9:00 - 10:30 a.m.	"Demonstration of Piaget's Developmental Stages" Donald Neuman
	"The Psychology of Jean Piaget" Berkheimer
	Break
10:45 - 11:45 a.m.	Micro-Teaching Preparation (grade 2 teachers) Study SCIS Sourcebook, pp. 34-39 (Grade 2 teachers)
	"Science in the Classroom", film
	Lunch
12:45 - 2:45 p.m.	Micro-Teaching: T_3 , T_1
	Break
3:00 - 4:00 p.m.	Demonstration Teaching: Grade 1, Material Objects, film, Activity 8, "Grouping Collections of Objects" Grade 2, Life Cycles
Thursday, August 15	
9:00 - 9:45 a.m.	"Modes of Teaching SCIS" Berkheimer
	"Material Objects Overview", film
9:45 - 10:30 a.m.	"Piaget's Developmental Theory: Classification", film
	Break
10:45 - 11:45 a.m.	Study Sourcebook, pp. 40-51
	Lunch
12:45 - 1:45 p.m.	16 P F Questionnaire, (personality test) Bruce

TABLE 18--Continued

2:00 - 4:00 p.m.	Demonstration Teaching: Grade 1, Organisms Grade 2, Interaction
Friday, August 16	
9:00 - 10:30 a.m.	"Piaget's Developmental Theory: Conservation", film
	"Psychological Foundations of SCIS" Berkheimer Discussion and film "Interaction Documentary"
	Break
10:45 - 11:45 a.m.	Inquiry Laboratory, "Classification" (Grade 1 teachers) Demonstration Teaching (Grade 2 teachers)
	Lunch
12:45 - 2:15 p.m.	Inquiry Laboratory, "Classification" Grade 2 teachers) Demonstration Teaching (Grade 1 teachers)
2:15 - 2:30 p.m.	SCIS Workshop Reaction, Form 2 Barnes
2:30 - 3:00 p.m.	"Relativity Documentary", film
	Break
3:15 - 4:00 p.m.	Demonstration Teaching
	Week III
Monday, August 19	
9:00 - 9:45 a.m.	"Classroom Management, Modes of Teaching and Inquiry Laboratories" Berkheimer
9:45 - 10:30 a.m.	film, Activity 9, "Invention of the Concept of Material" "Modes of Teaching SCIS: An Analysis of Teaching Episodes on Film" Berkheimer
	Break

TABLE 18--_Continued_

10:45 - 11:45 a.m.	_Material Objects_: for children who haven't had first grade (Grade 2 teachers) _Material Objects_ (Grade 1 teachers)
	Lunch
12:45 - 2:15 p.m.	Inquiry Laboratory: Grade 1 teachers, _Whirly birds_ Grade 2 teachers, _Mealworms_
	Break
2:30 - 4:00 p.m.	Demonstration Teaching: Grade 1 teachers, _Material Objects_
	Woodlot Fieldtrip and Discussion, Grade 2 teachers
Tuesday, August 20	
9:00 - 10:15 a.m.	"Operating Procedures for the 1968-69 School Year--Consultants, Biweekly Seminar, etc." Berkheimer
	"Guiding Students to Design Experiments--The Controlled Experiment" Berkheimer
	Break
10:30 - 11:45 a.m.	film, Activity 18, "Observing Liquids", Grade 1 teachers
	Inquiry Laboratory, _Systems and Subsystems_ Grade 2 teachers
	Lunch
12:45 - 2:00 p.m.	Woodlot Fieldtrip and Discussion, Grade 1 teachers
	Interaction, Grade 2 teachers
2:15 - 4:00 p.m.	Inquiry Laboratory, _Pendulums_, Grade 2 teachers
	Material Objects, Grade 1 teachers

TABLE 18--Continued

Wednesday, August 21	
9:00 - 9:30 a.m.	"SCIS Teachers and Public Relations" Berkheimer
9:30 - 9:45 a.m.	Teachers from each elementary school will outline plans for a PTA meeting
9:45 - 10:00 a.m.	film, Activity 20, "Inventing the Comparison of objects Using Signs"
	Break
10:15 - 11:45	Inquiry Laboratory: Pendulums, Grade 1 teachers Relativity, Grade 2 teachers
	Lunch
12:45 - 1:15 p.m.	A tour of facilities of the SMTC
1:30 - 2:30 p.m.	Detailed planning for 1968-69 school year
	Break
2:45 - 4:00 p.m.	Planning (con't.)
Thursday, August 22	
9:00 - 10:00 a.m.	"An Experienced SCIS Teacher's Reaction to the SCIS program" Dianne Westfall
	Break
10:15 - 11:45 a.m.	Reports from each school district Continuation of Planning, Dianne Westfall
	Lunch
12:45 - 1:45 p.m.	SCIS Workshop Content Achievement Evaluation Barnes
	Break
2:00 - 4:00 p.m.	Inquiry Laboratory films: "Experimenting with Air" "Karplus with Children"

TABLE 18--Continued

Friday, August 23

9:00 - 10:45 a.m.	Detailed Planning for 1968-69 School Year
	Break
11:00 - 11:45 a.m.	Planning for Biweekly Seminars
	Lunch
12:45 - 1:00 p.m.	Feedback
1:00 - 1:30 p.m.	Tapes of workshop reactions

TABLE 19

INTERACTION ANALYSIS CATEGORIES

Ned A. Flanders

TEACHER TALK	INDIRECT INFLUENCE	1.* ACCEPTS FEELING: Accepts and clarifies the feeling tone of the students in a nonthreatening manner. Feelings may be positive or negative. Predicting or recalling feelings included.
		2.* PRAISES OR ENCOURAGES: Praises or encourages student action or behavior. Jokes that release tension, not at the expense of another individual, are included. Nods head or says, "Um hm?" or "go on" also included.
		3.* ACCEPTS OR USES IDEAS OF STUDENT: Clarifying, building, or developing ideas suggested by a student. As teacher brings more of his own ideas into play, shift to category five.
		4.* ASKS QUESTIONS: Asking a question about content or procedure with the intent that a student answer.
	DIRECT INFLUENCE	5.* LECTURING: Giving facts or opinions about content or procedure: expressing his own ideas.
		6.* GIVING DIRECTIONS: Directions, commands, or orders to which a student is expected to comply.
		7.* CRITICIZING OR JUSTIFYING AUTHORITY: Statements intended to change student behavior from non-acceptable to acceptable pattern; bawling someone out; stating why the teacher is doing what he is doing; extreme self-references.
STUDENT TALK		8.* STUDENT TALK-RESPONSE: Talk by students in response to teacher. Teacher initiates the contact or determines type of student statement. As a student exponds his own ideas, shift to Category 9.

TABLE 19--Continued

	9.*	STUDENT TALK - INITIATION: Talk initiated by students. The ideas expressed are created by students: statement content not easily predicted by previous action of teacher.
SILENCE OR CONFUSION	10.*	NONE OF ABOVE: Routine administrative comments, silence or confusion; interaction not related to learning activities.

* NOTE: The category numbers are purely nominal, no scale is implied.

TABLE 20

OBSERVER TALLY SHEET

Teacher________________________ Date____________ Observer____________

TABLE 21

OBSERVATION MATRIX

Class Code ____________ Date__________ Observer____________________

Remarks____

____

	1	2	3	4	5	6	7	8	9	10	Total
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
Totals											
%											
of											
Totals	Teacher total							Student total		Silence	

TABLE 22

SCIENCE TEACHING OBSERVATIONAL INSTRUMENT CATEGORIES

Teacher__________ Date________ Observer__________

Remarks______________________________

QUESTION TYPES	NUMBER OF QUESTIONS ASKED	% OF TOTAL
1. RECALL FACTS Teacher asks any simple factual question. She appears to expect only information.		
2. SEE RELATIONSHIPS Students must relate facts, but without going much beyond given facts.		
3. MAKE OBSERVATION Students must observe some ongoing activity and report sense data.		
4. HYPOTHESIZE Student asked to reason out or guess an answer which is not given as an immediate fact.		
5. TEST HYPOTHESIS Student is asked to validate or test answer, fact, or hypothesis.		
Total number of questions asked		

TABLE 23

RAW SCORE FREQUENCIES OF TWO GROUPS
OF ELEMENTARY SCHOOL TEACHERS ON THE SCIENCE PROCESS
TEST FOR ELEMENTARY SCHOOL TEACHERS

Michigan-Maryland Teachers		SCIS Teachers			
Number 103 Summer-1968		Number 16 Summer-1968		Number 16 Spring-1969	
Raw Score	Frequency	Raw Score	Frequency	Raw Score	Frequency
31	2	29	1	25	3
29	5	26	2	24	3
28	6	25	1	21	4
27	7	24	1	19	1
26	7	23	2	18	1
25	7	22	2	16	2
24	7	21	1	14	1
23	11	20	1	6	1
22	3	19	1		
21	4	18	1		
20	9	16	2		
19	7	5	1		
18	3				
17	3				
16	8				
15	2				
14	3				
13	2				
12	1				
11	2				
10	1				
9	1				
5	1				
4	1				

SCIENCE PROCESS TEST

for

ELEMENTARY SCHOOL TEACHERS
(3rd Revised Edition)

DIRECTIONS: Choose the response that is most correct and mark its corresponding number on the IBM Scoring Sheet. Be sure your name, student number, and course number are completed on the Answer Sheet.

DO NOT MARK IN THE TEST BOOKLET

Items 1-11 are concerned with an experiment on behavior in mealworms. In this experiment a Q-tip was used. This is a small stick with a bit of cotton firmly attached to the end.

A Q-tip saturated with water was thrust near a mealworm. The mealworm backed up.

1. The hypothesis which was best tested in the above experiment is:

    (1) Mealworms are sensitive to water.
    (2) Mealworms can see objects moving toward them.
    (3) Mealworms are sensitive to (or will react to) a Q-tip saturated with water.
    (4) None of the above hypotheses were tested.

2. At this stage there is most justification for saying that

    (1) the mealworm responded negatively to water.
    (2) the mealworm could see an object moving towards it.
    (3) the mealworm responded to moist approaching cotton.
    (4) mealworms do not like to be disturbed.
    (5) mealworms will respond negatively to anything foreign to their environment.

3. The experimental variable in this experiment was

    (1) the mealworm.
    (2) the Q-tip.
    (3) the water.
    (4) the habitat of the mealworm.
    (5) none of the above.

4. How could the initial aspect of this experiment be improved?

    (1) Use a larger piece of cotton and more water.
    (2) Use 15-30 mealworms, one at a time.
    (3) Run 15-30 trials on successive days using a single mealworm.
    (4) Do both (1) and (2) above.
    (5) Do both (2) and (3) above.

The experiment described above was extended by testing the single mealworm with 30 trials with the following results: The mealworm

    (a) backed up 10 times.
    (b) went sideways 2 times.
    (c) advanced 10 times.
    (d) gave no observable reaction 10 times.

5. In this series of experiments the control (constant factor) was

    (1) the water.
    (2) the Q-tip.
    (3) the temperature.
    (4) the habitat of the mealworm.
    (5) none of the above.

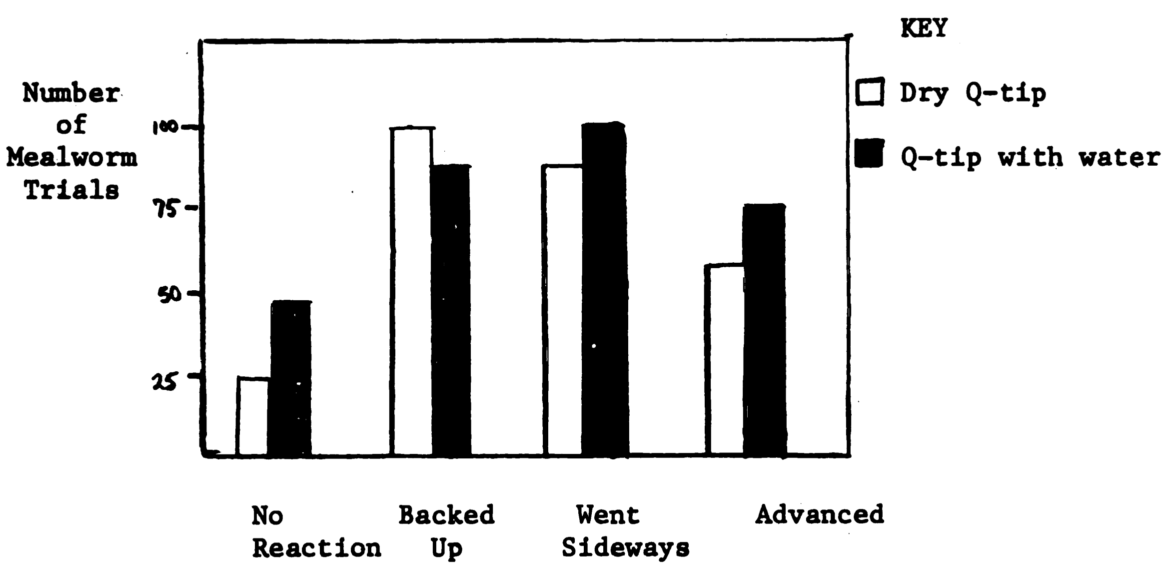
6. Based upon this and the preceding data, the best interpretation of these results would be that

    (1) this mealworm was getting tired.
    (2) this mealworm will move away from a Q-tip.
    (3) this mealworm is usually sensitive to (reacts to) the moving Q-tip.
    (4) this mealworm is usually sensitive to (reacts to) the water on the moving Q-tip.
    (5) both (2) and (4) above are correct.

7. In this series of experiments there was an experimental variable. The experimental variable was

    (1) the water.
    (2) the Q-tip.
    (3) the mealworm.
    (4) the habitat of the mealworm.
    (5) none of the above.

The following graph shows the reaction of several mealworms, each used separately, over a large number of trials using alternately a dry Q-tip and a Q-tip saturated with water.



8. If you approached a mealworm with a dry Q-tip, the best prediction that you could make based upon the above data would be:

    (1) the mealworm would not react to the stimulus.
    (2) the mealworm would go sideway from the stimulus.
    (3) the mealworm would advance toward the stimulus.
    (4) the mealworm would back away from the stimulus.
    (5) either (2) or (4).

9. The best interpretation that can be made based upon the data in the chart is that

   (1) mealworms see Q-tips.
   (2) mealworms are sensitive to water on Q-tips.
   (3) mealworms are sensitive to Q-tips thrust at them.
   (4) mealworms are not sensitive to wet Q-tips.
   (5) none of the above interpretations can be accurately made.

10. Refer to the chart. What is the average of the combined number of trials in which a mealworm reacted negatively, that is, backed-up or went sideways?

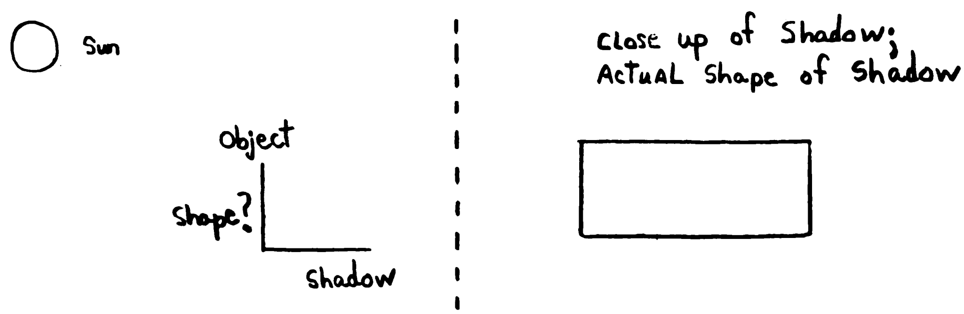
   (1) greater than 150.
   (2) less than 60.
   (3) between 40 and 50.
   (4) between 75 and 100.
   (5) between 100 and 150.

11. Which of the following hypotheses was best checked by the experiment shown in the chart?

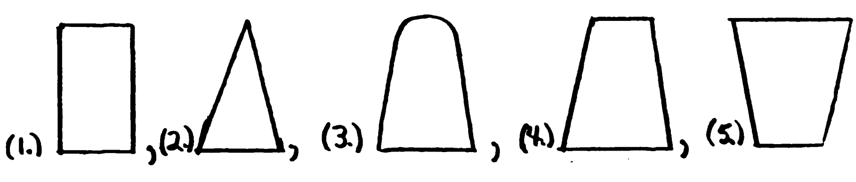
   (1) mealworms will react to Q-tips.
   (2) mealworms will react to water on a Q-tip.
   (3) mealworms will respond negatively to anything foreign to their environment.
   (4) mealworms will respond to any moving object.
   (5) none of the above hypotheses were checked in this series of experiments.

- -

12. The following type of shadow was observed cast by an object in bright sun light in the approximate position shown in the diagram.

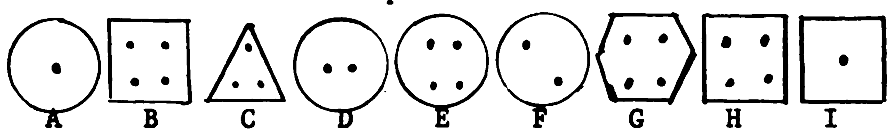


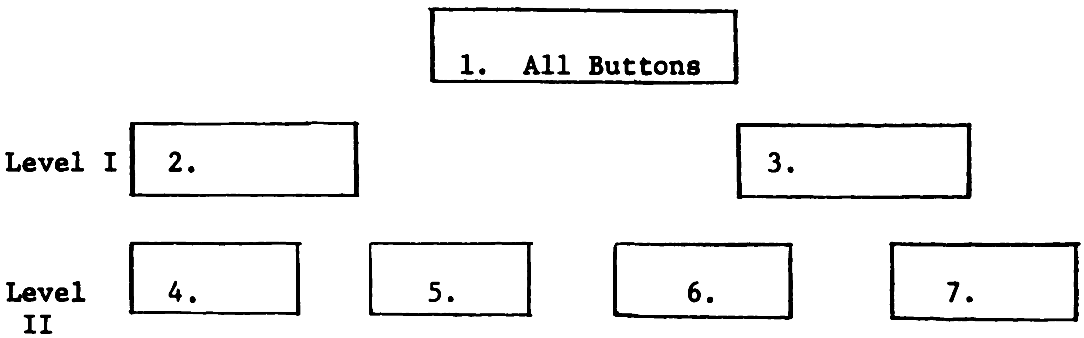
Which of the following objects could have cast a shadow in that given situation? NOTE: The view of the object is that side (or front) view toward the sun.



Items 13-17 are concerned with the classification of buttons.

The following button shapes are to be classified using the chart below. The dots represent holes.





Classification Chart

13. Which of the following would be the best observable characteristic to use to classify the buttons at Level I.

    (1) roundness vs. number of holes.
    (2) squareness vs. number of holes.
    (3) one hole vs. two holes.
    (4) one-holed vs. not one hole.
    (5) roundness vs. squareness.

14. If only buttons H, I & B are to be classified into box 3, what are the characteristics of the buttons in box 2?

    (1) round, triangular.
    (2) round, non-square.
    (3) round, non-round.
    (4) all buttons with less than four holes.
    (5) round.

15. If only buttons H, I & B are in box 3, and if some round buttons are found in box number 4 of Level II, what is (are) the characteristic(s) of all buttons found in box number 2 of this key?

    (1) round and one hole.
    (2) round and more than one hole.
    (3) not square.
    (4) square less than four holes.
    (5) both round and square.

16. Based upon the information in the preceding question number 15, what is the characteristic to be found in Level II box number 5 of the classification key?

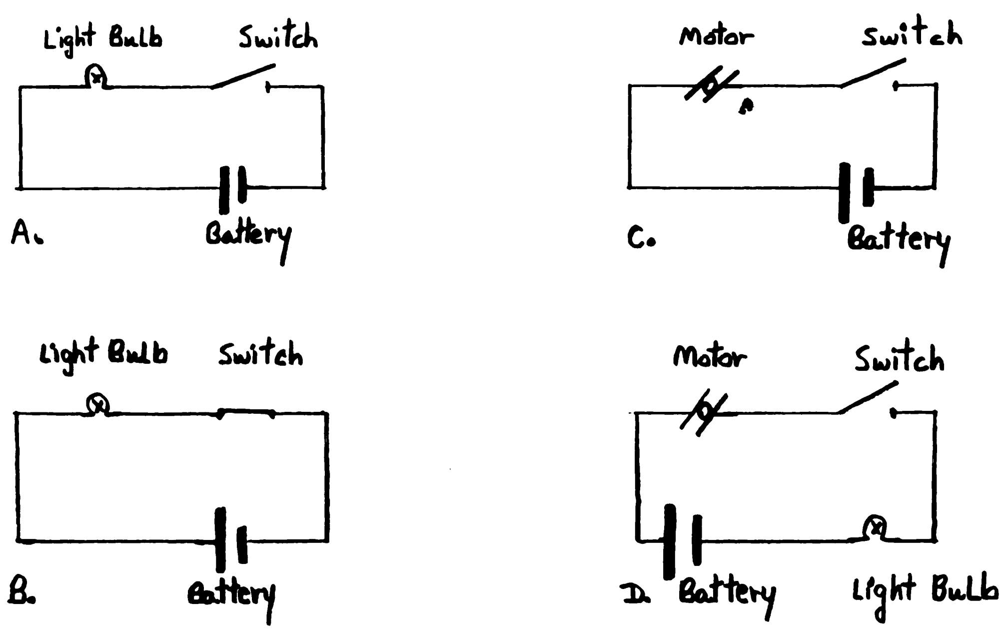
    (1) not round and more than one hole.
    (2) round and more than one hole.
    (3) square.
    (4) round and one hole.
    (5) not round and one hole.

17. Based upon the information in the preceding question number 16, what buttons would be classified in box number 5 of Level II of the key?

    (1) A
    (2) B, C, G, H
    (3) D, E, F
    (4) C, G
    (5) B, H, I

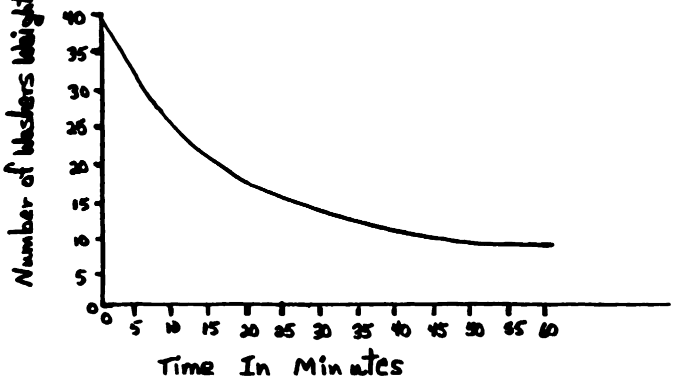
---

18. Which of the following diagrams would represent a circuit in which the light and/or the motor would operate. The battery is of a high enough voltage that it will operate the above mentioned items.



    (1) Diagram A
    (2) Diagram B
    (3) Diagram C
    (4) Diagram D

19. The following graph was plotted on the amount of evaporation from a wet paper towel over a period of time. The relative humidity was 40%.

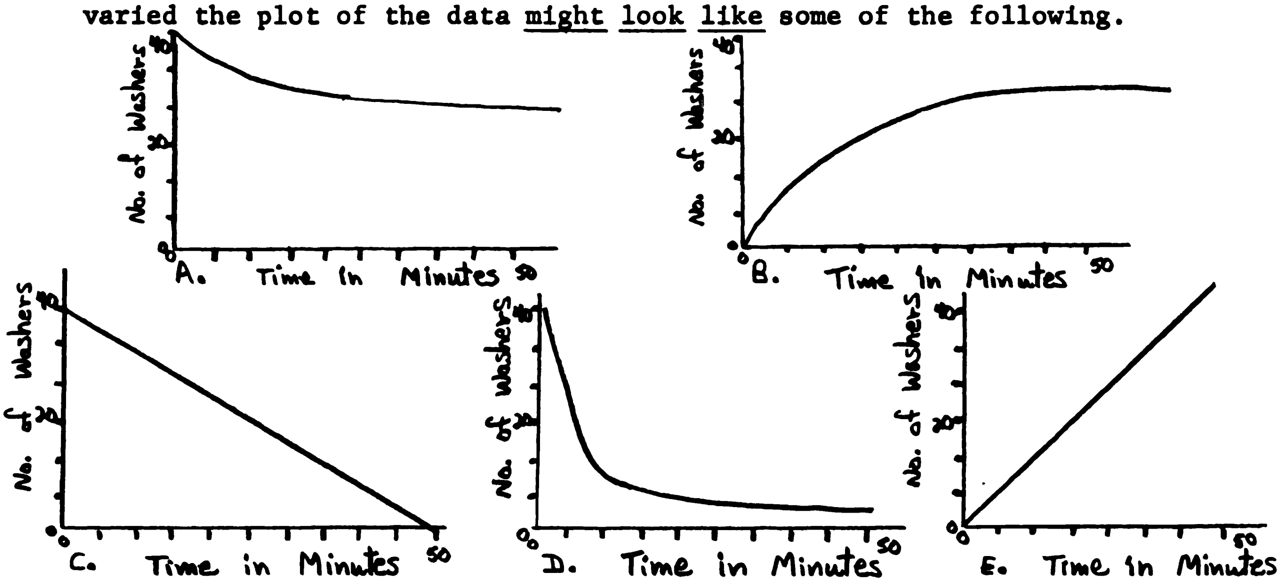


Based upon the data in the graph one could best conclude that more water evaporated.

(1) between 0 and 10 minutes.
(2) between 10 and 20 minutes.
(3) between 20 and 30 minutes.
(4) between 30 and 40 minutes.
(5) after 40 minutes.

Items 20 - 21 are concerned with the following information.

In preceding experiment in question 19, if certain conditions were varied the plot of the data <u>might</u> <u>look</u> <u>like</u> some of the following.



20. On a dry day the results might best be represented by

(1) chart A.
(2) chart B.
(3) chart C.
(4) chart D.
(5) chart E.

21. If a larger paper towel was used and the day was humid the data could best be represented by

(1) chart A.
(2) chart B.
(3) chart C.
(4) chart D.
(5) chart E.

- -

Items 22-26 are concerned with the following chemical test.
Certain chemical tests were conducted as follows. A series of powders (solids) were checked with a series of liquids with the following results:

POWDERS	A	B	C
LIQUIDS 1	RX	RX	NR
2	RX	RX RY	RY
3	NR	RY	RY

KEY: RX = Bubbled
RY = Turned green
NR = No reaction

22. In an experiment in which one wishes to determine what an unknown chemical substance consists of, what is the purpose of running a series of tests on known substances which may be the unknown substances.

(1) to establish an experimental variable.
(2) to establish an unknown variable.
(3) to check on known variables.
(4) both (2) and (3) above.
(5) both (1) and (3) above.

23. From the results indicated in the chart, one can conclude that:

(1) substance A and B are the same chemical substance.
(2) substance B contains some of substance A.
(3) substance A contains some of substance B.
(4) substance A contains some of substance C.

24. One can conclude from these chemical tests that:

(1) Liquids 1, 2, and 3 are unique.
(2) Liquids 1 and 2 are unique.
(3) Liquids 1 and 2 are the same.
(4) Liquid 2 contains some of liquid 1 and 3.
(5) Liquid 3 contains some of liquid 1.

25. If one was given an unknown which was tested with a mixture of liquid No. 1, and No. 3 and the only observed reaction was Ry, what could you conclude about the composition of the unknown substance:

    (1) that it was the same as substance A.
    (2) that it was the same as substance B.
    (3) that it may have contained some of substance B.
    (4) that it may have contained some of substance C.
    (5) that it may have contained some of substance A.

26. In using the chemical test of question 23 as a basis of conclusions for question 25, we have used the chemical tests in question 23 as:

    (1) Unknowns.
    (2) Controls.
    (3) Uncontrolled variables.
    (4) None of the above.

- -

Items 27-28 are concerned with the following experiment on the growth of bean seeds.
An experiment was conducted in fourth grade on the growth of bean seeds. The pupils measured the plants three days to determine the amount of growth. The rate of growth was defined as the average of all plants growth every three days. The class wanted to place a graph of this on their bulletin board.

27. What type of measuring factor were they using when they translated rate of growth measure to a graph?

    (1) Scalar.
    (2) preditive measurement.
    (3) vector measurement.
    (4) both (2) and (3).
    (5) None of the above.

28. The average of the measured growth for four measuring periods was: 1/2", 3/4", 1", 1 1/4". What is the ratio they would use if the first measurement is to be translated into 1" on the graph.

    (1) 1 1/2 to 1.
    (2) 1 to 2.
    (3) 2 to 1.
    (4) 1/2 to 2.
    (5) 4 to 2.

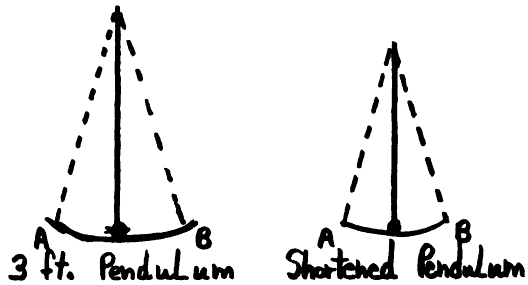
- -

29. Which of the following diagrams are symmetrical?

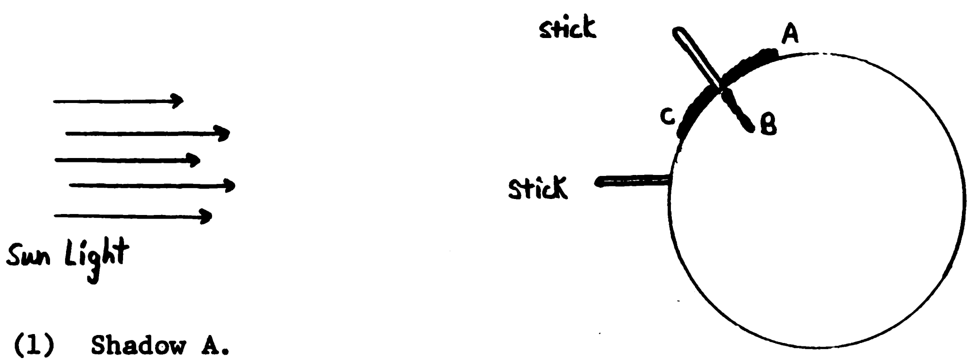
(1) A
(2) A & B
(3) A & C
(4) A, B, and C.
(5) A, B, and D.

30. An elementary science class is studying the phenomena of a swinging pendulum. They set up a pendulum 3 ft. long. If it took time x to swing through arc (distance) A to B, see drawing below, what would be the rate of time needed to cover the same arc if the pendulum was shortened?

(1) increased.
(2) decreased.
(3) remain the same.
(4) insufficient evidence.



31. The following is a diagram of an experiment conducted by John Brown. He was to find out whether the top stick in the diagram would cast a shadow and if so where would the shadow fall. The bottom stick is set up such that the shadow is at a minimum at its base. Both rods are perpendicular to the sphere and on the same longitude line. Examine the diagram and then predict in which of the three positions labeled A, B, C the top stick would cast its shadow.



(1) Shadow A.
(2) Shadow B.
(3) Shadow C.
(4) It would cast a shadow in a position not labeled A, B, or C.

32. The best Operational definitions of the area of this paper is:

    (1) how many one-inch blocks will fill it.
    (2) how large it is.
    (3) how many one-inch squares will cover its surface.
    (4) both (1) and (2) above.
    (5) both (1) and (3) above.

33. Mrs. Smith's class was studying science when the word porosity appeared. Mrs. Smith had prepared illustrations to aid the students understanding of the word. The illustrations were as follows:

    A. Took a box of marbles and poured one cup of sand over the marbles before the box was entirely full.
    B. Took a jar of sand and added one pint of water before the water was ready to spill over the edge of the jar.

    Probably the best operational definition of the word porosity would be?

    (1) The amount of solid you can add to a loosely packed solid without changing the volume.
    (2) The amount of liquid or solid that can occupy the spaces between liquid or solid particles without changing the volume.
    (3) The amount of liquid that can be added to a solid without changing the volume.
    (4) The amount of liquid or solid that can be added to a loosely packed solid without changing the volume.

34. Select one of the following as the best operational definition of density

    (1) The amount of matter in 1 gram of lead.
    (2) 10 cubic centimeters of substance weighing 5 grams.
    (3) The volume of water displaced by an immersed body, as compared to its mass.
    (4) The mass of an object compared to its weight.

35. The selection of the answer in question 34 is based upon

    (1) Numerical factors of a specific density.
    (2) What to do and what to observe in determining density.
    (3) How much something weighs.
    (4) None of the above.

36. When a student uses a series of small washers in one pan to counter balance a penny in a 2-pan level arm balance, he is:

    (1) deriving his own measurement scale.
    (2) substituting washers for gram weight.
    (3) using the gram as a unit of weight.
    (4) doing (1) and (2).
    (5) doing (1) and (3).

37. A candle goes out when a closed glass jar is inserted over it. Which of the following can we conclude from the information given.

    (1) Oxygen is required for burning.
    (2) The air was all used up.
    (3) The candle no longer has enough of something to continue burning.
    (4) Candles burn oxygen.
    (5) Both (1) and (4).

38. A classification system can be based upon:

    (1) Structural similarities.
    (2) Structural differences.
    (3) Functional similarities.
    (4) Both (1) and (2) above.
    (5) (1), (2), and (3), above.

39. Prediction is used in science learning activities because it allows us to

    (1) go from the unknown to known.
    (2) go from the known to unknown.
    (3) to make judgment on very little evidence.
    (4) Both (1) and (3).

40. The concept of measurement

    (1) is limited to area and volume.
    (2) may involve arbitrarily chosen units.
    (3) is limited to length and weight.
    (4) does not involve time.
    (5) both (1) and (3).

APPENDIX B

SUMMARY OF DATA ANALYZED FOR BOTH THE SCIS TEACHERS AND THOSE TEACHERS USING CONVENTIONAL SCIENCE TEACHING METHODS AND MATERIALS

APPENDIX B

SUMMARY OF DATA ANALYZED FOR BOTH THE SCIS TEACHERS AND THOSE TEACHERS USING CONVENTIONAL SCIENCE TEACHING METHODS AND MATERIALS

TABLE 24

ID RATIOS OF THOSE SIXTEEN TEACHERS USING SCIS TEACHING METHODS AND MATERIALS

Teacher Number	Observation Times				
	T_1	T_2	T_3	T_4	T_5
1.	1.11	6.30	1.36	0.65	4.39
2.	2.10	4.35	3.50	1.48	1.96
3.	1.19	0.46	0.76	1.78	1.20
4.	0.76	0.70	0.46	0.43	0.44
5.	3.17	0.87	1.16	2.07	1.12
6.	0.87	0.88	0.88	1.29	0.72
7.	0.88	2.68	1.69	1.84	1.29
8.	1.04	0.77	0.91	0.44	0.24
9.	1.99	4.42	0.60	1.42	0.79
10.	3.32	3.00	1.42	0.91	1.40
11.	1.86	1.50	1.00	1.50	3.33
12.	1.64	2.64	0.75	0.52	1.70
13.	1.67	0.78	2.82	1.00	1.20
14.	1.91	0.36	0.69	1.10	1.49
15.	2.21	1.04	0.67	1.46	0.64
16.	0.98	2.34	1.50	0.75	1.98

TABLE 25

ID RATIOS OF THOSE SIXTEEN TEACHERS USING CONVENTIONAL SCIENCE TEACHING METHODS AND MATERIALS

Teacher Number	Observation Times	
	T_1	T_2
1.	3.40	4.00
2.	4.30	9.50
3.	5.80	1.90
4.	.74	.58
5.	.79	2.80
6.	1.60	2.10
7.	1.04	.52
8.	.52	1.10
9.	.67	.32
10.	.55	.48
11.	2.00	2.37
12.	.83	.90
13.	.73	.36
14.	.57	1.10
15.	.42	.48
16.	.98	1.10

TABLE 26

PERCENTAGE OF TEACHER TALK IN THOSE SIXTEEN CLASSROOMS
USING SCIS TEACHING METHODS AND MATERIALS

Classroom Number	Observation Times				
	T_1	T_2	T_3	T_4	T_5
1.	43.7	36.7	58.8	53.8	60.0
2.	56.8	29.8	29.5	43.9	26.0
3.	56.2	8.2	39.2	36.0	50.0
4.	32.75	58.2	59.7	46.4	52.8
5.	69.6	35.8	49.5	48.1	40.9
6.	45.1	57.8	45.4	50.0	57.8
7.	62.2	57.7	50.2	49.0	32.8
8.	37.7	76.8	52.9	47.4	48.3
9.	48.0	56.1	40.3	45.6	28.0
10.	48.6	43.4	50.9	49.0	43.1
11.	28.9	48.4	43.0	48.7	52.8
12.	66.8	61.2	35.0	39.9	44.0
13.	15.4	40.0	49.7	37.9	49.3
14.	42.0	56.7	59.9	47.4	55.9
15.	44.4	44.6	52.6	59.3	58.3
16.	65.3	47.6	50.6	44.2	52.3

TABLE 27

PERCENTAGE OF TEACHER TALK IN THOSE SIXTEEN CLASSROOMS USING CONVENTIONAL SCIENCE TEACHING METHODS AND MATERIALS

Teacher Number	Observation Times	
	T_1	T_2
1.	63.3	55.1
2.	43.7	36.7
3.	59.4	50.1
4.	32.4	34.8
5.	55.0	48.0
6.	44.7	46.1
7.	49.8	27.8
8.	58.0	63.0
9.	49.9	44.0
10.	58.6	49.3
11.	54.8	56.3
12.	64.2	61.6
13.	66.0	62.7
14.	53.0	60.8
15.	68.2	59.0
16.	48.5	41.9

TABLE 28

PERCENTAGE OF STUDENT TALK IN THOSE SIXTEEN CLASSROOMS
USING SCIS TEACHING METHODS AND MATERIALS

Classroom Number	Observation Times				
	T_1	T_2	T_3	T_4	T_5
1.	36.9	62.0	38.0	23.4	37.3
2.	38.3	68.9	79.4	54.4	68.8
3.	31.5	88.4	53.3	55.4	31.9
4.	44.5	29.7	18.5	35.7	37.5
5.	23.9	62.6	48.4	49.6	54.2
6.	47.1	37.7	46.8	48.0	39.5
7.	28.7	40.1	43.2	34.2	66.6
8.	52.2	58.5	49.0	51.5	51.0
9.	46.1	27.2	57.6	46.2	71.4
10.	39.3	47.3	48.2	50.2	54.1
11.	29.2	50.8	56.3	50.4	46.3
12.	25.7	38.4	18.8	53.8	55.5
13.	65.7	58.4	47.8	61.9	49.9
14.	35.9	42.6	38.2	51.4	42.8
15.	51.3	53.0	32.7	38.2	38.6
16.	28.8	45.8	48.2	46.4	45.8

TABLE 29

PERCENTAGE OF STUDENT TALK IN THOSE SIXTEEN CLASSROOMS USING CONVENTIONAL SCIENCE TEACHING METHODS AND MATERIALS

Classroom Number	Observation Times T_1	Observation Times T_2
1.	33.1	42.5
2.	56.5	62.9
3.	34.6	41.1
4.	66.0	63.3
5.	43.2	50.0
6.	51.8	52.7
7.	46.0	19.1
8.	36.8	36.2
9.	47.2	54.3
10.	35.7	38.5
11.	44.2	43.0
12.	30.7	31.0
13.	22.7	23.5
14.	46.0	38.8
15.	24.6	37.8
16.	23.6	34.0

TABLE 30

PERCENTAGE OF CONTINUOUS STUDENT COMMENT
IN THOSE SIXTEEN CLASSROOMS USING SCIS
TEACHING METHODS AND MATERIALS

Classroom Number	Observation Times				
	T_1	T_2	T_3	T_4	T_5
1.	17.5	35.4	17.4	5.5	9.9
2.	11.9	36.0	52.5	38.7	55.8
3.	13.9	83.7	37.1	37.4	12.4
4.	29.8	10.6	8.0	16.9	10.1
5.	7.8	45.9	34.8	27.9	37.5
6.	30.8	16.1	27.1	20.5	10.8
7.	19.4	22.6	22.9	14.3	46.5
8.	31.9	36.2	20.0	32.2	29.7
9.	25.9	11.3	32.6	25.9	56.7
10.	23.8	21.7	15.1	22.0	26.4
11.	15.5	27.1	33.8	21.2	15.0
12.	19.6	16.4	8.1	54.9	27.8
13.	52.2	37.8	22.4	46.6	26.6
14.	17.5	24.9	18.0	27.1	17.6
15.	32.7	36.8	17.0	11.9	10.6
16.	16.9	26.8	27.7	30.4	25.0

TABLE 31

PERCENTAGE OF CONTINUOUS STUDENT COMMENT IN THOSE CLASSROOMS USING CONVENTIONAL SCIENCE TEACHING METHODS AND MATERIALS

Classroom Number	Observation Times	
	T_1	T_2
1.	8.2	11.7
2.	26.8	34.5
3.	15.7	12.1
4.	46.2	37.7
5.	17.2	16.2
6.	21.2	21.2
7.	22.6	5.8
8.	14.7	8.4
9.	19.9	29.6
10.	11.9	23.5
11.	13.3	10.4
12.	5.6	6.8
13.	2.3	6.5
14.	22.6	10.8
15.	6.3	11.3
16.	4.7	9.9

APPENDIX C

DATA COLLECTED ON TEACHER QUESTION TYPE PREFERENCES

APPENDIX C

DATA COLLECTED ON TEACHER QUESTION TYPE PREFERENCES

TABLE 32

PERCENTAGE OF QUESTION TYPE PREFERENCES FOR THOSE SIXTEEN TEACHERS USING SCIS TEACHING METHODS AND MATERIALS

Teacher Number	Question Types	Observation Times				
		T_1	T_2	T_3	T_4	T_5
1.	recall facts	83.0	15.4	24.5	17.9	62.7
	see relationships	4.2	0.0	15.1	7.1	3.0
	make observation	13.9	65.4	47.2	60.7	23.5
	hypothesize	0.0	19.2	13.2	14.3	11.8
	test hypothesis	0.0	0.0	0.0	0.0	0.0
2.	recall facts	59.8	28.3	70.0	16.7	3.1
	see relationships	26.8	28.3	0.0	12.5	9.4
	make observation	23.4	43.5	30.0	66.7	78.1
	hypothesize	0.0	0.0	0.0	4.7	9.4
	test hypothesis	0.0	0.0	0.0	0.0	0.0
3.	recall facts	80.8	100.0	0.0	33.3	15.0
	see relationships	15.4	0.0	0.0	28.6	2.5
	make observation	3.8	0.0	88.9	38.1	77.5
	hypothesize	0.0	0.0	5.6	0.0	5.0
	test hypothesis	0.0	0.0	5.6	0.0	0.0
4.	recall facts	77.8	19.5	22.2	76.9	76.0
	see relationships	0.0	2.4	11.1	3.8	16.0
	make observation	22.2	65.9	55.6	15.4	0.0
	hypothesize	0.0	4.9	11.1	3.8	8.0
	test hypothesis	0.0	7.3	0.0	0.0	0.0
5.	recall facts	36.5	43.5	13.0	27.9	25.0
	see relationships	6.8	4.4	4.3	0.0	5.0
	make observation	55.9	47.8	60.9	62.8	42.5
	hypothesize	0.9	4.4	17.4	9.3	10.0
	test hypothesis	0.0	0.0	4.3	0.0	17.5

TABLE 32--Continued

Teacher Number	Question Types	Observation Times T_1	T_2	T_3	T_4	T_5
6.	recall facts	90.8	21.9	12.1	33.3	60.7
	see relationships	7.9	3.1	0.0	17.9	10.7
	make observation	1.3	56.2	69.7	38.5	17.9
	hypothesize	0.0	18.7	18.2	10.3	10.7
	test hypothesis	0.0	0.0	0.0	0.0	0.0
7.	recall facts	83.3	17.8	26.3	24.2	54.8
	see relationships	6.3	32.9	2.6	0.0	3.2
	make observation	10.4	38.3	56.6	65.2	19.3
	hypothesize	0.0	1.4	11.8	10.6	22.6
	test hypothesis	0.0	9.6	2.6	0.0	0.0
8.	recall facts	99.0	34.8	20.7	7.4	90.0
	see relationships	1.0	6.1	10.3	0.0	16.0
	make observation	0.0	59.1	58.6	55.6	0.0
	hypothesize	0.0	0.0	10.3	37.0	0.0
	test hypothesis	0.0	0.0	0.0	0.0	0.0
9.	recall facts	96.9	35.2	15.6	6.0	35.7
	see relationships	3.2	17.1	0.0	0.0	7.1
	make observation	0.0	47.7	65.6	88.0	35.7
	hypothesize	0.0	0.0	15.6	2.0	21.5
	test hypothesis	0.0	0.0	3.1	4.0	0.0
10.	recall facts	71.6	15.4	56.3	45.2	59.1
	see relationships	5.6	3.8	15.6	3.2	9.1
	make observation	22.7	73.1	21.9	48.4	31.8
	hypothesize	0.0	7.7	6.3	3.2	0.0
	test hypothesis	0.0	0.0	0.0	0.0	0.0
11.	recall facts	25.0	50.0	36.8	33.3	18.3
	see relationships	16.7	5.9	5.3	20.8	12.0
	make observation	58.3	44.1	57.9	41.7	60.2
	hypothesize	0.0	0.0	0.0	4.2	8.6
	test hypothesis	0.0	0.0	0.0	0.0	0.0
12.	recall facts	52.6	27.9	0.0	30.0	40.0
	see relationships	17.1	16.3	28.6	10.0	6.0
	make observation	15.8	53.5	0.0	40.0	36.0
	hypothesize	7.9	2.3	57.1	20.0	18.0
	test hypothesis	6.6	0.0	14.3	0.0	0.0

TABLE 32--Continued

Teacher Number	Question Types	Observation Times				
		T_1	T_2	T_3	T_4	T_5
13.	recall facts	100.0	33.3	22.4	34.3	27.3
	see relationships	0.0	0.0	24.5	11.5	4.5
	make observation	0.0	41.7	42.9	28.6	18.2
	hypothesize	0.0	25.0	10.2	17.1	45.5
	test hypothesis	0.0	0.0	0.0	8.6	4.5
14.	recall facts	82.0	57.1	21.7	13.7	25.6
	see relationships	4.1	14.3	6.5	3.0	25.6
	make observation	13.5	21.4	50.0	15.7	33.3
	hypothesize	0.0	7.1	21.7	68.6	15.4
	test hypothesis	0.0	0.0	0.0	0.0	0.0
15.	recall facts	85.5	9.1	21.2	33.3	57.1
	see relationships	11.6	12.5	0.0	2.2	14.3
	make observation	1.0	46.4	78.8	64.4	28.6
	hypothesize	2.0	25.0	0.0	0.0	0.0
	test hypothesis	0.0	7.1	0.0	0.0	0.0
16.	recall facts	57.8	17.9	29.3	57.1	23.7
	see relationships	15.9	7.1	2.4	4.8	2.6
	make observation	26.4	75.0	41.5	19.0	42.1
	hypothesize	0.0	0.0	7.3	19.0	26.3
	test hypothesis	0.0	0.0	19.5	0.0	5.3

TABLE 33

PERCENTAGE OF QUESTION TYPE PREFERENCES FOR THOSE SIXTEEN TEACHERS USING CONVENTIONAL SCIENCE TEACHING METHODS AND MATERIALS

Teacher Number	Question Types	Observation Times	
		T_1	T_2
1.	recall facts	24.8	64.0
	see relationships	33.7	21.9
	make observations	35.6	1.6
	hypothesize	5.9	12.5
	test hypothesis	0.0	0.0
2.	recall facts	90.2	14.3
	see relationships	9.8	0.0
	make observations	0.0	20.2
	hypothesize	0.0	26.2
	test hypothesis	0.0	0.0
3.	recall facts	47.0	30.3
	see relationships	53.0	5.0
	make observations	0.0	62.6
	hypothesize	0.0	2.0
	test hypothesis	0.0	0.0
4.	recall facts	100.0	100.0
	see relationships	0.0	0.0
	make observations	0.0	0.0
	hypothesize	0.0	0.0
	test hypothesis	0.0	0.0
5.	recall facts	83.4	98.2
	see relationships	16.7	1.8
	make observations	0.0	0.0
	hypothesize	0.0	0.0
	test hypothesis	0.0	0.0
6.	recall facts	97.6	93.8
	see relationships	2.4	6.2
	make observations	0.0	0.0
	hypothesize	0.0	0.0
	test hypothesis	0.0	0.0
7.	recall facts	95.9	87.0
	see relationships	4.0	0.0
	make observations	0.0	13.0
	hypothesize	0.0	0.0
	test hypothesis	0.0	0.0

TABLE 33--Continued

Teacher Number	Question Types	Observation Times	
		T_1	T_2
8.	recall facts	57.1	89.3
	see relationships	3.6	7.7
	make observations	35.7	3.0
	hypothesize	3.6	0.0
	test hypothesis	0.0	0.0
9.	recall facts	100.0	100.0
	see relationships	0.0	0.0
	make observations	0.0	0.0
	hypothesize	0.0	0.0
	test hypothesis	0.0	0.0
10.	recall facts	97.2	100.0
	see relationships	2.8	0.0
	make observations	0.0	0.0
	hypothesize	0.0	0.0
	test hypothesis	0.0	0.0
11.	recall facts	87.0	78.0
	see relationships	11.1	18.0
	make observations	0.0	2.0
	hypothesize	1.9	2.0
	test hypothesis	0.0	0.0
12.	recall facts	89.2	83.0
	see relationships	10.8	6.4
	make observations	0.0	10.6
	hypothesize	0.0	0.0
	test hypothesis	0.0	0.0
13.	recall facts	100.0	100.0
	see relationships	0.0	0.0
	make observations	0.0	0.0
	hypothesize	0.0	0.0
	test hypothesis	0.0	0.0
14.	recall facts	78.4	85.5
	see relationships	2.7	4.8
	make observations	18.9	6.5
	hypothesize	0.0	3.2
	test hypothesis	0.0	0.0

TABLE 33--Continued

Teacher Number	Question Types	Observation Times	
		T_1	T_2
15.	recall facts	93.9	97.8
	see relationships	6.0	0.0
	make observations	0.0	2.2
	hypothesize	0.0	0.0
	test hypothesis	0.0	0.0
16.	recall facts	52.4	86.7
	see relationships	9.5	6.7
	make observations	26.2	2.2
	hypothesize	11.9	4.4
	test hypothesis	0.0	0.0

APPENDIX D

COVER LETTERS

APPENDIX D

COVER LETTERS

MICHIGAN STATE UNIVERSITY East Lansing · Michigan 48823

Science and Mathematics Teaching Center · McDonel Hall

This letter reaches your desk with the hope that you might be willing to assist me in a proposed doctoral study that will be conducted through Michigan State University. I am a graduate teaching assistant employed by the Science and Mathematics Teaching Center, and have been assisting Dr. Glenn Berkheimer in the implementation of the Science Curriculum Improvement Study in selected school districts this year.

I am quite interested in the possible effects that the introduction of the Science Curriculum Improvement Study might have in changing elementary school teachers' procedures during science activities. With your permission I would like to visit your classroom on two separate occasions this spring, and on two additional occasions next fall, after your participation in this summer's SCIS workshop has been completed. These visitations would only be during science activities and would last approximately thirty minutes each. I will bring a small, portable tape recorder so that I may better analyze verbal comments between the children and the teacher.

I sincerely hope that you will lend me your assistance in this study. I am enclosing a post card that can be used as a reply. I could visit your classroom whenever it would be most convenient for you. I can be reached at the Science and Mathematics Teaching Center or at my home telephone number, 676-2797 (Mason) if you have any questions that need clarification. I look forward to your reply.

Sincerely,

Thomas C. Moon
E 37 McDonel Hall
Michigan State University
East Lansing, Michigan 48823

TM:bj

Enclosure

MICHIGAN STATE UNIVERSITY East Lansing · Michigan 48823

Science and Mathematics Teaching Center · McDonel Hall

March 6, 1969

I wish to personally thank you for allowing me the opportunity to visit your classroom recently during science lessons. The taped recordings I obtained gave me a closer insight into the types of comments children make during these types of activities.

Thank you for your kind assistance.

Sincerely,

Tom Moon
E-37 McDonel Hall