ABSTRACT

A DETERMINATION OF THE RELATIONSHIPS AMONG SCIS TEACHERS' PERSONALITY TRAITS, ATTITUDE TOWARD TEACHER-PUPIL RELATIONSHIP, UNDERSTANDING OF SCIENCE PROCESS SKILLS AND QUESTION TYPES

By

Larry Rhea Bruce

The purpose of this study was to examine the extent of relationships that exist among teacher personality factors, science process skills, attitude toward the teacher-pupil relationship, and the verbal characteristic of question asking. The population consisted of 33 elementary school teachers who had volunteered to participate in a 3-week SCIS workshop held at Michigan State University during the summer of 1968. These teachers further agreed to teach the SCIS program in their respective classrooms.

Fifteen of the teachers were observed during the spring of 1968 prior to their formal involvement in the SCIS program. Their science lessons were taped on a small cassette-type tape recorder. The entire population of SCIS teachers was observed after formal involvement in

the program, and a total of 229 lessons was taped. Each of the tapes was analyzed to determine the kinds of questions asked by the teacher during the lesson. The questions were categorized as follows: recognition, recall of fact, demonstration of skill, comprehension, analysis, and synthesis. The proportion of question types asked by each teacher was calculated. Each teacher was observed an average of seven times during formal involvement in the program.

The instruments used to measure attitude, personality and understanding of the processes of science were: the 16 Personality Factor Questionnaire, Minnesota Teacher Attitude Inventory, and the Science Process Test for Elementary Teachers.

The attitude inventory and the process test were administered during the summer workshop and again in April, 1969.

The pertinent findings of this study were:

1. There was a significant difference in the level of questions asked by the teacher before and during formal involvement in the SCIS program. Before formal involvement in the program, a significantly greater proportion of recall of fact questions was asked. High level questions were asked in greater proportion during formal involvement in the program and the proportion of analysis questions asked was significantly greater.

2. There was no significant difference in the teacher's attitude toward the teacher-pupil relationship before and during formal involvement in the program.

3. There was no significant difference in the teacher's understanding of the processes of science before and during formal involvement in the program.

4. No clear relationship was found between the teacher's personality factors and her attitude toward the teacher-pupil relationship.

5. Little evidence existed for establishing a significant relationship between the personality factors and the question asking behavior of the SCIS teacher.

6. There did not appear to be a significant relationship between the personality factors and the teacher's understanding of the processes of science.

7. A strong relationship was found between the change score on the process test and change in the proportion of high level questioning.

8. A negative correlation existed between years of teaching experience and the degree of change in the asking of high level questions.

9. A significant positive correlation existed between the number of hours of science in the teacher's academic background and the degree of change on the process test.

Significant negative correlations existed between the change on the process test and the variables of increasing age and years of experience.

10. There was a significant positive correlation between the process test and the Minnesota Teacher Attitude Inventory.

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CHAPTER I

INTRODUCTION

The purpose of this study was to investigate the extent of relationships that exist among selected characteristics of the elementary teachers involved in the Science Curriculum Improvement Study (SCIS) program. The characteristics of the teachers examined for relationships were: the verbal behavior of question asking, science process skills, attitude toward the teacher-pupil relationship, and personality factors.

Interaction between the teacher and the pupil is of extreme importance to the teaching and learning of science. The nature of the interaction can do much to enhance the success of any science program. Part of the interaction which takes place between the teacher and the pupil is question asking. The science curriculum model in which the participants of this study are involved emphasizes question asking and stresses the importance of asking the higher-level divergent-question types.

Curriculum innovators have introduced many programs which they feel will produce students capable of solving new and unexpected problems. Much money and many hours have been devoted to this endeavor. A considerable portion of the money appropriated for curriculum development and implementation has been used to train teachers.

There seems to be little doubt as to the importance of the teacher in the new science program. The Fifty-Ninth Yearbook of the National Society for the Study of Education[1] refers to the teacher as one who establishes within the classroom the tone or social climate within which pupil learning occurs.

Sanders states that his book on classroom questions is based on the following two hypotheses:

> First, teachers can lead students into all kinds of thinking through careful use of questions, problems, and projects. Second, some teachers intuitively ask questions of high quality, but far too many overemphasize those that require students only to remember, and practically no teachers make full use of all worthwhile kinds of questions.[2]

The student inquiry emphasis of the modern elementary school science programs makes the asking of exclusively lower-level convergent question types untenable.

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[1] Fletcher G. Watson and William W. Cooley, "Needed Research in Science Education," Rethinking Science Education, Fifty-Ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1960), p. 307.

[2] Morris M. Sanders, Classroom Questions, What Kinds? (New York: Harper & Row, 1966), p. 1.

The importance of the teacher in the modern science programs indicates the need for further research on teacher characteristics. The Fifty-Ninth Yearbook refers to teacher characteristics as follows:

> How teacher personality factors affect science classroom learning and how, when, and which people become able science teachers are certainly important but unanswered questions to which personality psychology and sociology should provide at least partial answers.[3]

In this study, the science program in which the teachers were involved was referred to as the SCIS[4] program and the participating teachers as SCIS teachers.

Statement of Problem

The problem was to investigate certain characteristics of the elementary school teachers associated with the Science Curriculum Improvement Study Trial Center located at Michigan State University. This study includes the following areas:

1. The characteristics of the SCIS teachers as revealed by the scores on the SIXTEEN PERSONALITY FACTOR QUESTIONNAIRE (16 PF), THE MINNESOTA TEACHER ATTITUDE INVENTORY (MTAI), and the SCIENCE PROCESS SKILLS TEST FOR ELEMENTARY TEACHERS.

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[3]Watson and Cooley, op. cit., p. 307.

[4]SCIS refers to the Science Curriculum Improvement Study.

2. Certain verbal characteristics as revealed by <u>question</u> types asked by the SCIS teacher in the SCIS lessons as analyzed by the researcher.

3. The question types asked by the teacher in the science classroom prior to formal involvement in the SCIS program.

4. Descriptive data such as age, experience, school district, area of preference in science, and the number of hours of science in the SCIS teachers' academic background.

The SCIS program and the in-service training in which the teachers participated was supported by the National Science Foundation.

These data were analyzed to answer the following questions:

1. Is there a significant relationship between the SCIS teacher's measured personality factors and any of the following characteristics of the SCIS teacher:

a. rank on the proportion of high-level questions asked in the SCIS classroom;

b. rank on the degree of change in the proportion of high-level questions asked before and during formal involvement in the SCIS program;

c. rank on the proportion of high-level questions asked in the SCIS classroom when the variables of age, experience, science preference, school district, and hours of science are held constant;

d. rank on the degree of change in the proportion of high-level questions asked before and during formal involvement in the SCIS program when variables of age, experience, science preference, school district, and hours of science are held constant;

e. ranks on the score of the MTAI before and during formal involvement in the SCIS program;

f. rank on the degree of change in the score on the MTAI before and during formal involvement in the SCIS program;

g. ranks on the score of the MTAI before and during formal involvement in the SCIS program when the variables of age, experience, school district, science preference, and hours of science in the academic background are held constant;

h. rank on the degree of change between the scores on the MTAI before and during formal involvement in the SCIS program when the variables of age, experience, school district, science preference, and hours of science in the academic background are held constant;

i. ranks on the score of the science process test before and during formal involvement in the SCIS program;

j. rank on the degree of change in the scores on the science process test before and during formal involvement in the SCIS program;

k. ranks on the score of the science process test before and during formal involvement in the SCIS program when the variables of age, experience, science preference, and hours of science are held constant?

2. Is there a significant relationship between the SCIS teacher's score on the process skills test and any of the following characteristics of the SCIS teacher:

a. rank on the proportion of high-level questions asked in the SCIS classroom;

b. rank on the proportion of high-level questions asked in the science classroom before formal involvement in the SCIS program;

c. rank on the degree of change in the proportion of high-level questions asked in the science classroom before and during formal involvement in the SCIS program;

d. ranks on the proportion of high-level questions asked before and during formal involvement in the SCIS program when the variables of age, experience, school district, science preference, and hours of science are held constant;

e. ranks on the score of the MTAI before and during formal involvement in the SCIS program;

f. rank on the degree of change in the MTAI score before and during formal involvement in the SCIS program;

g. ranks on the score of the MTAI before and during formal involvement in the SCIS program when the variables of age, experience, school district, science preference, and hours of science are held constant?

3. Is there a significant relationship between the teacher's scores on the MTAI and the following characteristics:

a. rank on the proportion of high-level questions asked in the pre-SCIS classroom;

b. rank on the proportion of high-level questions asked in the SCIS classroom;

c. rank on the degree of change in the proportion of high-level questions asked;

d. ranks on the above when the variables of age, experience, school district, science preference and hours of science in academic background are held constant?

4. Is there any significant relationship between the proportion of high-level questions asked by the SCIS teacher and any of the following characteristics of the SCIS teacher:

a. age,

b. experience,

c. hours of science in academic background?

5. Is there any significant relationship between the degree of change in the proportion of high-level questions asked before and during formal involvement in the SCIS program and the following characteristics of the SCIS teacher:

a. age,

b. experience,

c. hours of science in academic background?

6. Is there a significant difference in the proportion of high-level questions asked by the teacher before and during formal involvement in the SCIS program?

7. Is there a significant difference between the SCIS teacher's score on the MTAI before and during formal involvement in the SCIS program?

8. Is there a significant difference in the SCIS teacher's score on the science process skills test before and during formal involvement in the SCIS program?

Definition of Terms

The SCIS teachers are those teachers who participated in the 1968 SCIS Summer Workshop and subsequently implemented the SCIS program. The summer workshop was held at the Science and Mathematics Teaching Center of Michigan State University.

The personality factors are operationally defined by the SCIS teacher's score on each of the sixteen factors of the SIXTEEN PERSONALITY FACTOR QUESTIONNAIRE.

The attitude toward the teacher pupil relationship is defined by the SCIS teacher's score on the MINNESOTA TEACHER ATTITUDE INVENTORY. This instrument is referred to as the MTAI in this study.

The science process skills are defined by the SCIS teacher's score on the SCIENCE PROCESS TEST FOR ELEMENTARY TEACHERS.

Formal involvement in SCIS is defined as that period of time from the 1968 SCIS Summer Workshop to and including the 1968-69 school year.

The level of questions asked are defined as follows:

1. Lower level.

    a. Recognition. Requires only the recognition of the correct option between two or more options.

    b. Recall. Simple recall of facts.

2. Higher level.

    a. Demonstration of skill. Translates the original to some other form.

    b. Comprehension. Refers to the type of question that requires the type of understanding such that the individual knows what is being communicated and can make use of the material or idea being communicated without relating it to other material.

c. Analysis. This question requires the student to break down the idea into its constituent elements or parts.

d. Synthesis. This question requires the student to combine or reorganize facts or ideas so as to develop new generalizations.

Delimitations of Study

The study was limited to those teachers who volunteered for the 1968 SCIS Summer Workshop held at Michigan State University. These teachers also participated in the implementation of the SCIS program in their respective districts. These districts were DeWitt, East Lansing, Grand Ledge, Perry, Michigan.

The study did not attempt to:

1. assess the effectiveness of the SCIS program or the SCIS teachers;

2. assess the effectiveness of the questions asked in the science classrooms;

3. present an inferential statistical treatment; but rather the study is limited to identifying the extent of relationships and differences among the data.

Need for Study

The role of the teacher is central in teaching the SCIS program. The classroom has been converted into a laboratory, and the teacher does not present information in lecture fashion nor explain from a textbook. Instead, the SCIS teacher is expected to guide the students to make observations and to form inferences based on the evidence. The teacher's question asking is the major vehicle for guiding the child's activity.

The modern science programs all share the characteristic of student activity. The SCIS program heavily emphasizes student activity. This activity is expressed in the forms of child-to-child interaction, child-to-object interaction, and teacher-child interaction.

According to Robert Karplus, director of the SCIS program:

> In a curriculum like SCIS which not only has the long term objective of changing adult behavior (developing scientific literacy), the <u>actions and attitudes of the teacher become essential to the success of the program</u>.[5] (Emphasis added.)

Piaget, upon whose theory of cognitive development the SCIS program is based, states, "Learning is provoked, perhaps by a teacher or a situation."[6] In the SCIS program, great care has been taken regarding the instructional

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[5]Robert Karplus and Herbert D. Their, <u>A New Look at Elementary School Science</u> (Chicago: Rand-McNally and Company, 1967), pp. 12-14.

[6]Jean Piaget, "Cognitive Development in Children: Development and Learning," <u>Journal of Research in Science Teaching</u>, II (1964), pp. 176-186.

situation. The types and sequence of lessons have been planned so as to be consistent with Piaget's model of cognitive development. The teacher, however, cannot be so structured or programmed and remain within the SCIS model of science teaching. Because each teacher is unique with respect to her interests, attitudes, academic and social background and personality, different SCIS classrooms are managed in varying manners.

Through interaction with the children, perhaps the teacher can hinder or facilitate the learning of the child. The teacher's personality and attitude toward the teacher-pupil relationship may be critical in determining the nature of classroom dialogue.

Questions, one of the most important forms of verbal interaction in the classroom, range from simple recall to the more sophisticated synthesis types. Sanders[7] reports that the types of questions used most by teachers are recall of fact. If the teacher is to use questions as a means of promoting thought and further experimentation on the part of the students, overuse of these lower level question types is not consistent with the SCIS model of science teaching.

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[7]Sanders, op. cit., p. 2.

Piaget's[7] theory of cognitive development postulates four main factors that influence the development from one set of structures to the other. These four factors are: maturation, which the schools can do little about since it is physiological; experience, which conceivably can be partially enriched by the science program; social transmission, which the child can understand only when he is in the proper stage of intellectual development; and equilibrium, which the science program also can presumably influence. The science program may produce experiences which reduce equilibrium for the moment and consequently the child tends to move back toward the state of equilibrium.

Perhaps questions can be used to establish the state of disequilibrium. The inquiry nature of science and science teaching can be evoked in the student by the use of higher level questions.

Because of the importance of the actions and attitudes of the teachers in the SCIS program, the characteristics which may be related to question asking and attitudes toward the teacher-pupil relationship were examined in this study. These factors and their interrelationships, to the extent they are related, should be major considerations in the training of future SCIS teachers.

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[8]Piaget, op. cit., p. 173.

This study examined the teachers' behavior regarding the types of questions asked by direct observation. Research which allows for direct observation in the classroom is needed.[9]

By relating the direct observations to the other measured characteristics of the SCIS teachers, profiles of the teachers who ask the high-level questions were established. Perhaps even more important are the profiles of the type of teacher who change long held attitudes, questioning techniques, and science process skills.

The information gained by this study could be used in developing models for teacher training and curriculum implementation.

Overview

In Chapter Two, the pertinent literature has been reviewed. Studies dealing with teacher personality, attitudes, and question asking have been especially analyzed.

In Chapter Three, the population is specifically defined, the statistical hypotheses stated, the statistical

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[9]Donald M. Medley and Harold E. Mitzel, "Measuring Classroom Behavior by Systematic Observation," Handbook of Research on Teaching (Chicago: Rand McNally and Company, 1962), p. 249.

models which were used to test the hypotheses described, and the assumptions made in the statistical models delineated.

Tables are used in Chapter Four to consolidate data for the purpose of anlayzing the hypotheses. The meaning of the data is interpreted in Chapter Four under the discussion of each hypothesis.

Chapter Five is the summary and conclusion.

CHAPTER II

REVIEW OF THE LITERATURE

Since it was the purpose of this study to examine the extent of relationships that exist among teacher personality factors, science process skills, attitude toward the teacher-pupil relationship, and the verbal characteristic of question asking, pertinent literature was reviewed, particularly concentrating on the studies having a bearing on one or more of the areas in question. The writer has attempted to relate the studies to each other in a meaningful manner.

The Thirty-First Yearbook of the National Society for the Study of Education[1] suggested that all science instruction be organized about certain broad generalizations or principles and that the purpose of science teaching was the development of understandings of major generalizations and associated scientific attitudes. One quickly realizes that the objectives of the "new" science are not exclusively the product of the post-Sputnik era.

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[1]Guy Montrose Whipple, ed., A Program for Teaching Science, The Thirty-First Yearbook of the National Society for the Study of Education, Part I (Chicago: The University of Chicago Press, 1932), p. 44.

Science educators had stated in the Thirty-First Yearbook the need for instruction that only now is being reflected in modern elementary school science programs. The Forty-Sixth Yearbook[2] urged further recognition of fundamental values in the advancement of scientific knowledge as well as the improvement of science education. The Fifty-Ninth Yearbook[3] also stresses the process nature of science and its relationship to science teaching. Hurd states in the Fifty-Ninth Yearbook that,

> Science is a process in which observations and their interpretations are used to develop new concepts, to extend our understanding of the world, to suggest new areas for exploration, and to provide some predictions about the future. It is focused upon inquiry and subsequent action.[4]

Sears and Kessen maintain that the central task of science education is to awaken in the child "a sense

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

[3]Nelson B. Henry, ed., Rethinking Science Education, The Fifty-Ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: The University of Chicago Press, 1960), p. 31.

[4]Paul DeH. Hurd, "Science Education for Changing Times," Rethinking Science Education, The Fifty-Ninth Yearbook of the National Society for the Study of Education (Chicago: University of Chicago Press, 1960), p. 33.

of joy, excitement, and intellectual power of science."[5] They further state that science is best taught as a procedure of inquiry and that the procedures do not vary greatly from the small child to the mature adult. The procedures that they identify are: statement of problem, seeking sources of reliable information, ability to observe, comparison of phenomena, systems of classification, instruments of science or measurement, experiment, evaluate evidence, and draw conclusions.

The basic processes of science mentioned above are essentially those which the Science Process Test for Elementary Teachers used in this study attempted to measure. Considerable emphasis was placed upon developing the SCIS teacher's process skills.

In the SCIS program the teachers are urged to ask questions which stress processes as well as concepts. Jacobson[6] states that question asking is one of the most crucial aspects of effective teaching in the SCIS program. Karplus[7] urges teachers to consider the importance

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[5] Paul B. Sears and W. Kessen, "Statement of Purpose and Objectives of Science Education in the Schools," Journal of Research in Science Teaching, II (1964), pp. 3-6.

[6] Willard Jacobson and Allen Kondo, SCIS Elementary Science Sourcebook (Trial Edition) (Berkeley: University of California, June 1968), p. 44.

[7] Robert Karplus and Herbert Their, A New Look at Elementary School Science (Chicago: Rand McNally and Company, 1967), p. 86.

of question asking and considers question asking to be a major aspect of the teacher's planning for the science lesson.

Wilson[8] did a study which was designed to determine whether the teachers who had been instructed in the SCIS program were asking higher level questions than those who had not had instruction in any "new" science program. Fifteen teachers were in each group. The teachers represented all grade levels. Each teacher was observed twice and the lesson was tape recorded. Wilson[9] concluded that the SCIS teachers asked a significantly greater degree of high-level questions. He also concluded that the SCIS teachers asked more questions than the traditional group.

In another project, Kondo[10] studied the questioning behavior of SCIS teachers and the possible relationship between their questioning behavior and the different types of SCIS lessons. SCIS has identified three types

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[8]John H. Wilson, "Differences between the Inquiry-Discovery and the Traditional Approaches to Teaching Science in Elementary Schools" (unpublished Ph.D. dissertation, University of Oklahoma, 1967), pp. 9-10.

[9]*Ibid.*, p. 67.

[10]Allen K. Kondo, "A Study of the Questioning Behavior of Teachers in the Science Curriculum Improvement Study (unpublished Ph.D. dissertation, University of California, Berkeley, 1967), p. 2.

of lessons, of which Kondo examined two. The same sequence of four lessons, two invention and two discovery, was tape recorded for four first-grade teachers. In general, his findings indicated that the lesson type was not related to the questioning behavior. Kondo[11] further indicated that, in most cases, the differences of question types among individual teachers were more striking than the average across lessons, which seemed to point out the importance of the individual teacher's style and personality on the types of questions she asks.

Since Wilson found a difference in question asking behavior between teachers and Kondo indicated that the teacher's style seemed important, there seemed to be a need for another study which considered factors other than simply question types. There was also a need for a study using a larger group of SCIS teachers with more observations per teacher. Furthermore, the use of the wireless microphone may have made it possible to more closely describe the actual questioning behavior.

Kleinman,[12] in a study on teacher questions and student understanding of science, found a very high

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[11] Ibid., p. 2.

[12] Gladys S. Kleinman, "Teachers' Questions and Student Understanding Science," Journal of Research in Science Teaching, III (1965), pp. 307-317.

correlation between three judges of question types, indicating good inter-observer reliability. She had made the assumption that the questioning behavior of teachers could be measured and therefore concluded that the assumption was justified. Kleinman further reports a consistency of the teacher's questioning behavior of 0.57, which is high enough to consider the behavior as relatively stable.

The 23 teachers used in Kleinman's[13] study taught in grades ranging from K-12 of which 6 were singled out for observation after all 23 had been observed once. These 6 were selected because 3 asked 9 or more critical thinking or high-level questions while the other 3 asked no critical thinking questions. Each group was observed 3 times for computational purposes, and it was reported that the high group asked significantly fewer rhetorical and factual questions. The high group asked less than half as many lower-type questions and almost 4 times as many higher-type questions as the low group.

Kleinman also rated the teachers on certain teacher behaviors that are relatively close to the 16 PF factors in nature. The trend indicated that the high teachers differed from the low teachers in that they

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[13] Ibid., p. 309.

received higher ratings on such behaviors as: unimpressive - attractive, erratic - steady, excitable - poised, uncertain - confident, and disorganized - systematic. There was no correlation between the number of high-level questions asked and educational or experiential background. Approximately 50 per cent of the questions asked by the original 23 teachers were memory questions.

Kleinman raises the following questions:

1. Are there factors other than questioning common to those teachers who ask high level questions?
2. Would training in asking higher level questions bring about higher ratings on teacher behavior by observers.[14]

The present study may provide evidence for the questions raised by Kleinman, at least for the 33 teachers studied.

Fischler[15] studied 12 fourth to sixth grade teachers for their questioning behavior before and after introduction to SCIS materials. Each teacher was tape recorded twice in the spring and once in the fall. One coder classified all questions. No reliabilities were computed, but he states that little difficulty was encountered in classifying the questions.

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[14] *Ibid.*, p. 308.

[15] Abraham S. Fischler and Nicholas J. Anastasiow, "In-Service Education in Science (a Pilot), The 'School within a School,'" *Journal of Research in Science Teaching*, III (1965), pp. 280-285.

Fischler[16] reports that for the ten teachers for which he had complete data available, significantly more teachers asked fewer questions and made greater use of observational questions after exposure to SCIS. Decreases were demonstrated for at least seven teachers in the percentage of questions asked and the number of direct questions asked. Increases were noted for at least eight teachers in the percentage of indirect questions used.

The importance of question asking behavior and question analysis is evident in that Flanders[17] reports that the asking of questions and the giving of information accounts for 70-90 per cent of all teacher talk. Smith[18] states that the analysis of transcribed accounts of classroom discourse shows that almost all of the verbal interaction between teacher and student took the interrogative form.

In attempting to address themselves to the question-asking behavior of teachers, Harris and McIntyre[19] designed the method of question analysis that

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[16] *Ibid.*, p. 284.

[17] Ned A. Flanders, *Teacher Influence, Pupil Attitudes and Achievement* (Ann Arbor: University of Michigan, 1962), p. 10.

[18] B. O. Smith, "A Concept of Teaching," *Teachers College Record* (1960), 61, pp. 229-241.

[19] Ben Harris and Kenneth McIntyre, *Teacher Question Inventory* (University of Texas, 1964).

was subsequently used in this study. They hold that an analysis of the questions a teacher asks reveals the kind of learning being structured in the classroom. This method was also used by Wilson.[20]

The hierarchial order established in Bloom's[21] Taxonomy of Educational Objectives would indicate that the question types also have a hierarchial nature ranging from simple recall of fact to looking for major generalizations. The questions may serve as a means of creating cognitive conflict along the hierarchy described by Bloom.

Palmer[22] reports in his study of cognitive conflict as viewed within the Piagetian position that the equilibrium - equilibration has important implications for instruction.

The four distinguishable phases of equilibration listed by Palmer are:

1. Perceived discrepancy, which gives rise to
2. A state of cognitive disequilibrium or conflict, the resolution of which results in
3. Cognitive reorganization, which terminates in
4. Attainment of a new level of equilibrium.[23]

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[20] Wilson, *op. cit.*, p. 83.

[21] Benjamin Bloom, ed., *Taxonomy of Educational Objectives: Cognitive Domain* (New York: David McKay Company, Inc., 1956).

[22] E. L. Palmer, "Accelerating the Child's Cognitive Attainment through Inducement of Cognitive Conflict: An Interpretation of the Piagetian Position," *Journal of Research in Science Teaching*, III (1965), pp. 318-325.

[23] *Ibid.*, p. 320.

The questions generated by the teachers do not operate in isolation. Anyone who uses questions in the classroom must assume, as Kleinman[24] did, that the kinds of questions used are an indication of the levels of thinking that are being stimulated. Further, when the questions are analyzed, one must also assume that questions influence the outcome of science teaching and that question asking behavior is measurable.

Kleinman's study indicates, then, that there may be some relationship between teacher characteristics such as attitude, personality factors and question types.

Shulman[25] states that, given one set of goals, one model for curriculum may be better than another or vice versa but that there are other decisions that should be considered in making curricular decisions such as characteristics of the child, subject matter, objectives, and characteristics of the teacher. The importance of teacher characteristics and their effect on the classroom is critical to this study.

Many studies attempt to examine the relationship between personality or attitude factors with student achievement.

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[24]Kleinman, op. cit., p. 311.

[25]Lee S. Shulman, "Perspectives on the Psychology of Learning and Teaching of Mathematics," Improving Mathematics Education for Elementary School Teachers, ed. (East Lansing: Michigan State University, 1967), p. 36.

This study differs from the others to be cited in that the degree of relationships that exist among teacher personality, attitude, science process skills and questioning behavior are analyzed. The exploratory step taken here seemed to be logical in light of prevailing assumptions that questioning behavior is important to successful science teaching. Since the processes are an integral part of science, it was assumed that the teacher's knowledge of the processes of science was important.

A study by Heil[26] indicated teacher personality has an effect on the achievement of children. The personality of each teacher fell into one of three profile groups: turbulent person, self-controlling person, and the fearful person, as measured by the Manifold Interest Schedule. Stanford Elementary and Intermediate Achievement batteries were used to obtain evidence regarding the achievement gain during the year. A device called "Assessing Children's Feelings" was used to determine the children's personalities.

The findings of interest were:

> For all children, the self-controlling teacher obtained a significantly greater achievement than the turbulent or fearful teacher. For conforming children, the self-controlling teacher obtained

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[26] L. M. Heil, M. Powell, and I. Feifer, Characteristics of Teacher Behavior and Competency Related to the Achievement of Different Kinds of Children in Several Elementary Grades (New York: Office of Testing and Research, Brooklyn College, 1960).

> significantly greater improvement. For opposing children, the self-controlling teacher obtained significantly greater achievement than the turbulent teacher, but not significantly greater than the fearful teacher. The achievement of anxious children does not appear to differ significantly with the different types of teachers. The achievement of striving children appears to be almost independent of teacher types.[27]

An earlier study by Anderson[28] indicated that teacher personality affects classroom interaction. Teacher contacts with the children were observed. The contacts were classified as dominative or socially integrative behavior. There were three classes of dominant behavior: domination, with evidence of conflict; domination, with no evidence of conflict; domination, with evidence of working together. Two degrees of integrative behavior were indicated: integration, with no evidence of working together; integration, with evidence of working together. The dominant teacher very rigidly controls the actions of the child. The integrative teacher in no way uses force or other pressure on the child in her contacts with him.

An interesting aspect of this study indicates that the teachers did not change their patterns of

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[27] Ibid.

[28] H. H. Anderson and J. E. Brewer, "Studies of Teachers' Classroom Personalities, II: Effects of Teachers' Dominative and Integrative Contacts on Children's Classroom Behavior," Applied Psychological Monograph, No. 8 (Stanford Press, June 1946), pp. 1-128.

behavior from one year to the next. This was determined by the fact that the teacher's behavior did not differ significantly from one study to the next when the same method of observation was used. The dominant teacher still had more dominant encounters with her children than did the integrative teacher.

Further research by the same individuals[29] indicated further support for consistency of these characteristics in the teachers. The classrooms were observed in consecutive studies in the fall and winter. The teachers were still significantly different, and their behavior patterns in regard to dominative and integrative behavior had not significantly changed except in the following ways.

The integrative teacher provided more help for children who sought it. This teacher often turned the problem back to the student in such a way that permitted the student to work out the final solution for himself. The dominating teacher tended to give the child the answers or solve the problem for him. In the fall, the dominating teacher worked with the individual child more

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[29] H. H. Anderson, J. E. Brewer and Mary F. Reed, "Studies of Teachers' Classroom Personalities, III: Follow-up Studies of the Effects of Dominative and Integrative Contacts on Children's Behavior," Applied Psychological Monograph, No. 11 (Stanford, California: Stanford Press, 1946).

than she worked against him. By the winter, the dominating teacher was working against the individual child more than she worked with him.

Rathman, Welch and Walberg[30] while working with secondary school teachers, found that the teachers' personalities and value systems are more strongly related to the students' changes in physics achievement, attitude toward physics, and interest in science than are the following teacher variables: extent of preparation in physics, mathematics, history and philosophy of science; their knowledge of physics; or their years of teaching experience. They report the single teacher variable related to most measures of student learning is heterosexuality. These teachers were regarded as somewhat more physically attractive.

Lamke[31] compared the scores of ten "good" teachers and eight "poor" teachers on the Sixteen Personality Factor Questionnaire. The teachers were rated as "good" or "bad" by their principals and two observers. Lamke reports that the two groups differed on three of the

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[30] A. I. Rathman, W. W. Welch and H. J. Walberg, "Physics Teacher Characteristics," Journal of Research in Science Teaching, VI (1969), pp. 59-63.

[31] T. A. Lamke, "Personality and Teaching Success," Journal of Experimental Education, No. 20 (1951), pp. 217-259.

factor scores of the Sixteen Personality Factor Questionnaire. The "good" teachers were above average and the "poor" teachers below average on factors F (sober vs enthusiastic) and G (expedient vs conscientious). The "good" teachers were average or slightly below average on factor N (forthright vs shrewd) and the "poor" teachers were definitely below average. Because of selection and the small number, Lamke would not generalize to other teachers.

Ryans'[32] work indicated that teachers who had been rated superior in ways they handled classroom situations had the following characteristics: a strong liking for children and interest in their development; personal admiration for such human characteristics as friendliness, permissiveness, and fairness; strong satisfaction with the job of teaching; dreams of becoming a teacher prior to college enrollment; and superior personal achievement in schools.

Klausmeier states the following about teacher characteristics:

> It is generally assumed that the teacher who has favorable attitudes toward self and others, is realistic about others, accepts self, and works with vigor and enthusiasm toward socially acceptable goals connected with teaching and personal living is

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[32] D. G. Ryans, Characteristics of Teachers (Washington, D. C.: American Council on Education, 1960).

> more desirable in the classroom and achieves better results than does one who does not possess these characteristics.[33]

The attitude that the teacher has toward teaching and students has been deemed important. Several studies have utilized the Minnesota Teacher Attitude Inventory which, although developed in 1951 after ten years of research and study, is still one of the very few and perhaps the best attitude inventory of its kind.

Taylor[34] did a study using the MTAI on secondary school teachers and found no significant relationships between changes in student interest or achievement and teachers' attitude, preparation in science, or years of experience. The present study examines the relationship between the SCIS teachers' attitude and age, experience, and science background as well as question types.

Beamer[35] used the MTAI to examine the attitudes of various educational personnel. He found a difference

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[33] Herbert J. Klausmeier, Learning and Human Abilities (New York: Harper & Row and Brothers, 1961), p. 106.

[34] T. W. Taylor, "A Study to Determine the Relationships between Growth in Interest and Achievement of High School Science Students and Teacher Attitudes, Preparation, and Experience" (unpublished Doctoral dissertation, North Texas State College, 1957), pp. 74-76.

[35] C. C. Beamer and Elaine W. Ledbetter, "The Relation between Teacher Attitudes and the Social Service Interest," Journal of Educational Research, No. 50 (1957), pp. 655-666.

between the scores on the MTAI for experienced and inexperienced education majors. The inexperienced education majors had higher mean scores. The elementary school teachers had a higher mean score than the secondary school teachers.

According to Getzels,[36] attempts have been made to correlate the attitudes measured by the MTAI and other personality variables. The MTAI was found to be correlated with several factors of the Minnesota Multiphasic Personality Inventory. In the present study, the relationship of the MTAI to the 16 PF was examined for the 33 SCIS teachers.

Conclusion

In this chapter, the need for the emphasis of the processes in science teaching was examined. The importance of the teacher and her question asking behavior in the SCIS program was related to the over-all recommendations of the Thirty-First, Forty-Sixth and Fifty-Ninth Yearbooks of the National Society for the Study of Education. The relationship of the teacher's personality and attitudes to the classroom environment was exemplified by the pertinent studies. Most of the studies attempted to relate teacher

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[36] J. W. Getzels and P. W. Jackson, "The Teacher's Personality and Characteristics," Handbook of Research on Teaching (Chicago: Rand McNally and Company, 1963), p. 515.

personality or attitude directly to successful teaching. There seemed to be a need for the intermediate step, this being the examination of certain aspects of the teacher's behavior as it is related to the teacher's personality and attitude. This study was an attempt to explore and describe very specific aspects of the SCIS teacher's behavior. The analysis of the data collected in this exploratory study may provide a rationale for future studies concerning teacher characteristics and behavior.

CHAPTER III

DESCRIPTION OF POPULATION

The teachers who participated in this study were employed by four school districts near Michigan State University where the study was conducted. All of these teachers were participating in the implementation of the SCIS program in school districts which were reasonably close to Michigan State University due to the nature of the consulting services required of the trial program. The teachers of each district were visited on a bi-weekly basis, and the services of the consultant were available at all times throughout the 1968-69 school year. Feedback meetings were conducted on the bi-weekly basis with all of the teachers of a particular level present. The bi-weekly meetings were intended to perform an educational as well as a feedback function. Subjects ranging from classroom discipline to the life cycle of fruit flies were discussed at these meetings. The bi-weekly meetings were also intended to help solve common problems and to increase the teachers' enthusiasm for the SCIS program. In short, the SCIS teachers received much more individual attention than would the average classroom teacher.

All of the teachers who participated in the SCIS Summer Workshop held at Michigan State University were intended to be used in the study. Four teachers were lost to the program: one due to pregnancy, two who left teaching, and one who refused to cooperate. The final number in the completed study was thirty-three.

Each of the participants volunteered to attend the summer workshop with the understanding that they would teach the SCIS program in their classrooms during the 1968-69 school year. The SCIS teachers were told that research would be conducted throughout the year and that their continued cooperation would be necessary.

Arrangements had been made, by the SCIS Trial Center Coordinator, for SCIS to be taught in the teachers' respective school districts prior to the teachers' decisions to accept the summer workshop. It was only after the teacher's decision to accept the SCIS program that her classroom was designated to become one of the SCIS trial classrooms.

During the three-week summer workshop, the participants were exposed to the following areas: (See Appendix A for complete outline of SCIS Summer Workshop.)

a. Lecture on the "Nature of Science,"

b. Films and lectures on the modes of teaching SCIS,

c. Psychology of Jean Piaget,

d. Inquiry laboratories,

e. Micro-teaching,

f. Demonstration teaching of specific lessons,

g. Planning for the 1968-69 school year.

Fifteen of the teachers who had volunteered to participate in the SCIS program prior to the Spring of 1968 agreed to allow observations to be made in their science classrooms. Pre-SCIS observations were established for these fifteen teachers. Each of the pre-SCIS teacher's science lessons was recorded using a cassette-tape recorder. (See Appendix B for demographic data on pre-SCIS teachers.)

All of the subjects of this study were female. The participants' ages ranged from 20 to 61 years. The median age was 27. The hours of science in the academic background of the participants ranged from 3 to 54. The median number of hours in the science background was 12.8. Twelve of the participants preferred to teach biological sciences, physical science was preferred by 16, and 3 indicated no preference at all. The years of experience of the SCIS teachers ranged from 0 to 43. The median number of years of experience was 2.8. (See Appendix B for complete data on age, experience, school district, hours of science, and science preference.)

Fifteen of the SCIS teachers were employed in East Lansing, 7 in DeWitt, 7 in Perry, and 4 in Grand Ledge, Michigan. DeWitt, Grand Ledge, and Perry could be considered rural, while East Lansing is primarily a suburban university community.

The SCIS teachers were not selected at random, and no assumptions regarding the nature of the population were made for statistical or inferential purposes.

Method of Observation

Each lesson was recorded with a small cassette-tape recorder. Since part of the SCIS consultants' normal routine was to observe regularly the teachers to whom he was responsible, each time the consultant visited a SCIS teacher the lesson was taped. Three consultants, including the writer, were involved in taping the lessons.

Whereas the pre-SCIS lessons were almost exclusively non-laboratory, it was soon discovered that since the SCIS lessons were more laboratory in nature, a modification was necessary in the tape recording system of the SCIS lessons. A wireless microphone was used to better facilitate analyzing the types of questions asked by the SCIS teacher. The microphone was worn in necklace fashion by the teacher during the lesson. The consultant carried the tape recorder and FM tuner in a briefcase or carrying case. The equipment remained in the cases and, as much as possible, out of the sight of both teacher and students.

The SCIS observations were made over a period of time from September, 1968 through April, 1969. The pre-SCIS observations were made between April, 1968 and June 15, 1968.

An average of 7 observations was made for analysis on each SCIS teacher. Two observations were made on each of 11 and 1 on each of 4 pre-SCIS teachers. A total of 229 observations was made on the SCIS teachers, and 24 observations were made on the pre-SCIS teachers. (See Appendices C and D for number of observations on each teacher.) In 2 cases 5 observations were made. The unequal number of observations can be attributed to teacher absences, vacations, and difficulty with teachers' adherence to the taping and SCIS teaching schedule.

After spending considerable time studying the various question types, the researcher analyzed the tapes. The pre-SCIS tapes were not analyzed separately but were mixed in with the SCIS tapes. None of the other data had been analyzed for comparison purposes before the tapes were analyzed. Only science content questions were analyzed.

A random sample of one tape was made from all of the previously analyzed tapes each time the observer completed ten lessons. This tape was re-analyzed, and the Scott coefficient of reliability "pi" was used to determine stability.

The computational formula for the Scott Coefficient is as follows:

$$\pi = \frac{Po - Pe}{1 - Pe}$$

where

$$Po = 1.00 - \Sigma|P_1 - P_2|$$

$$Pe = \Sigma P_1^{\ 2}$$

P_1 is the proportion computed upon first analysis and P_2 is the proportion computed upon second analysis.

Po is the proportion of agreement between observations, and Pe is the proportion of agreement that would be expected by chance alone. Flanders[1] reports the Scott coefficient is sensitive to very small differences.

The stability of the question analysis seemed to be satisfactory. Only in 2 cases did the reliability drop below 0.70. In both instances, the number of questions asked was very small. The small number drastically affects the Scott coefficient when 1 or 2 questions are analyzed differently.

In the three instances of perfect reliability, rather peculiar circumstances existed. The first perfect

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[1]Ned A. Flanders, Interaction Analysis in the Classroom - Manual for Observers (Ann Arbor: University of Michigan, 1964), p. 10.

reliability can be accounted for by the fact that this was one of the first tapes analyzed and there was an extremely small number of questions asked. The writer simply remembered the question types from the first analysis. The second and third perfect reliabilities were established on the same teacher. This particular teacher always asked almost exclusively all recall questions. (See Appendix E for a summary of the intra-observer reliability.)

Instrumentation

The Minnesota Teacher Attitude Inventory was used to measure the teachers' favorable attitudes toward pupils, toward a somewhat permissive-learning situation, and toward the teaching profession generally.

The Minnesota Teacher Attitude Inventory seemed appropriate to use since the SCIS model recommends that the teacher allow a reasonable degree of freedom in the classroom. The children should be free to engage in child-to-child interaction during the activities. The child should be allowed the opportunity to describe his observations, and the teacher should allow the child to challenge other observations and inferences, including the teacher's. The teacher and the student should have respect for each other.

In the MTAI manual, the developers of the test make the following statement:

> . . . that a teacher ranking at the high end of the scale should be able to maintain a state of harmonious relations with his pupils characterized by mutual understanding. . . . The teacher and the pupils should work well together in a social atmosphere of cooperative endeavor of intense interest in the work of the day and with a feeling of security growing from a permissive atmosphere of freedom to think, act, and speak one's mind with mutual respect for others.[2]

The MTAI manual describes the teacher at the other end of the scale as:

> . . . attempts to dominate the classroom. He may be successful and rule with an iron hand, creating an atmosphere of tension, fear, and submission; or he may be unsuccessful and become nervous, fearful, and distraught in a classroom characterized by frustration, restlessness, inattention, lack of respect, and numerous disciplinary problems.[3]

Norms were established on the MTAI by its developers.[4] Elementary teachers from systems with 21 or more teachers with 4 years of training had a mean score of 55.1 and a standard deviation of 37.2. A random sample of 247 elementary teachers took the test. The MTAI has a range of scores from -150 to +150.

The MTAI was administered for the pretest on August 7, 1968. The posttest was administered on

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[2]Walter W. Cook, Carroll H. Leeds, and Robert Callis, *The Minnesota Teacher Attitude Inventory Manual* (New York: The Psychological Corporation, 1950), p. 3.

[3]*Ibid.*, p. 3.

[4]*Ibid.*, p. 9.

April 19, 1969. In both cases the MTAI was administered in a large group setting at the Science and Mathematics Teaching Center of Michigan State University. The conditions under which the pretest and posttest were administered were as nearly alike as possible. The SCIS teachers were asked to return to the campus for testing. (See Appendix F for invitation and schedule of testing for all posttests.)

The Sixteen Personality Factor Questionnaire developed by Cattell was utilized to collect personality data. This questionnaire measures the behavior of subjects by means of sixteen factors which were isolated by factor analysis. Bi-polar descriptions of the sixteen source traits or factors A through Q_4 can be found in Appendix I.

Cattell[5] describes the sixteen personality factors as leaving out no important aspect of the total personality and that the factors are relatively independent of each other. All of the factors are known to be important in the sense of each having a wide influence on behavior.

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[5]Raymond B. Cattell, Handbook for the Sixteen Personality Factor Questionnaire (Champaign, Ill.: The Institute for Personality and Ability Testing, 1964).

The reliability coefficients on the factors range from .71 to .93 using the split half method. Table 1 lists the reliability coefficients for factors A through Q_4.

TABLE 1

16 PF Reliability Coefficients[6]

A = 0.90	F = 0.84	L = 0.77	Q_1 = 0.71
B = 0.86	G = 0.85	M = 0.88	Q_2 = 0.79
C = 0.93	H = 0.83	N = 0.79	Q_3 = 0.76
E = 0.91	I = 0.76	O = 0.85	Q_4 = 0.88

The concept of construct validity of the 16 PF Questionnaire as calculated from known factor loadings of the items on the factors in the original reseraches are shown in Table 2.

TABLE 2

Validities, Estimated from Loadings[7]

A = 0.88	F = 0.91	L = 0.89	Q_1 = 0.74
B = 0.80	G = 0.85	M = 0.74	Q_2 = 0.81
C = 0.76	H = 0.96	N = 0.73	Q_3 = 0.92
E = 0.82	I = 0.84	O = 0.91	Q_4 = 0.96

[6] Ibid., p. 4.

[7] Ibid., p. 4.

The 16 PF Questionnaire was administered on August 15, 1968 during the SCIS Summer Workshop. The instrument was administered to the entire population in a large group.

The Science Process Skills Test for Elementary Teachers was administered to test the process skills of the SCIS teachers. The science process test was developed by Sweetser.[8] An item analysis was reported by the author of the test for two groups of experienced teachers. The Kuder Richardson reliability coefficient for the first group of 49 was 0.65. The reliability for the second group of 54 was 0.76. (See Appendix G for Science Process Test.)

The science process test was administered to the SCIS teachers on August 6, 1968. The test was administered for the second time to the group in order that the change in the process skills of the SCIS teacher could be assessed during formal involvement in the SCIS program.

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[8]Evan A. Sweetser, Science Process Test for Elementary Teachers, 3rd Edition (East Lansing, Michigan: Michigan State University, 1968).

Hypotheses Tested

The following null hypotheses were tested in this study:

1. There is no significant difference in the proportion of high-level questions asked by the SCIS teacher before and during formal involvement in the SCIS program.

2. There is no significant difference in the SCIS teacher's score on the MTAI before and during formal involvement in the SCIS program.

3. There is no significant difference in the SCIS teacher's score on the science process test before and during formal involvement in the SCIS program.

4. There are no significant correlations to be found between the measured "personality factors" and the following characteristics of the SCIS teacher:

   a. rank on the pre-MTAI;

   b. rank on the post-MTAI;

   c. rank on the MTAI change score;

   d. rank on the pre-Process Skills Test;

   e. rank on the post-Process Skills Test;

   f. rank on the Process Skills Test change score;

   g. rank on the proportion of high-level questions asked in the SCIS classroom;

   h. rank on degree of change in the proportion of high-level questions asked in the science classroom;

i. ranks on each of the above when the variables of age, experience, school district, science preference, and hours of science in the academic background are held constsnt.

5. There is no significant correlation between the SCIS teacher's score on the <u>process skills test</u> and any of the following characteristics of the SCIS teacher:

a. rank on the proportion of high-level questions asked in the SCIS classroom;

b. rank on the proportion of high-level questions asked in the pre-SCIS classroom when the variables of age, experience, school district, science preference, and hours of science in academic background are held constant;

c. rank on the degree of change in the proportion of high-level questions asked;

d. rank on the pre-MTAI;

e. rank on the post-MTAI;

f. rank on the MTAI change score;

g. ranks on the above when the variables of age, experience, school district, science preference, and hours of science in academic background are held constant.

6. There is no significant correlation between the variables of age, experience, and hours of science in

academic background and any of the following characteristics of the SCIS teacher:

a. rank on the degree of change in the proportion of high-level questions asked;

b. rank on the MTAI change score;

c. rank on the science process change score.

7. There is no significant correlation between the teacher's scores on the MTAI and the following characteristics:

a. rank on the proportion of high-level questions asked in the pre-SCIS classroom;

b. rank on the proportion of high-level questions asked in the SCIS classroom;

c. rank on the degree of change in the proportion of high-level questions asked;

d. ranks on the above when the variables of age, experience, school district, science preference, and hours of science in academic background are held constant.

Assumptions and Analysis Models

Since parametric statistics require certain assumptions to be satisfied for the statistical test to be the most powerful one, nonparametric statistics were used to test the hypotheses. The conditions which must be satisfied for parametric tests are at least these:

1. The observations must be independent.
2. The observations must be drawn from a normally distributed population.
3. These populations must have the same variance.
4. The variables involved must have been measured in at least an interval scale.
5. The effects must be additive.[9]

Due to the manner in which the SCIS teachers were chosen, we cannot assume that they are distributed normally. Some of the data collected are ordinal at best.

By choosing nonparametric tests and using the large number of the SCIS population, power nearly equal to the parametric tests can be maintained without making any assumptions about the population other than independence between observations.

Siegel states the following regarding nonparametric tests:

> A nonparametric statistical test is a test whose model does not specify conditions about the parameters of the population from which the sample was drawn. Certain assumptions are associated with most nonparametric statistical tests, i.e., that the observations are independent and that the variable under study has underlying continuity, but these assumptions are fewer and much weaker than those associated with parametric tests. Moreover, nonparametric tests do not require measurement so strong as that required for the parametric tests; most nonparametric tests apply to data in an ordinal scale, and some apply also to data in a nominal scale.
> . . . .

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[9] Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw Hill Book Company, 1956), p. 19.

> Because the power of any nonparametric test may be increased by simply increasing the size of N, and because behavioral scientists rarely achieve the sort of measurement which permits the meaningful use of parametric tests, nonparametric statistical tests deserve an increasingly prominent role in research in the behavioral sciences.[10]

Based upon the reasons set forth above, nonparametric models were used to analyze the data.

The statistical model used to determine the correlations was the Kendall Rank Correlation Coefficient.[11] The Kendall Rank Correlation Coefficient can be used if at least ordinal measurement of both variables has been achieved so that each teacher can be ranked on both variables. The sampling distribution of the Kendall rank correlation coefficient under the null hypothesis is known. For N = 8 the sampling distribution for the Kendall rank correlation coefficient is practically indistinguishable from the normal distribution.

The computational formula for the Kendall rank correlation coefficient, Tau, is:

$$\tau = \frac{S}{1/2N\ (N-1)}$$

where S is determined by starting with the first number on the left and counting the number of ranks to its right which are larger. N is the number involved in the study.

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[10] *Ibid.*, p. 31.

[11] *Ibid.*, pp. 213-223.

When testing hypotheses in which correlations are to be determined while holding a third variable constant, the Kendall Partial Rank Correlation Coefficient, $\tau_{xy \cdot z}$, was used.

Regarding the power-efficiency, Siegel states the following:

> When used on data to which the Pearson r is properly applicable, both the τ and r_s have efficiency of 91 per cent. That is, τ is approximately as sensitive a test of the existence of association between 2 variables in a bivariate normal population with a sample of 100 cases as is the Pearson r with 91 cases.

When testing for significant differences of question types, attitudes as measured by the MTAI, and process skills as measured by the process test between before and after formal involvement in the SCIS program, the Wilcoxon matched-pairs signed-ranks test was used.

These are the steps as described by Siegel[13] in the use of the Wilcoxon matched-pairs signed-ranks test:

1. For each matched pair the signed difference between the two scores is determined.

2. The differences are ranked without respect to sign.

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[12]*Ibid.*, p. 223.

[13]*Ibid.*, p. 76.

3. Determine T equal to the smaller of the sums of the like-signed ranks.

4. The computational formula used to determine the significance of the observed T for attitudes and processes is as follows:

$$Z = \frac{T - \frac{N\ (N + 1)}{4}}{\frac{N\ (N + 1)\ (2N + 1)}{24}}$$

where

T = the smaller of the sums of like-signed ranks,

N = the number of ranked pairs.

When the N is greater than 25, the Z values are normally distributed. The test for difference in question types has fewer than 25 matched-pairs; therefore, the T value is used to refer directly to a table of T values when determining significance. The power-efficiency of the Wilcoxon matched-pairs signed-rank test as compared to the parametric t-test is 95.5 per cent.

The computer program used for the Kendall rank correlation coefficients and the Kendall partial rank correlation coefficients is described in the Michigan State University Computer Institute for Social Science Research Technical Report 47.[14]

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[14]John Morris, programmer, Technical Report 47, Rank Correlation Coefficients, Computer Institute for Social Science Research, Michigan State University (January 5, 1967.

The computer program for the Wilcoxon test is described in the Michigan State University Computer Institute for Social Science Research Technical Report 45.[15]

The level of significance at which all hypotheses were tested was .05.

Summary

The subjects in this study were teachers who had volunteered to participate in the 1968 SCIS Summer Workshop and to teach the SCIS program during the 1968-69 school year. The entire population of 33 was used in the study.

The instruments used to assess the characteristics of the SCIS teachers were the following: The Sixteen Personality Factor Questionnaire, The Minnesota Teacher Attitude Inventory, and the Science Process Skills Test for Elementary Teachers.

Two hundred twenty-nine observations were made of the SCIS teachers, and twenty-four observations were made of the pre-SCIS teachers. Each lesson was analyzed for the type of questions asked by the teacher.

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[15]John Morris, programmer, Technical Report 45, Rank Correlation Coefficients, Computer Institute for Social Science Research, Michigan State University (September 15, 1967).

Nonparametric statistics were used to analyze the data because the assumptions required for parametric statistics could not be met. With the large number of subjects used in this study, little, if any, power was lost as a result of the use of nonparametric statistics.

The hypotheses were tested, and the analysis of the results is discussed in the following chapter.

CHAPTER IV

INTRODUCTION

The data collected by the procedures described in Chapter Three are presented in this chapter. Additional data are presented in the appendices. While the results of the analysis of the data testing the null hypotheses are found in this chapter, a more detailed analysis generally appears in each section. A brief summary also accompanies each section.

The results of the analysis are presented after the statement of the hypothesis for each section. A discussion and summary of the findings are presented at the end of the chapter.

Results of Question Analysis

As stated in Chapter Three, the lessons were tape recorded and later analyzed for the question types asked by the teacher. The results of the question analysis for all teachers involved in testing the following hypothesis are shown in Appendices C and D.

Due to the limited time, only 24 lessons were observed prior to involvement in the SCIS program. Some researchers may consider the number of pre-SCIS observations to be too few; however, the writer felt justified in using these data.

The teachers were asked to present the lessons just as they had been teaching science throughout the year. It is the writer's opinion after having made the observations that the teachers had chosen lessons which would permit both the children and themselves to perform well. It would seem that these data are representative of the pre-SCIS teacher's better teaching. This, it would appear, would not favor rejection of the null hypotheses.

> Hol: There is no significant difference in the proportion of high-level questions asked by the SCIS teacher before and during formal involvement in the SCIS program.

The results of the analysis of these data produced a Wilcoxon T value of 17 with a probability of .015; therefore, the null hypothesis was rejected.

A more complete analysis indicated specifically which question types were significantly different. Table 3 shows the results of this analysis.

It is interesting to note that only two question types were significantly different. Of the high-level question types, the teachers asked the greater proportion in three of the four question types after involvement in SCIS.

TABLE 3

Wilcoxon T-values for the Difference between Pre-SCIS and SCIS Question Types

Question Types	T-value	Probability	Higher Group
Recognition	31	0.098	SCIS
Recall	12	0.006*	Pre-SCIS
Demonstration of Skill	49.5	0.856	SCIS
Comprehension	38	0.210	SCIS
Analysis	10	0.004*	Pre-SCIS
Synthesis	13	0.482	Pre-SCIS

*Significant at the .05 level, two tailed test.

Results of MTAI Analysis

The results of the MTAI pretest and posttest are shown in Appendix H. The Wilcoxon matched-pairs signed-ranks test was used to test the following hypothesis:

> Ho2: There is no significant difference in the SCIS teacher's score on the Minnesota Teacher Attitude Inventory before and during formal involvement in the SCIS program.

The computed Wilcoxon T value was 266.5. The Z score associated with this Wilcoxon T value was -0.24. The probability that this Z score could have occurred by chance alone was 0.80. The null hypothesis was not rejected.

Results of the Process Test Analysis

The results of the process pretest and posttest are shown in Appendix H. These data were used to test the following hypothesis:

> Ho3: There is no significant difference in the SCIS teacher's score on the Science Process Test for Elementary School Teachers before and during formal involvement in SCIS.

Considerable emphasis was placed on the processes of science in the summer workshop (see Appendix A). All of the teachers satisfactorily completed all aspects of the workshop in that each teacher performed the activities and attended the lectures related to processes. The importance of the processes in elementary school science was established in Chapter Two.

The Wilcoxon T value which resulted from the analysis of these data was 195. The Z score attained from this value was -1.52. This Z score was not large enough to allow rejection of the null hypothesis. The probability that this score could have occurred by chance alone was 0.30.

Relationship between the 16 PF and the MTAI, Process Test, and Question Types

The results of the 33 teachers' scores on each of the factors of the 16 PF are shown in Appendix J. The bi-polar descriptions of the 16 PF are presented in Appendix I.

These data were analyzed to determine the relationship that may exist between them and other variables in question. (See Appendix K for correlation matrix of 16 PF, process test and MTAI.)

The null hypothesis tested was stated in the following manner for the purposes of examining the results of the analysis: first, the root of the null hypothesis was stated; and second, the stem was used as a heading for the specific analysis discussed.

> Ho4: There are no significant correlations between the measured "personality factors" and the following characteristics:
>
> a. rank on the pre-MTAI;
>
> b. rank on the post-MTAI;
>
> c. rank on the MTAI change score;
>
> d. rank on the pre-Process Skills Test;
>
> e. rank on the post-Process Skills Test;
>
> f. rank on the Process Skills Test change score;

g. rank on the proportion of high-level questions asked in the SCIS classroom;

h. rank on degree of change in the proportion of high-level questions asked in the science classroom.

Rank on the Pre-MTAI

Two factors were found to be significantly correlated to the pre-MTAI. The factors which were significantly correlated and the associated level of significance are as follows:

a. Factor C (emotional vs mature); Kendall tau value = 0.272; significance = 0.004.

b. Factor L (trustful vs jealous); Kendall tau value = -0.353; significance = 0.004.

Rank on the Post-MTAI

Factor C (emotional vs mature); tau = 0.368 and significance of 0.003; factor O (confident vs insecure); tau = -0.277 and significance of 0.023; and factor Q_4 relaxed vs tense); tau = -0.274 and significance equal to 0.025 were significantly correlated to the post-MTAI.

Rank on the MTAI Change Score

Only one factor, N (forthright vs shrewd), was significantly correlated to the teacher's change on the

MTAI from pre to post. The Kendall tau value was 0.260, with a level of significance of 0.023.

Figure 1 shows the correlation profiles for the relationship between the 16 PF and the MTAI.

Rank on the Pre-Process Test

Factors B (dull vs bright), tau = 0.251; and C (emotional vs mature), tau = 0.260 are significantly correlated to the pretest. The levels of significance are 0.040 and 0.033 respectively.

Rank on the Post-Process Test

No significant correlations were found between the 16 PF and the post-process test.

Rank on the Process Test Change Score

No significant correlations were found between the 16 PF and the process test change score. (See Figure 2 for profile of correlations between the 16 PF and process test.)

Rank on the Proportion of High-Level Questions

None of the personality factors was found to be significantly correlated with high-level questioning. The null hypothesis was not rejected for this dimension.

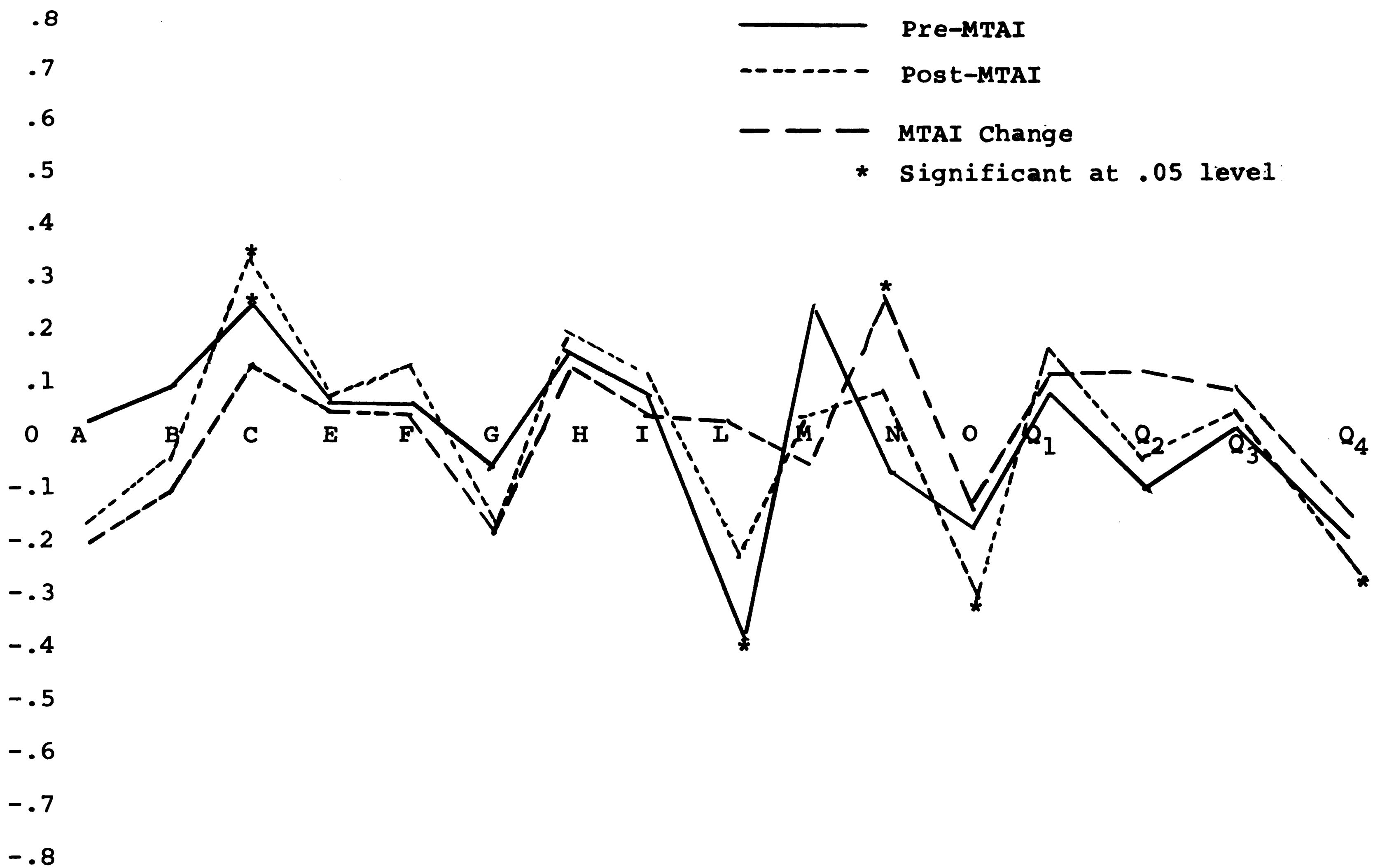

Figure 1. Profile of Correlations between 16 PF and MTAI.

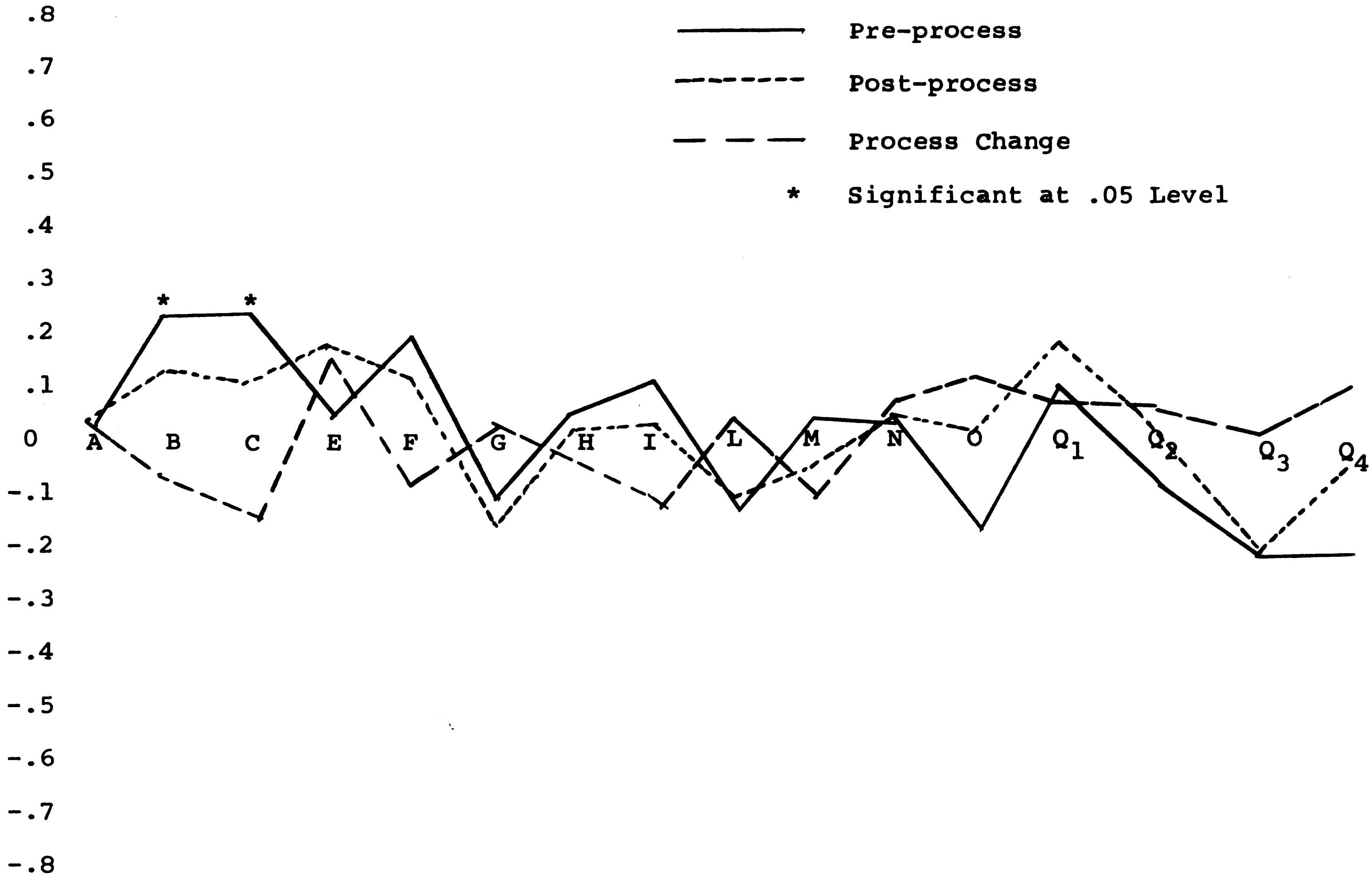

Figure 2. Profile of Correlations between 26 PF and Process Test.

In addition to analyzing the data for the relationships between the 16 PF and high-level questioning, these data were analyzed to determine specifically which question types were related to the 16 PF. Table 4 shows these significant correlations.

TABLE 4

Significant Kendall Tau Values between the 16 PF and High-Level Question Types Asked by SCIS Teachers

N = 33

	Tau	Level of Significance
Factor L (trustful vs jealous) with Demonstration of Skill	-0.347	0.007
Factor Q_3 (lax vs controlled) with Comprehension	-0.312	0.010
Factor L (trustful vs jealous) with Synthesis	-0.326	0.008
Factor O (confident vs insecure) with Synthesis	-0.299	0.014

While the questions in the table above are significantly related to personality factors, the over-all proportion of high-level questions was not significantly correlated with the 16 PF.

Rank on the Degree of Change in the Proportion of High-Level Questions Asked

No significant correlations were found between the 16 PF and the degree of change in the proportion of high-level questions asked; therefore, the null hypothesis was not rejected. Some significant correlations did exist between the personality factors and specific question types. (See Figure 3 for the profile of correlations between 16 PF and High-Level Questions.) Table 5 shows the results of the analysis of these data.

TABLE 5

Significant Kendall Tau Values between the 16 PF and Change in the Proportion of Question Types Asked

N = 15

	Tau	Probability
Factor Q_1 (conservative vs experimenting) with Demonstration of Skill	-0.413	0.008
Factor M (conventional vs imaginative) with Comprehension	-0.495	0.010

TABLE 5.--Continued

	Tau	Probability
Factor Q_1 (conservative vs experimenting) with Comprehension	-0.507	0.008
Factor Q_2 (imitative vs resourceful) with Comprehension	-0.422	0.028
Factor Q_4 (relaxed vs tense) with Comprehension	0.436	0.023

(See Appendix L for correlation matrix between 16 PF and question types.)

Summary of 16 PF Relationships

Factor C (emotional vs mature) was significantly correlated with both the pre-MTAI and post-MTAI. Only one factor, N (forthright vs shrewd) was significantly correlated to change in the teacher's attitude toward the teacher-pupil relationship. These results do not indicate the likelihood of a strong relationship between the 16 PF and the MTAI.

There was little evidence for an overall relationship between the 16 PF and the process test.

There was no evidence for establishing a significant relationship between the 16 PF and high-level questioning.

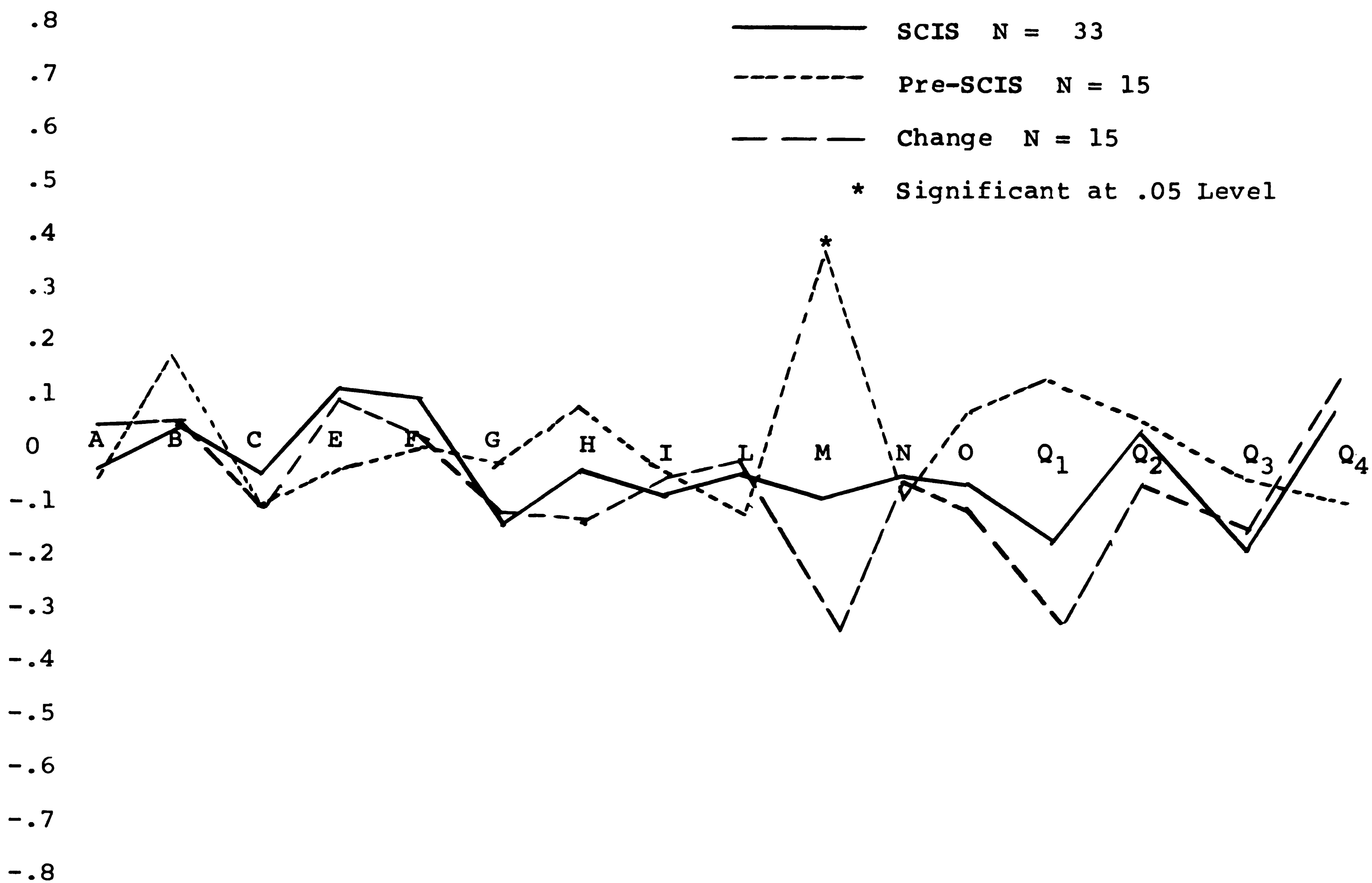

Figure 3. Profile of Correlations between 16 PF and High-Level Questions.

Relationship Between the Process Skills Test and Certain Characteristics of the SCIS Teacher

In this section the results of the analysis of the data is presented in the same manner in which it was presented for the preceding hypothesis. The root of the hypothesis is stated with the second parts of the hypothesis serving as the headings for subsequent subsections.

The hypothesis tested was:

Ho5: There is no significant correlation between the SCIS teacher's score on the process skills test and the following characteristics of the SCIS teacher:

a. rank on the proportion of high-level questions asked in the SCIS classroom;
b. rank on the proportion of high-level questions asked in the pre-SCIS classroom when the variables of age, experience, school district, science preference, and hours of science in academic background are held constant;
c. rank on the degree of change in the proportion of high-level questions asked;
d. rank on the pre-MTAI;
e. rank on the post-MTAI;
f. rank on the MTAI change score.

Rank on the Proportion of High-Level Questions Asked in the SCIS Classroom

The process posttest was found to be significantly correlated with high-level questioning. The correlation was 0.281 with a level of significance of 0.021. The null hypothesis was rejected for this pair of variables.

Further analysis revealed other significant correlations between the process test and question types. Table 6 shows the results of this analysis.

TABLE 6

Significant Kendall Tau Values between the Process Tests and SCIS Teacher Question Types

N = 33

	Tau	Probability
Pretest with Demonstration of Skill	0.372	0.002
Pretest with Comprehension	0.246	0.044
Change with Analysis	0.276	0.024

Rank on the Proportion of High-Level Questions Asked in the Pre-SCIS Classroom

Analysis of the data indicated that there was a negative correlation, -0.382, between the change score of the process test and high-level questioning before formal involvement in SCIS. The level of significance of this correlation was 0.046; therefore, the null hypothesis was rejected.

Further analysis indicated that a significant correlation existed between the proportion of demonstration of skill questions and the change score on the process test. The correlation between this pair of variables was -0.571 with a level of significance of 0.001.

Rank on the Degree of Change in the Proportion of High-Level Questions Asked Before and During Formal Involvement in the SCIS Program

The process change score was found to be significantly correlated with the degree of change in the proportion of high-level questions. This correlation was 0.463, with a level of significance of 0.016; therefore, the null hypothesis was rejected.

Analysis for the relationship of the process test to specific question types revealed a significant correlation between the process change score and the degree of change in the proportion of analysis questions asked. (See Appendix M for correlation matrix between process test and question types.)

Rank on the Pre-MTAI

The pre-MTAI was significantly correlated with the pre-process. The correlation was 0.271 with a level of significance of 0.027. The null hypothesis was rejected for this pair of variables.

Rank on the Post-MTAI

The pre-process was significantly correlated with the post-MTAI, as was the post-process. The correlations were 0.309 with a level of significance of 0.011 and 0.290 with a level of significance of 0.017 respectively. The null hypothesis was rejected for these variables.

Rank on the MTAI Change Score

No significant correlations were revealed by the analysis of the data. (See Appendix N for correlation matrix of process test and MTAI.)

Summary of Process Test Relationships

There was evidence of a relationship between the process test and high-level question asking behavior.

The finding that was of particular interest was the significant positive relationship between the change in high-level questioning behavior and change in the understanding of the processes of science. This finding seems reasonable since one would expect an increased awareness of the processes of science to facilitate improved question asking behavior.

The significant correlations between the process test and the MTAI would indicate that those teachers who had a more favorable attitude toward the teacher-pupil relationship also had a better understanding of the processes of science.

The Relationship between the MTAI and Selected Teacher Characteristics

The results of the analysis are presented in subsections with the subsection heading being the second part of the null hypothesis tested:

Ho6: There are no significant correlations between the teacher's score on the MTAI and the following characteristics:

a. rank on the proportion of high-level questions asked in the pre-SCIS classroom;

b. rank on the proportion of high-level questions asked in the SCIS classroom;

c. rank on the degree of change in the proportion of high-level questions asked.

Rank on the Proportion of High-Level Questions Asked in the SCIS Classroom

The analysis of these data revealed no significant correlation between the MTAI and high-level questioning. Further analysis indicated a significant relationship between the demonstration-of-skill question type and the pre-MTAI. The correlation was 0.355 with a level of significance of 0.003.

Rank on the Proportion of High-Level Questions Asked in the Pre-SCIS Classroom

No significant correlation existed between the MTAI and the pre-SCIS teacher's high-level questioning. Analysis of these data when considering specific question types did indicate a significant correlation between the pre-MTAI and the demonstration of skill question type. This correlation was 0.417 with a level of significance of 0.030. (See Appendix O for the correlation matrix of the MTAI and question types.)

Summary of MTAI Relationships

There was no evidence for establishing a relationship between the MTAI and high-level questioning.

Relationship between the Demographic Variables and the Teacher's Change Scores on the Process Test, MTAI, and High-Level Questioning

The results of the analysis were treated in the same manner in this section as in the preceding sections.

> Ho7: There is no significant correlation between the variables of age, experience, and hours of science in the academic background and any of the following characteristics of the SCIS teachers:
>
> a. rank on the degree of change in the proportion of high-level questions asked;
>
> b. rank on the MTAI change score;
>
> c. rank on the science process change score.

Rank on the Degree of Change in the Proportion of High-Level Questions Asked

Years of experience was found to be significantly correlated with the change in the proportion of high-level questions asked. The correlation between these variables was -0.410, and the level of significance was 0.033; therefore, the null hypothesis was rejected for this pair of variables.

Hours of science in the teachers' academic backgrounds was not significantly related to high-level questioning or any of the specific question types.

Age was not significantly related to the change in proportion of high-level questions asked; however, it was significantly correlated to high-level questioning among the 33 SCIS teachers. This correlation was -0.325 with a level of significance of 0.007. Further analysis shows age to be significantly related to two specific types of questions asked in the SCIS classroom. Table 7 shows the results of this analysis.

TABLE 7

Significant Kendall Tau Values between Age and Question Types of SCIS Teachers

N = 33

	Tau	Level of Significance
Recall of Fact	0.310	0.010
Analysis	-0.291	0.017

Rank on the MTAI Change Score

No significant correlations were found between the demographic variables and the MTAI change score. Further analysis does not reveal any significant correlations between the demographic variables and MTAI.

Rank on Process Test Change Score

All three demographic variables were significantly related to the process test change score. Significant negative correlations existed between the process change score and the variables of age and years of experience. These correlations were, respectively,-0.264 with a .031 level of significance and -0.243 with a 0.046 level of significance. The correlation between hours of science and the process change score was 0.274 with a level of significance of 0.025.

Summary of Demographic Variable Relationships

The findings indicated a significant negative correlation between the number of years of experience and the change in high-level questioning behavior. This finding takes on added meaning when one considers the negative correlation which existed among the 33 SCIS teachers between the years of experience and high-level questioning behavior. It would seem that the more experienced teachers were resistant to change in their high-level questioning behavior.

The significant correlations between the demographic variables and the change in the teacher's understanding of science processes is particularly important when one considers the negative relationship between the variables of age and years of experience and the change in process test scores. Again the more experienced teachers were more resistant to change.

A positive correlation existed between the number of hours of science in the teachers' academic backgrounds and change in the understanding of science processes.

Results of the Analysis of the Data when Certain Variables are Held Constant

In this section, the results of the analysis when the demographic variables are partialed out (held constant) are presented. Since the over-all analysis has been presented in preceding sections, only significantly different findings are presented.

Relationship between the 16 PF and MTAI when Demographic Variables are Held Constant

When these data were analyzed for all 33 teachers, factors C (emotional vs mature) and L (trustful vs jealous) were found to be significantly related to the MTAI pretest. Factors L (trustful vs jealous), O (confident vs insecure), and Q_4 (relaxed vs tense) were significantly related to the posttest, while factor N (forthright vs shrewd) was significantly correlated to the MTAI change score.

Physical Science Preference

Whereas factors C (emotional vs mature) and L (trustful vs jealous) were found to be significantly related to the pre-MTAI for all teachers, neither factor was found to be significant among the 16 SCIS teachers who preferred physical science. Only factor F (sober vs enthusiastic) was significantly correlated with the pre-MTAI.

Factors C (emotional vs mature) and L (trustful vs jealous) were found to be significantly related to the post-MTAI for those who preferred physical science. Factor L (trustful vs jealous) was not significantly related to the post-MTAI when these data were analyzed for the entire group.

No factors were found to be associated with the MTAI change, whereas factor N (forthright vs shrewd) was associated with MTAI change for the entire group. (See Appendix P for science preference instrument.)

Biological Science Preference

Thirteen teachers preferred biology. The only factor which was significantly correlated with the pre-MTAI was factor M (conventional vs imaginative). This factor did not appear when the tau value was computed for all teachers.

(See Appendix Q for correlations between 16 PF and MTAI when science preference is held constant.)

School District

The only significant correlations found when the' tau values were computed separately for each school district were revealed for school district number one, East Lansing. Factors A (aloof vs warm) and Q_1 (conservative vs experimenting) were determined to be significantly correlated to the MTAI change score; whereas, they were not significantly related for the over-all group. (See Appendix Q for correlations between 16 PF and MTAI when school district is held constant.)

Age, Hours of Science, and Experience

When age, hours of science, and experience are held constant, the only correlations obviously different from the Kendall tau correlations were those computed for the relationships between the process test and these same demographic variables. All three of these demographic variables are related. (See Appendix R.) Holding each variable constant did not produce a correlation which was large enough to be significant.

Relationship between the 16 PF and Process Test when Demographic Variables Are Held Constant

The analysis of these data for the entire group produced Kendall tau values which were significant for factors B (dull vs bright) and C (emotional vs mature) with the pretest; no factors with the posttest; and no factors with the process change score.

Prefer Physical Science

Among the sixteen teachers who preferred physical science, only two significant correlations existed between the 16 PF and the process test. The significant correlations found for the entire group were found for the physical science group; however, factors L (trustful vs jealous) and Q_4 (relaxed vs tense) were found to be significantly correlated to the post-process and process change respectively. (See Appendix Q for correlations between 16 PF and process test when science preference is held constant.)

Prefer Biological Science

Factor B (dull vs bright) is significantly correlated with both the pre-process and post-process tests.

School District

Three different correlations between the 16 PF and the process test were revealed when the Kendall tau was computed holding the school district constant. Factors C (emotional vs mature) M, (conventional vs imaginative), and Q_1 (conservative vs experimenting) were significantly correlated with the pre-process, process change score and post-process respectively. These results were only true of East Lansing.

Relationship between the 16 PF and High-Level Questioning

No significant correlations were found between high-level questioning and the 16 PF for the entire population. The only test which produced a significant correlation between the 16 PF and high-level questioning was when the Kendall tau correlation was computed for those teachers who preferred physical science. Factor Q_1 (conservative vs experimenting) was significantly correlated with high-level questioning. (See Appendix Q.)

There were no other pertinent significant correlations produced when the demographic variables were held constant.

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Summary for Relationships when Demographic Variables are Held Constant

Although some differences were noted when the original correlations were compared to the analysis if the demographic variables were held constant, no pattern was established which would indicate any significant deviations.

Profile Analysis

An attempt was made to describe the profile of the SCIS teacher who changes her verbal behavior of question asking, changes her attitude toward the teacher-pupil relationship, and increases her knowledge of the processes of science.

The 16 PF was administered as an instrument to measure the SCIS teacher's personality factors. The Minnesota Teacher Attitude Inventory was administered to assess the teacher's attitude toward the teacher-pupil relationship and teaching in general. The understanding of the processes of science was measured with the Science Process Test for Elementary School Teachers. Over 250 tapes of science lessons were analyzed for the types of questions asked by the teachers.

The analysis of these data produced only one significant correlation between the 16 PF and the areas of

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of change. There was a significant correlation between Factor N (forthright vs shrewd) of the 16 PF and the MTAI change score. This correlation could very likely have happened by chance alone, since one would expect at least two significant correlations out of 48. The correlation between factor N (forthright vs shrewd) and the MTAI was 0.260 with a level of significance of 0.017. A high score on N would indicate the following, in Cattel's terms:

> . . . ingenious, good at clinical diagnosis, flexible in viewpoint, alert to manners, to social obligations, and to the social reactions of others. The pattern represents some form of intellectual-educational development, not to be confused with intelligence, though it correlates both with intelligence and dominance. . . .
> . . . .
> Occupationally, the highest groups are the skilled professions and precision occupations, e.g., time-study engineers, scientists, pilots, and the lowest are priests, nurses, psychiatric technicians, cooks and convicts. . . . In group dynamics high N's are recorded with significantly greater frequency as leading in analytical, goal oriented discussion and constructive solutions, while low N's receive more checks as slowing and hindering proceedings.[1]

It would seem that the SCIS teachers do somewhat fit Cattell's description; however, since only one factor was significantly related to the MTAI change score, the correlation may not be descriptive.

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[1]Raymond B. Cattell and Herbert W. Eber, Handbook for the Sixteen Personality Factor Questionnaire (Champaign, Ill.: The Institute for Personality and Ability Testing, 1964), p. 17.

The process test change score was very highly correlated with the change in the proportion of high-level questions asked. This seems reasonable, for it would appear that an increased understanding of the processes of science would lead to the asking of higher-level questions. This finding takes on additional meaning with the knowledge that there were negative correlations, though not significant, between the proportion of recognition questions and the pre-process test for the pre-SCIS teachers.

The process test change score was also negatively correlated with three other characteristics. The proportion of demonstration of skill questions asked by the pre-SCIS teacher had a very significant correlation of -0.571, with a level of significance of 0.001. The asking of high-level questions by the pre-SCIS teacher was somewhat less correlated, -0.382, with a level of significance of 0.047. Both of these correlations seem reasonable.

The change in the proportion of analysis questions asked was positively correlated with the process test change score. The correlation was 0.430 with a level of significance of 0.024.

These analyses revealed a significant negative correlation between years of teaching experience and change in the proportion of high-level questions asked.

It is interesting to note that four of the sixteen personality factors were significantly correlated with the change in the proportion of comprehension questions asked. Comprehension questions are a form of hihg-level questioning and require that a child explain what he means. The four factors that were significantly related to this change are described bi-polarly as follows:

Factor M. U.I.(L) 13

AUTIA, M+ (BOHEMIAN INTRO-VERTED, ABSENT-MINDED)	Versus	PRAXERNIA, M- (PRACTICAL, CONCERNED WITH FACTS)
Unconventional, Self-absorbed	vs	Conventional, Alert to Practical Needs
Interested in Art, Theory, Basic Beliefs	vs	Interests Narrowed to Immediate Issues
Imaginative, Crea-tive	vs	No Spontaneous Creativity
Frivolous, Immature in Practical Judgment	vs	Sound, Realistic, De-pendable, Practical Judgment
Generally Cheerful but Occasional Hysterical Swings of "Giving Up"	vs	Earnest, Concerned or Worried, but Very Steady

Factor Q_1. U.I.(Q) 16

RADICALISM, Q_1+	Versus	CONSERVATISM OF TEMPERAMENT, Q_1-

Factor Q_2. U.I.(Q) 17

SELF-SUFFICIENCY, Q_2+ (SELF-SUFFICIENT, RESOURCEFUL)	Versus	GROUP DEPENDENCY, Q_2- (SOCIABLY GROUP DEPENDENT)

Factor Q_4. U.I.(Q) 19

HIGH ERGIC TENSION, Q4+ (TENSE, EXCITABLE	Versus	LOW ERGIC TENSION, Q4- (PHLEGMATIC, COMPOSED)[2]

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[2] *Ibid.*, pp. 16-19.

Factors M, Q_1 and Q_2 were negatively correlated, while Q_4 was positively correlated.

TABLE 8

Summary of Profile Analysis

Change		Tau	Significance
MTAI	Factor N (forthright vs shrewd)	0.260	0.017
Process	Analysis questions by SCIS teachers N = 33	0.276	0.024
	Demonstration of skill questions by pre-SCIS N = 15	-0.571 -0.571	0.001
	High-level questions by pre-SCIS N=15	-0.382	0.046
	Change in proportion of analysis questions N = 15	0.430	0.024
	Change in high-level questions N = 15	0.463	0.016
High-level questions	Years of experience	0.410	0.033

Summary of Question Analysis

Table 9 shows the results of the question analysis for the pre-SCIS teachers.

TABLE 9

Summary of Question Analysis for
Pre-SCIS Teachers

N = 15

Question Types	Number	Proportion
Recognition	85	0.078
Recall of Fact	623	0.570
Demonstration of Skill	36	0.033
Comprehension	75	0.069
Analysis	258	0.236
Synthesis	15	0.014
Total	1,092	
Over-all High Level	384	0.352

The summary of the question analysis agrees with earlier work cited in Chapter Two of this study. The 15 pre-SCIS teachers asked far more recall of fact questions than any other kind.

Table 10 lists a summary of the question analysis for the 33 teachers, including the 15 pre-SCIS teachers, after formal involvement in SCIS.

It is interesting to note that the recall of fact type question was still asked to a great degree though less than the analysis questions. This is to be expected because the recall question type is valuable to the teacher in helping her determine precisely what the children have learned. It would seem that the nature of the SCIS program forced the teacher to ask a greater proportion of high-level questions.

TABLE 10

Summary of Question Analysis for SCIS Teachers

N = 33

Question Types	Number	Proportion
Recognition	712	0.078
Recall of Fact	3,227	0.356
Demonstration of Skill	299	0.033
Comprehension	731	0.081
Analysis	4,059	0.448
Synthesis	34	0.004
Total	9,062	
Over-all High Level	5,123	0.565

Although the teachers were never told the exact nature of the research in which they were involved, the presence of the taping equipment undoubtedly affected their behavior. A few teachers indicated that they liked to be recorded because, "it made them concentrate more on what they were saying, and they weren't so critical of the children." Most teachers indicated that they personally felt that the taping did not affect their teaching significantly. It should be noted, however, that the longevity of the study (April, 1968 to April, 1969) may have allowed the teacher to become accustomed to the taping. The writer believes that because of the large number of observations, the question-asking behavior of the SCIS teacher has been very closely described.

Discussion of Study's Findings

Question Types

Although the null hypothesis was rejected for difference in proportion of high-level questions, only the analysis type of high-level question was asked in a significantly greater proportion after formal involvement in SCIS. The greatest reduction in the proportion of lower-level questions was of the recall of fact variety. It would appear that all the significant change in question asking behavior took place near the extreme of the question asking scale. Table 11 shows a summary of all of the pertinent findings of this study.

One would very likely have expected a significant increase in the proportion of demonstration of skill

TABLE 11

Summary of Findings

	Tested for the	Results Based upon $\alpha = .05$	Comment
1.	Difference in high-level questioning before and during involvement in SCIS.	Significant.	N = 15 Only one high-level question type, analysis, was significantly different.
2.	Difference in attitude toward the teacher-pupil relationship before and during involvement in SCIS.	Not significant.	N = 33 Pretest administered in August, 1968; posttest in April, 1969.
3.	Difference in the understanding of process skills before and during involvement in SCIS.	Not significant.	N = 33 Pretest administered in August, 1968; posttest in April, 1969.
4.	Relationship between the 16 PF and the MTAI.	Two factors significantly related.	N = 33 Factor C (emotional vs mature) with both pre and post). Factor N (forthright vs. shrewd) with MTAI change.

TABLE 11.--Continued

Tested for the	Results Based upon $\alpha = .05$	Comment
5. Relationship between the 16 PF and the process test.	No significant relationships.	N = 33
6. Relationship between the 16 PF and high-level questioning.	No significant relationships.	N = 33 for SCIS high-level questions. N = 15 for change in high-level questions.
7. Relationship between the process test and high-level questioning.	Significant.	Results significant for correlation between post-process and high-level questions for SCIS teachers (N = 33). Results significant for correlation between process change score and high-level questioning change (N = 15). Results significant for negative correlation between high-level questions and process change score (N = 15).

TABLE 11.--Continued

Tested for the	Results Based upon $\alpha = .05$	Comment
8. Relationship between the process test and MTAI.	Significant.	Results significant between pre-process and pre-MTAI; pre-process and post-MTAI; post-process and post-MTAI (N = 33).
9. Relationship between the MTAI and high-level questioning.	Not significant.	N = 33 for high-level. N = 15 for change in high-level.
10. Relationship between years of experience and change in high-level questioning.	Significant.	N = 15 Negative correlation.
11. Relationship between hours of science and change in high-level questioning.	Not significant.	N = 15
12. Relationship between age and change in high-level questioning.	Not significant	N = 15

TABLE 11.--Continued

Tested for the	Results Based upon $\alpha = .05$	Comment
13. Relationship between hours of science and change in the understanding of the process of science.	Significant.	N = 33 Positive correlation.
14. Relationship between age and change in the understanding of the processes of science.	Significant.	N = 33 Negative correlation.
15. Relationship between years of experience and change in the understanding of the processes of science.	Significant.	N = 33 Negative correlation.
16. Relationships between the variables of hours of science, years of experience, and age with the MTAI.	No significant relationships.	N = 33

questions since the SCIS program would require the child to depict his findings in a pictorial or graphical fashion. Tables 9 and 10 indicate that actually the SCIS and pre-SCIS groups asked the same proportions of demonstration of skill questions.

It is possible that the asking of demonstration of skill questions requires that the teacher have a greater understanding of the science processes. A significant positive correlation existed between the teacher's score on the pre-process test and the asking of demonstration of skill questions for SCIS teachers (N = 33). At the time the SCIS teachers took the post-process test, this correlation had decreased. These correlations were 0.372 and 0.177 respectively. An examination of the relationship between the change in the proportion of asking demonstration of skill questions and the process test change score indicates that a relatively high correlation, though not significant, existed. This correlation was 0.346 with a level of significance of 0.072.

Teacher Attitude

The attitude of the teacher toward the teacher-pupil relationship did not change significantly. One might think that since the Minnesota Teacher Attitude Inventory is a relatively old instrument, it is no longer valid. It is interesting to note the extreme range of scores exhibited on both the pretest and the posttest of the MTAI. (See Appendix H.)

Teacher Understanding of the Processes of Science

The findings indicated that there was no significant difference in the SCIS teacher's understanding of the processes of science before and during formal involvement in the program. From the descriptive data supplied by the test's author,[3] the SCIS teachers are not markedly different from the groups on which the test's reliability was established. The test author's group had a mean score of 21.34 while the SCIS teachers had a mean of 20.96 on the pretest and 20.30 on the posttest.

The findings further indicated a relationship between the process test and high-level question asking behavior.

Relationship between the 16 PF and Question Types

There was no indication that a significant relationship exists between high-level questioning and the 16 PF. However, nine correlations were found to be significantly related to either specific question types

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[3]Data was supplied by Evan Sweetser.

or change in the proportion of specific question types. This could have happened by change; however, four of the nine significant correlations occurred with the change in proportion of comprehension questions asked.

Relationship between the 16 PF and MTAI

One of the factors, C (emotional vs mature), of the 16 PF was significantly correlated to both the pre-MTAI and post-MTAI. Other than this factor, there was little evidence of strong relationship between the two variables for the SCIS teachers.

Relationship between the 16 PF and the Process Test

With the exception of one significant correlation, between factor C (emotional vs mature) and the pre-process, little evidence existed for the establishment of a relationship between the 16 PF and the process test for SCIS teachers.

Relationship between the Process Test and MTAI

The pre-MTAI and the pre-process test were significantly related. The post-MTAI was significantly correlated with both the pre-process and the post-process tests.

Relationships between Demographic Variables and the Process Tests and the MTAI

The change in the teacher's understanding of the processes of science was significantly related to all three of these demographic variables. This is not surprising, since the three variables are very highly correlated to each other. Negative correlations existed between the process test change score and experience and age. A positive correlation existed between the process test change score and the hours of science in the academic background.

None of the three demographic variables were significantly related to the pre-process test, while hours of science with a positive correlation and age with a negative correlation were related to the posttest. The number of hours of science in the academic background was not significantly correlated to the post-process test, but was very close with a level of significance of 0.054.

These findings seem reasonable in that those teachers with better science backgrounds were able to accommodate change in the understanding of science processes easier than those with poor backgrounds in science.

The MTAI was not significantly related to the demographic variables for the SCIS teachers.

Relationship between the MTAI and Question Types

Only two significant correlations existed between the MTAI and question types. The pre-MTAI was significantly correlated to the proportion of demonstration of skill questions asked by both the SCIS and pre-SCIS teachers.

Summary

In this chapter, the pertinent data were presented. The results of the analysis of the data for each question were reported. All of the decisions regarding the level of significance were made at the .05 level for a two-tailed test. Summaries of the findings were presented in later sections of this chapter. Chapter V consists of conclusions and implications.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

The purpose of this study was to analyze the possible relationships that exist among selected measured characteristics of a group of elementary school teachers involved in the SCIS program and to assess the changes exhibited by these teachers in their question asking behavior and understanding of the processes of science.

Conclusions

It has been shown that the teachers involved in this study did change their question asking behavior during formal involvement in SCIS. The high-level questions were asked to a significantly greater degree after formal involvement in the program. The type of high-level question preferred by the SCIS teachers was of the analysis type, which elicits a greater degree of cognitive skill than do the recall of fact questions, which were asked to a great degree by the pre-SCIS teachers.

Though there were several significant correlations between the measured personality factors and the question asking behavior, particularly the change in the proportion of comprehension questions asked, sufficient evidence was not obtained to conclude that there is a relationship between the personality factors and question asking behavior.

It may also be concluded that the number of hours of science in these SCIS teachers' academic backgrounds is related to their understanding of the science processes.

The significant negative correlation between the hours of science and years of teaching experience, coupled with the significant negative correlation between teaching experience and the change in the proportion of high-level questions asked, leads one to conclude that the more experienced teachers with poorer science background are least likely to change their high-level question asking behavior.

Implications

The findings of this study would indicate the work done in the summer workshop related to the understanding of processes did not have a lasting effect, since no difference was found between the pre-process and the post-process tests. This does not imply that the processes were not adequately taught during the summer workshop. It is possible that the instrument used to measure the understanding of processes may have been too difficult; therefore, serious consideration should be given to using more than one instrument or devising another. Neither a workshop nor consultant services can adequately provide the teacher with a total science background. In view of the findings of this study, perhaps more individual attention should be given those teachers whose science backgrounds are weak in order that they may improve their questions asking behavior and understanding of the processes of science.

Implications for Future Research

Further exploration into the relationships that may exist between teacher characteristics and classroom behavior is necessary.

Techniques which allow the researcher to adequately approximate the behavior of the teacher and the pupils in the classroom must be refined. The technique used in this study for collecting classroom data for analysis was suitable, providing one is only interested specifically in the verbal interaction of the teacher and those children in her immediate vicinity. A technique of providing visual as well as audio output needs to be employed.

Future research in question analysis should concentrate on the students' reactions to the teacher's questions as well as the question itself. The assumption made in this study and others regarding the level of cognitive activity might be further analyzed in this manner.

Other personality instruments and attitude inventories could be employed in an attempt to gather information which may be related to the teacher's behavior in the classroom.

An attempt should be made to train teachers to analyze their own questions in an effort to produce change in question asking behavior.

Perhaps more sophisticated analysis techinques need to be developed which would provide the researcher with the actual structure of the question. A more complete analysis might reveal patterns of individual differences which could then be related to other measurable characteristics and used for predictive purposes.

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APPENDICES

APPENDIX A

SCIS SUMMER WORKSHOP SCHEDULE

SCIS SUMMER WORKSHOP SCHEDULE

Week I

<u>Monday, August 5</u>

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 Kegayama
	Break
2:00 - 4:00 p.m.	Introduction to the SCIS Kits Grade 1 teachers, <u>Organisms</u> Grade 2 teachers, <u>Interaction</u>

<u>Tuesday, August 6</u>

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, <u>Material Objects</u> Grade 2 teachers, <u>Life Cycles</u>
	Lunch

12:45 - 1:45 p.m.	<u>The Science Process Test</u> Moon
	Break
2:00 - 4:00 p.m.	Inquiry Laboratory (Observed by College Science Educators)

<u>Wednesday, August 7</u>

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.	<u>Minnesota Teacher Attitude Inventory</u> Bruce
	Break
1:45 - 2:30 p.m.	"Introduction to Micro-Teaching" Berkheimer
2:30 - 4:00 p.m.	Laboratory: Grade 1, <u>Organisms</u> Grade 2, <u>Interaction</u>

<u>Thursday, August 8</u>

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 I Barnes

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 p.m.	Demonstration Teaching: Grade 1, _Organisms_ Grade 2, _Interaction_

Tuesday, August 13

9:00 - 10:30 a.m.	"Principles of Learning" Berkheimer
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
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, <u>Material Objects</u>, film, Activity 8, "Grouping Collections of Objects" Grade 2, <u>Life Cycles</u>

<u>Thursday, August 15</u>

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 PF Questionnaire (Personality test) Bruce
	Break
2:00 - 4:00 p.m.	Demonstration Teaching: Grade 1, <u>Organisms</u> Grade 2, <u>Interaction</u>

<u>Friday, August 16</u>

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	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
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

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 a.m.	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 Barnes
	Break
2:00 - 4:00 p.m.	Inquiry Laboratory Films: "Experimenting with Air" "Karplus with Children"

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

APPENDIX B

DEMOGRAPHIC VARIABLE DATA FOR

ALL TEACHERS N = 33

Teacher	Pre-SCIS SCIS	Career-Non-career	School District	Science Preference	Years of Experience	Hours of Science	Age
1	2	1	1	1	04	21	25
2	2	2	1	2	02	15	24
3	1	1	1	1	04	11	41
4	2	1	4	2	00	20	22
5	1	1	1	1	16	10	48
6	1	1	3	1	08	09	55
7	1	1	1	1	04	18	26
8	1	1	3	1	01	13	57
9	1	2	2	4	02	11	23
10	1	3	1	3	01	15	23
11	1	2	1	2	01	08	22
12	1	1	3	1	43	03	61
13	2	1	2	2	00	21	21
14	2	1	1	2	02	21	23
15	2	1	1	4	08	06	49
16	2	3	2	1	00	14	24
17	2	2	1	2	05	12	27
18	1	1	3	2	01	07	25
19	2	1	4	1	06	06	41
20	1	1	2	2	17	07	53
21	2	1	4	3	01	54	27
22	2	1	4	4	00	20	22
23	2	2	3	2	06	06	30
24	2	2	3	2	00	13	24
25	2	1	4	1	02	32	46
26	2	1	3	1	00	24	32
27	1	1	1	1	10	08	54
28	2	2	4	2	03	07	24
29	2	2	1	2	07	12	28
30	1	1	4	1	01	14	34
31	1	3	1	4	05	15	26
32	1	1	1	1	05	16	32
33	1	1	1	1	10	13	35

Legend: Teacher: (01-33); Pre-SCIS = 1; SCIS = 2; Career = 1; Non-career = 2; Undecided = 3; School District: East Lansing = 1; Grand Ledge = 2; DeWitt = 3; Perry = 4; Science Preference: Physical Science = 1; Biological Science = 2; Both equally = 3; No Preference = 4.

APPENDIX C

QUESTION ANALYSIS DATA FOR

PRE-SCIS TEACHER N = 15

24 OBSERVATIONS

	Recognition		Recall		Demonstration of Skill		Comprehension	
Teacher	No.	Prop.	No.	Prop.	No.	Prop.	No.	Prop.
3	2	0.016	37	0.291	5	0.039	16	0.126
5	0	0.000	33	0.943	0	0.000	2	0.057
6	4	0.210	15	0.789	0	0.000	0	0.000
7	23	0.159	37	0.255	6	0.041	12	0.083
8	0	0.000	17	1.000	0	0.000	0	0.000
9	4	0.080	45	0.900	0	0.000	0	0.000
10	2	0.025	67	0.838	0	0.000	6	0.075
11	3	0.035	68	0.800	0	0.000	1	0.012
12	20	0.137	104	0.712	3	0.020	4	0.027
18	0	0.000	18	0.750	2	0.083	1	0.042
20	4	0.051	41	0.519	4	0.051	1	0.013
27	0	0.000	5	0.454	2	0.182	0	0.000
31	1	0.037	15	0.556	0	0.000	6	0.222
32	6	0.046	85	0.659	2	0.016	12	0.093
33	16	0.138	36	0.310	12	0.103	14	0.121

Analysis		Synthesis		Total No. Ques.	Total No. Obs.	Prop. High Level Ques.
No.	Prop.	No.	Prop.			
61	0.480	6	0.047	127	2	0.693
0	0.000	0	0.000	33	2	0.057
0	0.000	0	0.000	19	2	0.000
61	0.421	6	0.041	145	2	0.586
0	0.000	0	0.000	17	1	0.000
1	0.020	0	0.000	50	1	0.020
7	0.088	0	0.000	80	2	0.163
13	0.153	0	0.000	85	2	0.165
15	0.103	0	0.000	146	2	0.151
3	0.125	0	0.000	24	1	0.250
27	0.348	2	0.025	79	1	0.430
4	0.364	0	0.000	11	1	0.545
5	0.185	0	0.000	27	1	0.407
24	0.186	0	0.000	129	2	0.294
37	0.319	1	0.009	116	2	0.552

APPENDIX D

QUESTION ANALYSIS FOR

SCIS TEACHERS N = 33

229 OBSERVATIONS

	Recognition		Recall		Demonstration of Skill		Comprehension	
Teacher	No.	Prop.	No.	Prop.	No.	Prop.	No.	Prop.
1	7	0.025	51	0.185	14	0.051	22	0.080
2	28	0.077	76	0.209	20	0.055	10	0.028
3	28	0.112	90	0.361	8	0.032	28	0.112
4	18	0.048	164	0.436	14	0.037	46	0.122
5	23	0.093	90	0.364	17	0.069	27	0.109
6	20	0.143	94	0.671	0	0.000	4	0.028
7	25	0.100	80	0.319	31	0.124	7	0.028
8	21	0.077	102	0.372	2	0.007	26	0.095
9	30	0.047	190	0.301	8	0.013	55	0.087
10	16	0.065	70	0.283	5	0.020	33	0.134
11	13	0.046	77	0.274	13	0.046	76	0.270
12	27	0.093	179	0.617	8	0.028	11	0.038
13	18	0.074	96	0.393	6	0.024	6	0.024
14	24	0.089	81	0.300	6	0.022	16	0.059
15	30	0.164	94	0.514	6	0.033	4	0.022
16	30	0.089	132	0.392	10	0.030	11	0.033
17	6	0.015	78	0.200	35	0.090	44	0.113
18	28	0.075	145	0.389	29	0.078	35	0.094
19	10	0.052	88	0.461	1	0.005	14	0.073
20	20	0.090	107	0.484	1	0.004	17	0.077
21	20	0.102	79	0.401	0	0.000	7	0.035
22	6	0.094	34	0.531	0	0.000	1	0.016
23	28	0.073	76	0.199	17	0.045	19	0.050
24	30	0.108	80	0.287	19	0.068	25	0.090
25	12	0.046	112	0.429	0	0.000	3	0.011
26	42	0.120	111	0.316	40	0.114	39	0.111
27	37	0.085	140	0.322	9	0.021	31	0.071
28	18	0.096	54	0.287	2	0.011	8	0.042
29	15	0.058	75	0.292	0	0.000	53	0.206
30	25	0.100	122	0.488	0	0.000	5	0.020
31	20	0.077	89	0.341	6	0.023	27	0.103
32	17	0.074	99	0.430	6	0.009	17	0.074
33	20	0.142	72	0.511	6	0.043	4	0.028

Analysis		Synthesis		Total No.	Total No.	Prop. High
No.	Prop.	No.	Prop.	Ques.	Obs.	Level Ques.
178	0.647	2	0.007	275	8	0.785
229	0.631	0	0.000	363	7	0.713
92	0.369	3	0.012	249	8	0.526
133	0.354	1	0.003	376	6	0.516
90	0.364	0	0.000	246	8	0.542
16	0.114	0	0.000	140	6	0.143
102	0.406	6	0.024	251	7	0.587
120	0.438	3	0.011	274	6	0.551
349	0.552	0	0.000	632	9	0.659
123	0.498	0	0.000	247	8	0.652
97	0.345	5	0.018	281	7	0.680
63	0.217	2	0.008	290	6	0.290
118	0.484	0	0.000	244	7	0.533
143	0.530	0	0.000	270	7	0.611
49	0.268	0	0.000	183	8	0.322
154	0.457	0	0.000	337	8	0.519
199	0.510	1	0.002	390	8	0.715
134	0.359	2	0.005	373	7	0.536
78	0.408	0	0.000	191	7	0.487
76	0.344	0	0.000	221	7	0.425
91	0.476	0	0.000	197	7	0.497
25	0.391	0	0.000	64	6	0.406
240	0.628	2	0.005	382	7	0.722
123	0.441	2	0.007	279	7	0.606
134	0.513	0	0.000	261	6	0.525
116	0.330	3	0.008	351	7	0.564
218	0.501	0	0.000	435	8	0.593
106	0.564	0	0.000	188	6	0.617
114	0.444	0	0.000	257	5	0.650
96	0.384	2	0.008	250	8	0.412
119	0.456	0	0.000	261	7	0.582
95	0.413	0	0.000	230	5	0.496
39	0.276	0	0.000	141	7	0.347

APPENDIX E

SCOTT COEFFICIENT OF RELIABILITY

FOR 253 OBSERVATIONS

Tape Number	A	B	C	D	E	F	π
008	0.000	0.250	0.000	0.250	0.500	0.000	1.00
008	0.000	0.250	0.000	0.250	0.500	0.000	
d	0.000	0.000	0.000	0.000	0.000	0.000	
012	0.153	0.153	0.050	0.102	0.508	0.034	.94
012	0.164	0.164	0.049	0.082	0.508	0.033	
d	0.011	0.011	0.001	0.020	0.000	0.001	
015	0.061	0.306	0.102	0.306	0.224	0.000	.81
015	0.042	0.375	0.104	0.292	0.188	0.000	
d	0.019	0.069	0.002	0.014	0.036	0.000	
038	0.000	0.511	0.021	0.064	0.383	0.021	.81
038	0.020	0.500	0.040	0.080	0.360	0.000	
d	0.020	0.011	0.019	0.016	0.023	0.021	
047	0.138	0.091	0.000	0.046	0.690	0.000	.76
047	0.111	0.111	0.000	0.031	0.746	0.000	
d	0.027	0.020	0.000	0.015	0.056	0.000	
044	0.045	0.344	0.000	0.119	0.505	0.000	.92
044	0.043	0.362	0.000	0.116	0.478	0.000	
d	0.002	0.018	0.000	0.003	0.027	0.000	
062	0.000	1.000	0.000	0.000	0.000	0.000	1.00
062	0.000	1.000	0.000	0.000	0.000	0.000	
d	0.000	0.000	0.000	0.000	0.000	0.000	
032	0.033	0.817	0.000	0.100	0.083	0.000	.75
032	0.030	0.773	0.000	0.091	0.106	0.000	
d	0.003	0.044	0.000	0.009	0.023	0.000	
041	0.034	0.483	0.000	0.034	0.448	0.000	.85
041	0.040	0.440	0.000	0.040	0.480	0.000	
d	0.006	0.043	0.000	0.006	0.032	0.000	
065	0.063	0.406	0.006	0.000	0.531	0.000	.95
065	0.074	0.407	0.000	0.000	0.518	0.000	
d	0.011	0.001	0.000	0.000	0.013	0.000	

Legend: Recognition = A, Recall = B, Demonstration of Skill = C, Comprehension = D, Analysis = E, Synthesis = F, Scott Coefficient of Reliability, = Absolute Difference.

Tape Number	A	B	C	D	E	F	π
009	0.000	0.029	0.206	0.147	0.588	0.029	.81
009	0.000	0.086	0.200	0.143	0.571	0.000	
d	0.000	0.057	0.006	0.004	0.017	0.029	
004	0.234	0.085	0.255	0.234	0.170	0.121	.69
004	0.302	0.140	0.256	0.163	0.140	0.000	
d	0.068	0.055	0.001	0.071	0.030	0.021	
109	0.000	0.769	0.000	0.000	0.231	0.000	.71
109	0.000	0.821	0.000	0.000	0.179	0.000	
d	0.000	0.052	0.000	0.000	0.052	0.000	
130	0.133	0.299	0.000	0.000	0.578	0.000	.74
130	0.146	0.354	0.000	0.000	0.500	0.000	
d	0.013	0.055	0.000	0.000	0.078	0.000	
053	0.030	0.119	0.059	0.169	0.624	0.000	.94
053	0.034	0.111	0.060	0.179	0.615	0.000	
d	0.004	0.008	0.001	0.010	0.009	0.000	
107	0.250	0.125	0.000	0.125	0.500	0.000	.77
107	0.200	0.200	0.000	0.100	0.500	0.000	
d	0.050	0.075	0.000	0.025	0.000	0.000	
120	0.143	0.714	0.000	0.000	0.143	0.000	.65
120	0.111	0.667	0.000	0.000	0.222	0.000	
d	0.032	0.047	0.000	0.000	0.079	0.000	
148	0.111	0.578	0.000	0.000	0.311	0.000	.78
148	0.106	0.511	0.000	0.000	0.362	0.000	
d	0.005	0.067	0.000	0.000	0.051	0.000	
067	0.074	0.444	0.000	0.000	0.481	0.000	.88
067	0.069	0.414	0.000	0.000	0.448	0.000	
d	0.005	0.030	0.000	0.000	0.033	0.000	
034	0.195	0.402	0.091	0.039	0.259	0.013	.83
034	0.203	0.419	0.068	0.014	0.297	0.000	
d	0.006	0.017	0.023	0.025	0.038	0.013	
038	0.000	0.511	0.021	0.064	0.383	0.021	.92
038	0.000	0.490	0.020	0.059	0.412	0.020	
d	0.000	0.021	0.001	0.005	0.019	0.001	

Tape Number	A	B	C	D	E	F	π
072	0.037	0.167	0.000	0.000	0.796	0.000	.89
072	0.034	0.186	0.000	0.000	0.780	0.000	
d	0.003	0.019	0.000	0.000	0.016	0.000	
207	0.428	0.572	0.000	0.000	0.000	0.000	1.00
207	0.428	0.572	0.000	0.000	0.000	0.000	
d	0.000	0.000	0.000	0.000	0.000	0.000	
035	0.026	0.128	0.128	0.282	0.436	0.000	.86
035	0.048	0.143	0.095	0.262	0.452	0.000	
d	0.014	0.015	0.033	0.020	0.016	0.000	
202	0.053	0.368	0.000	0.105	0.316	0.158	.82
202	0.077	0.346	0.000	0.115	0.346	0.115	
d	0.024	0.022	0.000	0.010	0.030	0.043	

APPENDIX F

LETTERS OF INVITATION AND POSTTESTING SCHEDULE

March 7, 1969

Dear

We hope your vacation will be a pleasant one and know that you are looking forward to the remainder of the year. As you are aware, the three of us are attempting to finish our degrees; and your continued help is most urgently needed. We realize that our work has, at times, been a nuisance to you. Your patience and understanding is appreciated. Without your cooperation, the attainment of our degrees is virtually impossible. We must now appeal to you for another favor.

On Saturday, April 19, we would like to invite you to a luncheon. Prior to the luncheon, we would like to administer the last instruments of our studies. We will have coffee and rolls served at 9:00 a.m. after which we plan to administer the two instruments and final questionnaire at intervals throughout the remainder of the morning. We will then go to the "63" Room of McDonel Hall for lunch and visiting. Since the instruments are not overly demanding or time consuming, this should be an enjoyable as well as profitable morning.

If anyone anticipates transportation problems, one of us will be happy to pick you up and return you to your home.

The importance of your attendance on Saturday, April 19, cannot be overemphasized. We realize that the luncheon is a small thing, but it is a token of our sincere appreciation for your continued support. We say continued because without these final measures, all of our research would have been to no avail; and our degrees cannot be completed.

Again, thank you and may the remainder of the year be both rewarding and successful.

Sincerely,

March 7, 1969

Dear

Part of our responsibility as a SCIS trial center is to conduct research related to the SCIS program. Research can provide information upon which science education decisions can be based, but research is usually hard work for the researcher and inconvenient for the participants. Realizing this, we want to sincerely thank you for your contributions to the research studies thus far.

While teaching the process of observation, many of you taught the children that you must observe before and after the event to collect evidence of interaction for comparisons. This is a fundamental notion in science which applies also to the research that Larry, Tom, and Steve are conducting.

The observations that they have made so far are of no value unless they can make the final observations. I urge you, therefore, to cooperate with them in collecting the last portion of data that is essential to their research and to the completion of their doctoral dissertations.

I assure you that all the information collected is held in the strictest confidence. Only Larry, Tom, and Steve will ever know your scores.

Thanking you for your continued cooperation in building better science experiences for children, I remain

Cordially yours,

Glenn D. Berkheimer
SCIS Trial Center Coordinator

APPENDIX G

SCIENCE PROCESS TEST FOR

ELEMENTARY SCHOOL TEACHERS

(Developed by Dr. Evan Sweetser

Currently of Virginia Polytechnical

Institute of Blacksburg, Virginia)

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.

<u>DO NOT MARK IN THE TEST BOOKLET</u>

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.

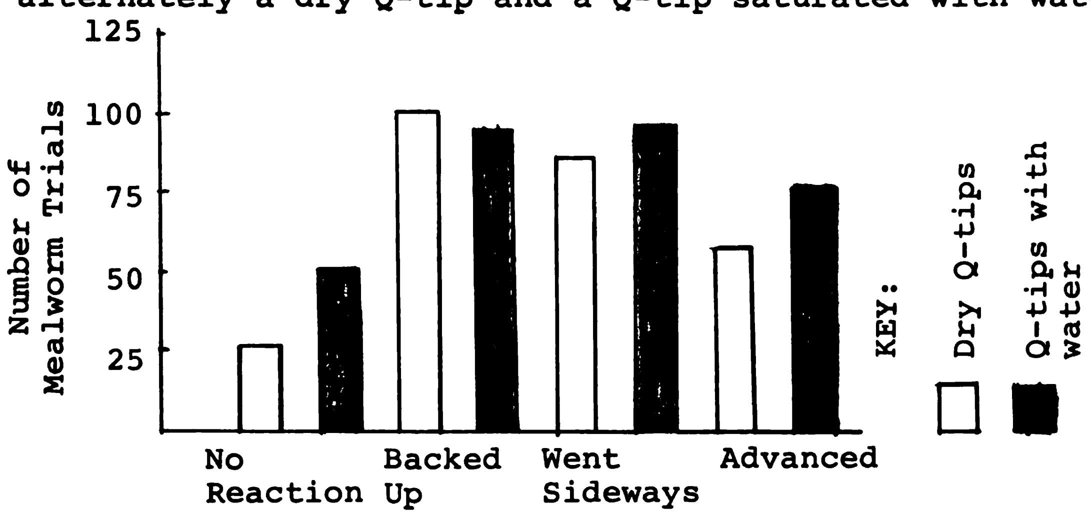
6. Based upon this and the preceding data, the best interpretation of these results would be that

(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.

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 sideways 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?

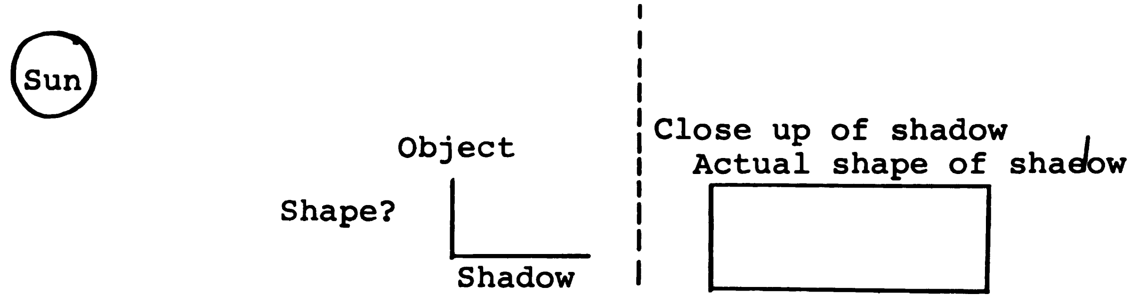
   (1) greater than 150.
   (2) less than 60.
   (3) between 40 and 50.
   (4) between 75 and 100.
   (5) between 100 and 150.

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

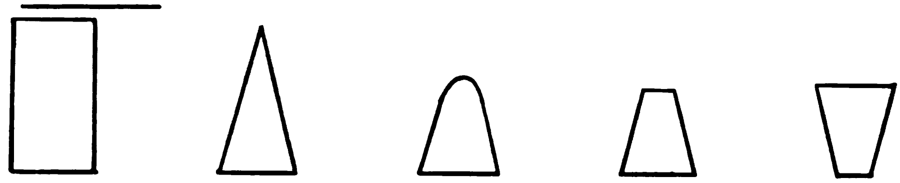
   (1) mealworms will react to Q-tips.
   (2) mealworms will react to water on a Q-tip.
   (3) mealworms will respond negatively to anything foreign to their environment.
   (4) mealworms will respond to any moving object.
   (5) none of the above hypotheses were checked in this series of experiments.

---

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



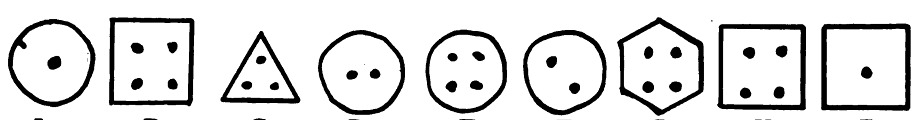
Which of the following objects could have cast a shadow in that given situation? NOTE: The view of the object is that side (or front) view toward the sun.



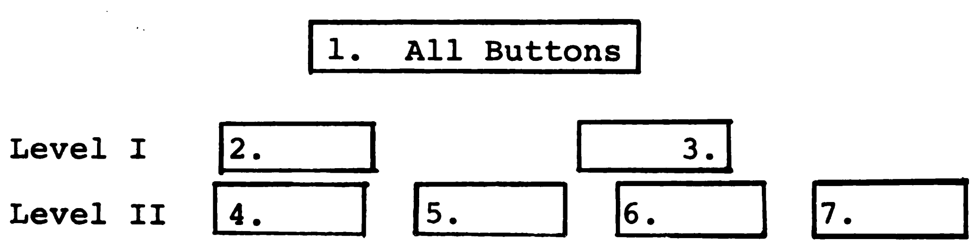
(1) (2) (3) (4) (5)

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.



A B C D E F G H I



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-holes 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?

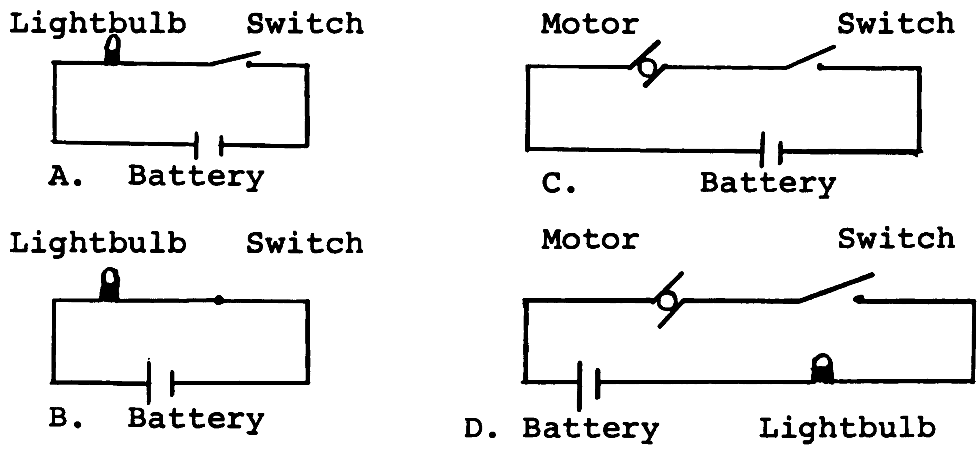
(1) not round and more than one hole.
(2) round and more than one hole.
(3) square.
(4) round and one hole.
(5) not round and one hole.

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

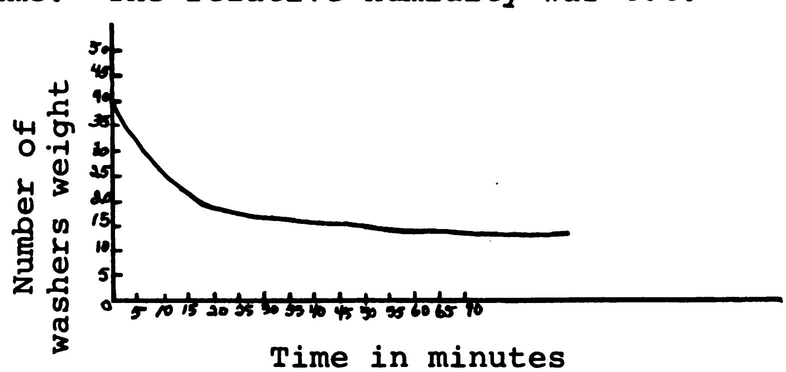
---

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%.

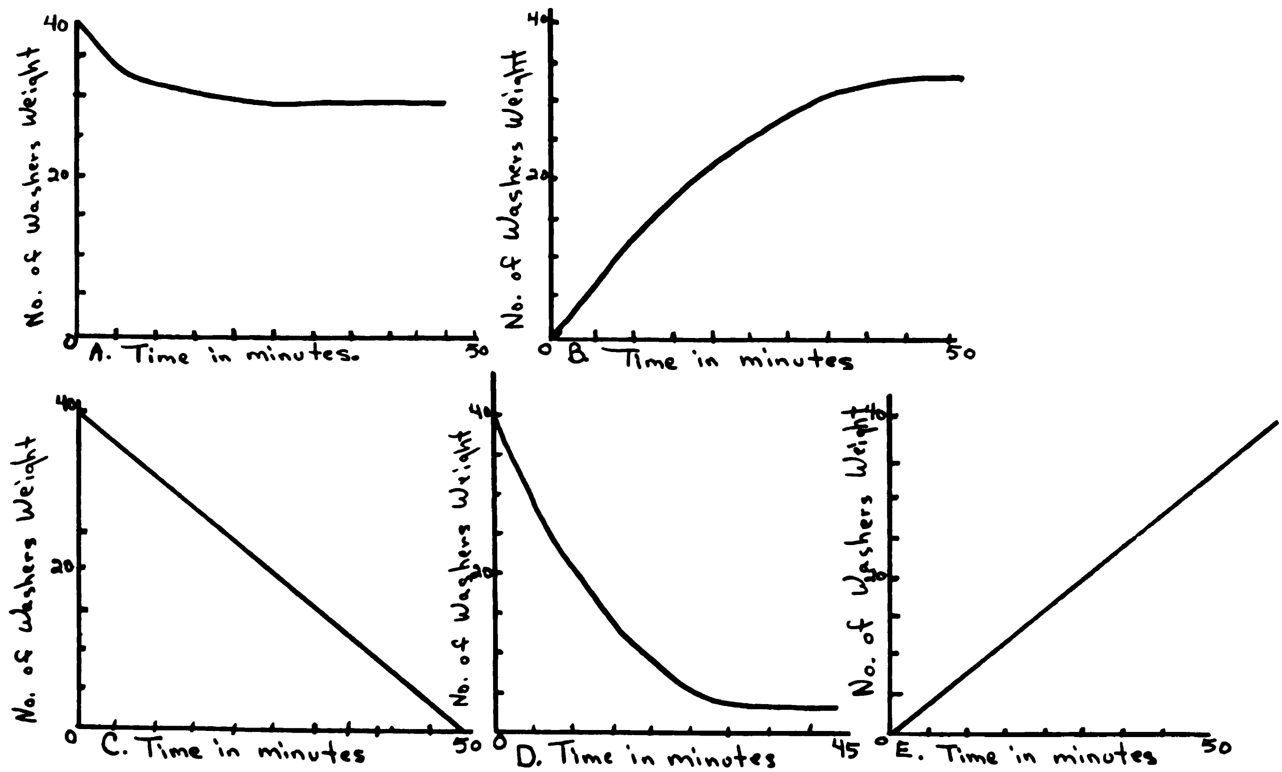


Based upon the data in the graph one could best conclude that more water evaporated.

(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 look 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 deserved 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?

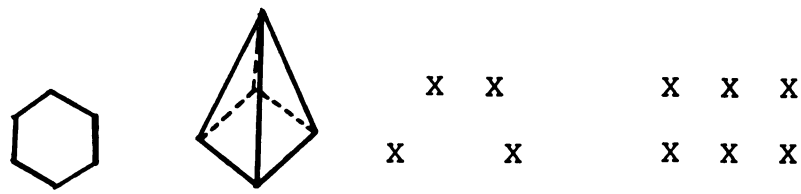
(1) Scalar.
(2) Preditive measurement.
(3) Vector measurement.
(4) Both (2) and (3).
(5) None of the above.

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?

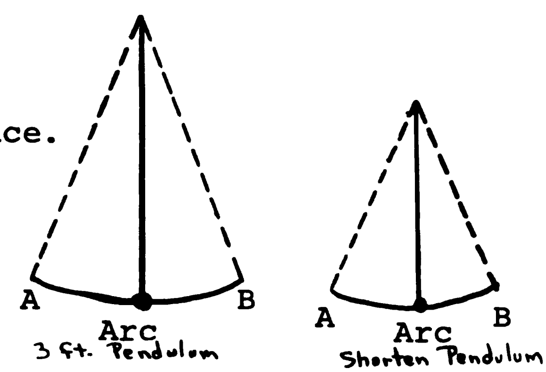


A B C D

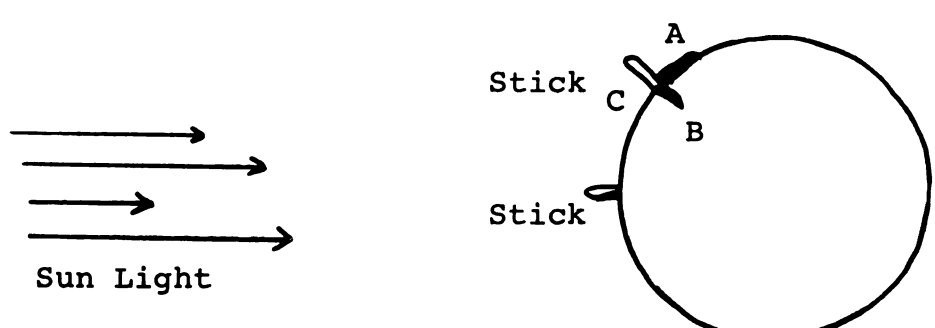
(1) A
(2) A & B
(3) A & C
(4) A, B, and C.
(5) A, B, and D.

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 <u>34</u> 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 <u>can we conclude</u> 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 H

SCORES ON MTAI AND

PROCESS TEST N = 33

Teacher	Pre-MTAI	Post-MTAI	Pre-Process	Post-Process
1	81	94	25	26
2	76	86	16	19
3	69	90	24	21
4	85	56	27	25
5	89	87	26	24
6	-32	-49	05	06
7	90	57	21	21
8	67	79	16	21
9	60	99	25	25
10	04	-06	23	25
11	58	32	22	21
12	64	79	22	18
13	78	83	22	28
14	66	49	23	30
15	77	70	24	18
16	93	47	14	12
17	83	81	25	21
18	69	58	26	24
19	43	52	21	14
20	29	33	18	14
21	32	66	20	17
22	79	93	23	20
23	38	15	26	17
24	48	56	17	18
25	57	36	17	20
26	76	80	24	19
27	73	76	19	16
28	44	39	16	21
29	84	76	21	24
30	30	41	12	20
31	46	72	23	24
32	78	56	20	16
33	80	87	29	25

APPENDIX I

BIPOLAR DESCRIPTION OF 16 PF FACTORS

1410

BRIEF DESCRIPTIONS OF FACTORS IN THE 16 PF TEST*

Factor	Low Score Description	High Score Description
A	Aloof, Cool, Reserved	Warm, Easy-going
B	Dull, Low Capacity	Bright, Intelligent
C	Emotional, Unstable, Low Ego Strength	Mature, Calm, High Ego Strength
E	Submissive, Mild	Dominant, Aggressive
F	Sober, Prudent, Depressed	Enthusiastic, Happy-go-lucky, Elated
G	Expedient, Casual, Low Superego Strength	Conscientious, Higher Superego Strength
H	Shy, Timid, Autonomically Over-reactive	Adventurous, "Thick Skinned"
I	Tough-minded, Realistic	Tender-minded, Over-protected
L	Trustful, Adaptable	Jealous, Paranoid
M	Conventional, Practical	Imaginative, Autistic
N	Forthright, Artless	Shrewd, Polished
O	Confident, Placid	Insecure, Guilt-prone
Q_1	Conservative, Cautious	Experimenting, Critical Radical
Q_2	Group-dependent, Imitative	Self-sufficient, Resourceful
Q_3	Lax, Low Self-concept Integration	Controlled, Integrated Self-sentiment
Q_4	Relaxed, Expressed	Suppressed Ergic Tension

*Cattell, 16 PF Handbook, pp. 11-19.

APPENDIX J

SCORES ON 16 PF QUESTIONNAIRE

N = 33

Teacher	A	B	C	E	F	G	H	I	L	M	N	O	Q_1	Q_2	Q_3	Q_4
1	10	08	22	20	16	07	20	08	04	12	12	04	12	09	13	16
2	04	07	07	15	10	04	05	14	06	14	06	10	10	10	10	17
3	08	07	15	13	14	14	07	14	02	14	14	10	12	11	09	16
4	12	09	13	11	13	07	11	12	04	16	08	10	12	11	10	12
5	11	11	18	05	12	17	04	16	06	10	10	13	09	08	07	23
6	10	06	18	13	13	16	11	12	12	08	14	13	10	09	17	15
7	11	10	12	07	09	13	09	08	05	11	08	11	07	14	11	15
8	16	07	12	07	13	05	07	16	06	11	06	11	08	11	12	19
9	11	08	16	12	20	07	16	08	09	09	12	07	10	11	06	09
10	12	10	12	16	20	11	08	10	11	10	07	20	10	11	09	23
11	11	09	12	10	13	17	04	14	05	07	10	10	04	05	09	21
12	12	06	19	07	11	14	11	15	06	11	10	07	15	14	11	10
13	18	10	16	11	13	20	19	12	06	10	10	05	10	07	16	10
14	18	10	16	06	17	18	12	14	08	10	12	11	12	11	09	12
15	12	10	19	06	11	16	08	13	03	16	06	10	08	11	13	08
16	13	08	16	10	16	15	19	08	06	13	11	11	11	11	14	15
17	10	11	21	14	17	11	12	13	06	16	15	06	08	14	15	09
18	13	08	13	10	08	10	07	13	07	11	08	13	10	08	05	19
19	08	10	10	05	09	06	11	14	09	13	11	06	07	09	13	13
20	16	07	10	09	17	15	09	10	09	09	10	17	09	08	07	21
21	10	10	13	06	09	15	13	10	09	10	11	15	05	15	14	18
22	10	07	24	13	19	14	18	08	05	10	13	05	12	11	14	08
23	16	09	14	10	15	12	10	10	10	12	06	07	10	12	10	13
24	14	09	14	08	17	15	12	11	02	10	09	07	11	10	10	07
25	11	09	12	06	04	15	06	11	05	20	09	17	10	10	09	20
26	18	11	19	10	09	15	19	12	06	10	13	04	07	08	12	06
27	12	09	15	03	13	13	13	16	12	16	08	13	10	08	10	20
28	08	05	14	06	07	14	08	09	06	12	08	15	06	13	12	17
29	16	09	14	20	12	12	19	12	10	12	11	12	12	11	09	11
30	15	12	13	16	08	10	13	09	12	14	14	06	12	16	13	18
31	04	08	14	16	12	08	12	12	10	16	18	18	12	15	12	06
32	12	09	13	18	14	08	15	13	08	19	06	08	10	08	07	16
33	12	10	15	08	19	07	14	17	08	17	07	13	13	10	10	11

APPENDIX K

KENDALL RANK CORRELATION COEFFICIENTS BETWEEN 16 PF AND PROCESS SKILLS TEST FOR ELEMENTARY TEACHERS: 16 PF AND MTAI

N = 33

Factor	Pre-Process	Post-Process	Process Change	Pre-MTAI	Post-MTAI	MTAI Change
A	0.025	0.048	0.031	0.040	-0.133	-0.195
B	0.251*	0.156	-0.083	0.130	-0.008	-0.105
C	0.250*	0.117	0.147	0.272*	0.368	0.131
E	0.042	0.172	0.158	0.074	0.087	0.045
F	0.213	0.128	-0.081	0.073	0.158	0.039
G	-0.116	-0.148	0.020	-0.045	-0.177	-0.179
H	0.040	0.018	-0.032	0.182	0.221	0.147
I	0.119	0.021	-0.128	0.082	0.164	0.044
L	-0.142	-0.108	0.033	-0.353	-0.230	0.020
M	0.037	-0.039	-0.114	0.233	0.056	-0.050
N	0.028	0.045	0.065	-0.052	0.118	0.260*
O	-0.143	0.016	0.144	-0.178	-0.277*	-0.136
Q_1	0.131	0.211	0.121	0.118	0.188	0.138
Q_2	-0.056	0.028	0.091	-0.086	-0.018	0.164
Q_3	-0.198	-0.184	0.004	0.016	0.048	0.126
Q_4	-0.194	-0.044	0.151	-0.155	-0.274*	-0.161

*Significant at the .05 level; two tailed test.

APPENDIX L

KENDALL RANK CORRELATION COEFFICIENTS BETWEEN THE 16 PF AND QUESTION TYPES FOR SCIS TEACHERS (N=33); 16 PF AND CHANGE IN HIGH-LEVEL QUESTIONING (N=15)

Factor	High Level 1	Demonstration of Skill 3	Comprehension 3	Analysis 3	Synthesis 3	High Level 3
A	-0.026	-0.141	0.306	0.125	0.123	0.052
B	0.033	0.234	-0.172	0.061	-0.120	0.041
C	-0.046	-0.105	-0.153	-0.040	0.095	-0.111
E	0.139	-0.051	-0.239	0.088	-0.058	0.098
F	0.114	-0.260	0.121	0.040	-0.153	0.010
G	-0.141	0.143	0.168	-0.254	-0.012	-0.108
H	-0.033	-0.328	-0.279	0.009	-0.116	-0.128
I	-0.092	-0.186	0.040	-0.089	0.211	-0.080
L	-0.030	-0.350	-0.030	0.177	-0.023	-0.010
M	-0.078	-0.354	-0.495*	-0.179	-0.200	-0.330
N	-0.050	-0.042	-0.062	-0.111	-0.120	-0.061
O	-0.053	-0.160	-0.134	0.041	-0.193	-0.112
Q_1	-0.150	-0.113*	-0.507*	-0.146	-0.135	-0.324
Q_2	0.002	0.163	-0.422*	0.000	-0.111	-0.073
Q_3	-0.177	-0.031	-0.232	-0.179	0.106	-0.130
Q_4	0.068	0.112	0.436*	0.117	0.058	0.147

Factor	Recognition 1	Recall of Fact 1	Demonstration of Skill 1	Comprehension 1	Analysis 1	Synthesis 1
A	0.054	0.036	0.014	0.042	-0.106	0.131
B	-0.046	-0.056	0.179	0.023	-0.025	0.010
C	0.199	0.052	0.148	-0.072	-0.036	-0.045
E	-0.211	-0.145	-0.036	0.163	0.104	0.044
F	-0.103	-0.108	0.018	0.166	0.098	-0.111
G	0.264*	0.096	-0.004	-0.126	-0.164	-0.076
H	-0.010	0.039	-0.021	-0.088	0.103	-0.154
I	0.080	0.090	0.126	0.156	-0.231	0.020
L	-0.044	0.056	-0.347*	0.002	0.074	-0.326*
M	-0.103	0.064	0.034	-0.115	0.098	-0.088
N	0.014	0.048	-0.120	0.086	-0.038	0.042
O	0.091	0.059	-0.188	0.055	-0.006	-0.300*
Q_1	0.021	0.148	-0.075	-0.062	-0.031	-0.005
Q_2	0.115	-0.008	-0.134	-0.119	0.133	0.013
Q_3	0.166	0.143	-0.097	-0.312*	0.014	-0.008
Q_4	-0.107	-0.066	-0.112	0.066	0.048	0.055

1 = SCIS, 3 = Change.
*Significant at the .05 level; two tailed test.

APPENDIX M

KENDALL RANK CORRELATION COEFFICIENTS BETWEEN PROCESS TESTS AND QUESTION TYPES

	Pre-Process	Post-Process	Process Change
Recognition 1	-0.143	-0.224	-0.100
Recall	0.111	-0.232	-0.184
Demonstration of Skill 1	0.372*	0.177	-0.175
Comprehension 1	0.246*	0.187	-0.045
Analysis 1	-0.082	0.159	0.276*
Synthesis 1	0.081	0.082	-0.225
High-Level 1	0.124	0.281*	0.225
Recognition 2	-0.169	-0.136	-0.103
Recall 2	0.039	0.163	0.370
Demonstration of Skill 2	-0.022	-0.228	-0.571*
Comprehension 2	0.358	0.272	-0.175
Analysis 2	-0.010	-0.134	-0.345
Synthesis 2	0.084	-0.044	-0.276
High-Level 2	0.126	-0.031	-0.382*
Demonstration of Skill 3	0.030	0.213	0.346
Comprehension 3	-0.186	-0.093	0.162
Analysis 3	0.097	0.346	0.430*
Synthesis 3	-0.160	-0.012	0.249
High-Level 3	0.029	0.256	0.463*

*Significant at the .05 level; two tailed test.

APPENDIX N

KENDALL RANK CORRELATION COEFFICIENTS BETWEEN THE MTAI AND PROCESS TESTS

	Pre-Process	Post-Process	Process Change
Pre-MTAI	0.271*	0.223	-0.078
Post-MTAI	0.309*	0.290*	-0.061
MTAI Change	0.016	0.051	0.002

*Significant at the .05 level; two tailed test.

APPENDIX O

KENDALL RANK CORRELATION COEFFICIENTS BETWEEN THE MTAI AND QUESTION TYPES

	MTAI	Post-MTAI	Change
Recognition 1	-0.065	0.042	0.115
Recall 1	-0.038	-0.047	0.067
Demonstration of Skill 1	0.355*	0.187	-0.137
Comprehension 1	0.067	0.061	-0.038
Analysis 1	-0.021	0.046	0.030
Synthesis 1	0.050	0.031	0.019
High-Level 1	0.048	0.042	-0.068
Recognition 2	-0.099	-0.129	-0.069
Recall 2	-0.230	-0.086	0.010
Demonstration of Skill 2	0.417*	0.043	-0.128
Comprehension 2	0.217	0.129	0.029
Analysis 2	0.243	0.058	-0.058
Synthesis 2	0.236	0.153	0.028
High-Level 2	0.298	0.116	-0.019
Demonstration of Skill 3	0.010	-0.050	-0.239
Comprehension 3	-0.204	-0.039	0.039
Analysis 3	-0.134	0.048	0.105
Synthesis 3	-0.226	-0.091	-0.056
High-Level 3	-0.164	-0.019	0.038

*Significant at the .05 level; two tailed test.

APPENDIX P

SCIS TEACHERS' SCIENCE PREFERENCE

Of the major areas of science covered in SCIS, which do you find most interesting?

Physical Science __________

Biological Science __________

APPENDIX Q

CORRELATION VALUES WHEN HOLDING DEMOGRAPHIC VARIABLES CONSTANT WHICH DIFFER FROM OVER-ALL CORRELATIONS

	Tau	Level of Significance
Physical Science Preference N = 16	0.373	0.044
Factor F with pre-MTAI	0.373	0.044
Factor C with post-MTAI	0.393	0.033
Factor L with post-MTAI	-0.435	0.019
Factor L with post-process	-0.436	0.019
Factor Q_4 with process change	0.436	0.019
Factor Q_1 with high level questioning (SCIS)	-0.383	0.038
Biological Science Preference N = 13		
Factor M with pre-MTAI	0.439	0.037
Factor B with pre-process	0.421	0.045
Factor B with post-process	0.424	0.023
School District		
Factor A with MTAI Change (N = 15)	-0.444	0.021
Factor Q_1 with MTAI Change (N = 15)	0.450	0.019

APPENDIX R

KENDALL RANK CORRELATION COEFFICIENTS BETWEEN THE VARIABLES OF AGE, HOURS OF SCIENCE, YEARS OF EXPERIENCE AND PROCESS TEST

N = 33

	Experience	Hours of Science	Age
Hours of Science	-0.433*		
Age	0.566*	-0.315*	
Pre-Process	0.079	-0.018	-0.136
Post-Process	-0.144	0.235	-0.377*
Process Change	-0.264*	0.274*	-0.243*

*Significant at the .05 level; two tailed test.