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

By
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* * * * *

The Ohio State University
1970

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CHAPTER ONE

NATURE AND PURPOSE OF THE STUDY

Introduction

This study resulted from an effort to evaluate the effectiveness of an inservice program for science teachers. The teachers in the study were asked to teach a newly adopted earth science course in the Akron City School System beginning in September 1969. Most of the teachers had been teaching junior high general science and/or mathematics prior to the 1969-1970 school year. The adoption of the earth science program required the inservice education of forty teachers. The problem of this study was to determine whether the inservice program had produced changes in the teacher behavior, and to assess the relationship between teacher behavior and pupil achievement.

The National Science Foundation provided funds for the inservice program, and the Akron Board of Education supplied monetary support for textbooks, laboratory equipment, audio-visual materials and other items. Both NSF and the Akron Board of Education wanted a careful examination of the inservice program's effectiveness. Change in teacher behavior with respect to more classroom
laboratory activity was desired. The evaluation data were collected before, during and after the inservice program between May 1969 and June 1970.

Need For the Inservice Program

The need for inservice programs for teachers is not new. Richey has briefly outlined the need for and evolution of inservice programs over the past century.\(^1\) However the combination of the level of funding from the National Science Foundation (NSF); local commitments of teachers, pupils, and classroom materials; and university faculty involvement in the program is relatively new to education in the United States. The National Science Foundation has supported workshops and institutes which have invigorated the science teaching profession by meeting a part of the need for continuing the education of science teachers over the past decade.\(^2\)

On the local level the timing for the inservice program was based on practical considerations. In the Akron Schools new textbooks were to be adopted for the


1969-1970 school year. The teachers were ready for a change, and the school administrators wanted to make the new textbook adoption a part of a new science curriculum program.

The academic background of the Akron science teachers lacked earth science components. Nearly all of the Akron teachers received their college degrees from colleges and universities in Northeastern Ohio. Approximately two-thirds of the teachers were graduates of the University of Akron. Prior to 1967-1968 there was no program at the University of Akron for earth science majors. Therefore the Akron science teachers lacked a background in the earth sciences.

Objectives of the Inservice Program

The three major objectives of the inservice program were:

1. To change the teaching of eighth grade science toward a more laboratory oriented science course. (A general science course had been offered for several years at the eighth grade level in Akron.)

2. To prepare the teachers to direct outdoor field studies with their classes in the Akron area. (The field studies were considered a part of the laboratory activity desired. Teachers were to be exposed to studies published about the environmental phenomena of the Akron area and participate in the field studies directed by university faculty.)
3. To evaluate the change produced by the inservice program and the adoption of the earth science course.

Prior to the 1968-1969 school year there were only two Akron teachers certified in earth science. The inservice program was designed to increase the subject matter background of the teachers. Additional work during the summer of 1970 was planned for teachers wanting and/or needing additional course work beyond the inservice program's offerings. An average of sixteen quarter hour credits were earned by participants in the ten week summer phase of the program. A description of the inservice program of this study is on pages 82-85 of Appendix A.

Purpose of the Study

There has been a need for the evaluation of inservice programs from the beginning of their use in this country over a century ago. Most evaluations of inservice programs in the past have been based on subjective judgments.

Professional teachers can and do evaluate any inservice program in which they participate and the opinions expressed by teachers and administrators often are the sole means of program evaluation. Subjective assessment is useful, but does not provide empirical data needed for more objective and detailed analyses.

The inservice program included ten weeks of academic work during the summer of 1969 and fifteen meetings
throughout the 1969-1970 school year. A change from a general science lecture-demonstration oriented course to a laboratory oriented earth science course was made as a result of the inservice program being funded by the NSF under the Cooperative College-School Science Program (CCSSP). The assessment of changes in teacher behavior and the relationship of these changes to pupil achievement and factors influencing both teacher behavior and pupil achievement were included in the investigation.

**Hypotheses Tested**

The following null hypotheses were established to guide the study:

1. The means of the study group teachers' measures of classroom activity based on how they believed they were teaching in May 1969, October 1969 and May 1970 will indicate no significant difference in sample means.

2. The means of the study group teachers' measures of possible classroom activity based on how they could have been teaching in a more favorable environment in May 1969, October 1969 and May 1970 will indicate no significant difference in sample means.

3. The means of pupil measures of classroom activity will indicate no significant difference in sample means when the May 1970 study group's mean is compared to the May 1970 comparison group's mean.
4. The means of pupil measures of classroom activity will indicate no significant difference in sample means when the May 1969 study group's mean is compared to the May 1969 comparison group's mean.

5. The means of pupil measures of classroom activity will indicate no significant difference in sample means when the May 1969 study group's mean is compared to the May 1970 study group's mean.

6. The means of pupil measures of classroom activity will indicate no significant difference in sample means when the May 1969 comparison group's mean is compared to the May 1970 comparison group's mean.

Definition of Terms

1. The population of the study is the eighth grade earth science teachers of the Akron City Schools who volunteered to be in the study. For all analyses of this study, the teacher is taken as the basic unit of the investigation.

2. The phrase, effectiveness of the inservice program, as used in this study includes the measured change produced by the program in teacher behavior and classroom activity.

3. Laboratory oriented earth science course refers to a science course that emphasizes an inquiry approach to learning with at least twenty-five per cent of class
time devoted to observation, measurement and interpretation of data in the earth sciences by pupils.

4. **Outdoor field studies** are opportunities for pupils to observe the results of natural processes, take measurements and make inferences outside the science classroom. The field studies are to provide experiences for the pupils to which course content can be related.

5. **Classroom activity** refers to several dimensions of the classroom environment which are mutually supportive. The teacher is the primary manipulator of the dimensions that are measured in this study. The seven dimensions of classroom activity included are: classroom role of the teacher, student classroom participation, use of textbook and reference materials, design and use of tests, and laboratory follow-up activities.3

6. **Teacher behavior** as used in this study relates to the classroom activity of the teacher as measured by the instruments designed to assess a part of the role that the teacher plays in the classroom.

7. **School environment** was measured indirectly and in this study is based on the percentage of Black pupils in the school, the percentage of pupils on Aid to Dependent Children in the school, and the age of the school building.

---

8. The study group refers to twenty-two science teachers who agreed to participate in the evaluation of the inservice program and who were teaching junior high science in May 1969 and taught a full year of earth science during the 1969-1970 school year. The study group had approximately 2400 pupils in their 1969-1970 earth science classes.

9. The two comparison groups were junior high science teachers who were not in the inservice program and who agreed to participate in the project evaluation. The first comparison group of ten teachers supplied data about their science classes in May 1969. The second comparison group of twelve teachers supplied data about their earth science classes in May 1970.

Limitations of the Study

1. The instruments used in the evaluation of classroom activity and the achievement tests are similar to instruments used in other studies, however national norms on the instruments are not available. Therefore the data obtained from these instruments relate only to the Akron City School System and do not allow broad generalizations.

2. The earth science teachers were given the choice of two textbooks, one with a conventional orientation and one with a laboratory orientation. The Pupil Achievement Test probably favors the pupils whose teacher chose to use the more laboratory-oriented text and ancillary materials.
Selection of the achievement test items was based in part on recommendations and test items supplied, with the more laboratory-oriented text.

3. The correlation and regression analyses of this study are mathematical relationships. Several significant correlations between different data were found. However these correlations are not considered to be cause and effect relationships. Further it is not assumed that these mathematical relationships would be found associated with other inservice programs in other school systems.

4. Limitations were also placed upon the inservice program and hence on its evaluation by the late arrival in the Fall of 1969 of some laboratory equipment that had been expected in late August 1969.

5. There was more difficulty in scheduling fieldtrips than had been anticipated. Fewer fieldtrips were conducted by the teachers than had been planned.

6. The selection of the inservice program participants, the study group, and the comparison groups was not random.

Assumptions

1. It was assumed that measurable changes in teacher behavior would be produced by the inservice program.

2. It was assumed that the objective instruments used are reasonable measures of the true classroom activities that occurred.
Data Collection and Analysis

A model for the data collection is given on page 32 of Chapter Three. Measures of classroom activity were obtained for the study group teachers before and after the inservice program. The data collected for the analysis of teacher behavior change were:

5. Number of academic year meetings attended by the teacher during the school year 1969-1970.
6. Teacher test score on the Sources of Local Information Test in August 1969.
7. Number of field trips conducted by teacher.
8. Teacher's undergraduate point average.
9. Number of different class preparations by teacher (e.g. two biology classes and three earth science classes would be two preparations).
10. The number of years teaching experience of the teacher during the 1969-1970 school year.
11. Using only ESCP Text.
13. Number of earth science classes taught each day by teacher.
14. Rank of the teacher in the study group from 5 for lowest to 99 for highest score on the August 1969 Teacher Achievement Test.

The measurement of the change produced by the inservice program required the consideration of the school environments within which these changes were to take place. Certainly not all school environments are conducive to change. According to Herrick, "It is just as important
to study factors which determine resistance to change as it is to examine those which promote change." Indirect measures of school environment were obtained. These measures were based on the age of the school building, the percentage of Black pupils in the school and the percentage of pupils on Aid to Dependent Children in the school.

The procedures used in the collection of the data are discussed in Chapter Three. The analysis of the data is delineated in Chapter Four. The analysis of the data was accomplished through standard computer programs for analysis of variance, correlation, and step-wise linear regression.

Summary

The factors that led to the initiation of this study were discussed. The broad objectives of the inservice program evaluated in this study were stated. The purpose of the study and hypotheses tested were given. Statements of definitions, limitations and assumptions in the study were made. Brief descriptions of the data collected and the data analysis were included.

---

1 Virgil E. Herrick, "The Evaluation of Change in Programs of In-service Education," In-service Education for Teachers, Fifty-sixth Yearbook, p. 312.
CHAPTER TWO

REVIEW OF THE RELATED LITERATURE

Introduction

This chapter deals with the rebirth of earth science in school systems across the country, and the accompanying programs for earth science teacher preparation. Inservice programs are discussed in conjunction with science teacher preparation. The final portions of the chapter delineate the assessment of pupil changes in science knowledge in connection with recent inservice programs and the assessment of teacher changes related to the inservice program.

The Rebirth of Earth Science

Woodburn and Obourn have summarized the waning and rebirth of earth science. Earth science or physical geography or physiography was the most common science offering in the public schools at the ninth grade level at the turn of the century. Considering the smaller population of the United States and the lower percentage

of pupils enrolled in public schools in the early 1900's the 154,513 pupils reported enrolled in earth science courses was significant. In 1949 only 20,575 pupils were enrolled in earth science. By 1955 the rebirth of earth science was underway. In that year New York State adopted a new earth science syllabus. "In 1959 Pennsylvania produced a Teaching Guide for Earth Science and Space Science." 6 By 1961 twenty-four states had or were planning to include earth science in their curricula. The growing interest in earth science eventually led to a major curriculum project funded by the National Science Foundation. 7

Because of strong teacher interest in resource materials the Duluth Conference was held in 1959 at Duluth, Minnesota to develop up-to-date resource materials. The American Geological Institute supported the conference. In 1962 Holt, Rinehart and Winston, Inc. published the Geology and Earth Science Sourcebook for Elementary and Secondary Schools which was a revised and edited version of materials produced at the 1959 Duluth Conference.

The Executive Committee of the American Geological Institute (AGI) submitted a proposal to the National Science Foundation in June, 1962 for a major course-content improvement program. The National Science Foundation (NSF) funded the initial phase of the project for $147,182 early in

6 Woodburn, Pursuit of Science, p. 246.
7 Woodburn, Pursuit of Science, pp. 245-247.
1963. This was the beginning of the Earth Science Curriculum Project (ESCP) that operated under the control of the AGI.8

By the academic year 1962-1963 there were 190,000 pupils taking an earth science course across the nation. All fifty states and the District of Columbia had earth science courses or units in progress, or in advanced planning stages, by the Fall of 1963.9

Teams of outstanding earth scientists, science educators and secondary school teachers cooperated in the writing of the teaching resource materials. The participants in the writing of materials, the sequence of events, guidelines, and philosophies of the ESCP are carefully set forth in the ESCP Newsletters numbers 1-19 published between October 1963 and May 1969. The publication of a textbook, Investigating the Earth, Investigating the Earth: Teacher's Guide Part I and Part II and ancillary materials resulted in a laboratory science or inquiry approach in earth science being available to schools by 1967.10

The basic philosophical tenent of ESCP most pertinent to this study was "Materials developed by ESCP should place


9ESCP, Newsletter, No. 1, p. 1.

strong emphasis on laboratory and field study in which the student actively participates in the genuine process of scientific inquiry, rather than mechanically repeating 'cookbook' exercises." The materials produced by the Earth Science Curriculum Project were designed to emphasize a laboratory, field oriented science course.

The Newsletters also record increasing numbers of pupils enrolled in earth science classes. By 1968-1969 Ohio had over 50,000 pupils in earth science classes and 613 earth science teachers. The adoption of earth science by the Akron City School System added about 4200 pupils to the Ohio enrollment in earth science.

Earth Science Teacher Preparation

Parallel to increasing pupil enrollment in earth science there have been increasing demands for earth science teachers. Summer institutes, inservice institutes, and cooperative college-school science programs have been utilized to reduce the shortage of earth science teachers. Sound pre-service programs are seen by some educators as the best answer to meeting the shortage of qualified earth science teachers.

11ESCP, Newsletter, No. 1, p. 5.
13ESCP, Newsletter, No. 10, p. 4.
14ESCP, Newsletter, No. 19, pp. 1-5.
Stotler, Richardson, and Williamson listed "teacher preparation" as a major frustration to curriculum change. By teacher preparation they refer to teacher attitudes adverse to change as well as content background deficiencies.\textsuperscript{15}

A good undergraduate program should produce teachers "well prepared in mathematics and basic sciences (biology, chemistry, and physics), and should have a major or minor in one of the earth sciences (astronomy, geology, meteorology) with supporting work in the other three."\textsuperscript{16} A fifth year, for rounding out the teacher's background, is highly recommended.\textsuperscript{17}

Shrum has recommended the following academic program for sound pre-service preparation of teachers:

A. Emphasis in Earth Science

Earth Science is defined as the interdisciplinary study of materials, energy, and processes in four areas: (a) the solid earth and its interior, (b) the atmosphere, (c) the hydrosphere and (d) earth's environment in space. The study of earth science is based on physical and biological processes and their role in the evolution of the


\textsuperscript{16}John S. Richardson, Stanley E. Williamson, and Donald W. Stotler, \textit{The Education of Science Teachers} (Columbus, O.: Charles E. Merrill Co., 1968), p. 79.

\textsuperscript{17}Richardson, Williamson, and Stotler, \textit{Education of Science Teachers}, p. 80.
earth and its environs. The program of study in earth science should contain the following elements:

1. Studies including investigative laboratory work concerned with the solid earth and in at least two of the other three areas above, preferably all four.

2. At least one-half of the earth science study should be at the junior-senior level in one of the four areas above, or in an integrated program combining two or more of the four areas.

3. At least four weeks of full-time practical field experience in one of the four areas above.

B. Emphasis in Related Sciences

The related sciences needed in support of an earth science major include college-level study to the point of understanding basic concepts in each of the following areas (a year of each is recommended): (a) biology, (b) chemistry, (c) mathematics and (d) physics.18

The Education Committee of the Ohio Academy of Science has recommended the following "Suggested Certification Requirements for Earth Science Teachers":

A. Basic Foundation for Scientific Literacy (27-30 sem. hrs.)
1 year of Biological Science
1 year of Chemistry
1 year of Physics
1 year of Mathematics (including an Introduction to Calculus)
1 year of Introductory Earth Science (the first course should be a Geology-oriented introduction to Earth Science followed by an

introductory course in Astronomy, Meteorology, Oceanography, or Physical Geography.

B. Additional Preparation for Competency in the following areas: (18-24 sem. hrs.)
1. The solid earth: materials, structure, processes, and landforms.
2. Earth History and Paleobiology.
3. The atmosphere.
4. The hydrosphere.
5. The earth's environment in space.

C. Laboratory work of an investigatory nature should be undertaken in at least three of the five areas listed above.

D. Four weeks of field work in Earth Science should be undertaken in one of the areas or in two or more combined.

E. At least one course should demonstrate the interdisciplinary nature of Earth Science.

In the report of the 1965 ESCP survey of earth science teachers, Shea noted that ninety percent of the earth science teachers responding had been teaching earth science less than five years. Seventy-five per cent of the schools had been offering earth science less than five years. The article further indicated deficiencies in the formal preparation of the teacher respondents to the survey.

19Ray Skinner, Jr., John Bybee, and Dean Shappell, "Suggested Certification Requirements for Earth Science Teachers," Earth Science in Ohio (Columbus, O.: The Ohio Academy of Science).

Shea cited the following data to indicate that teachers of earth science were inadequately prepared in the earth sciences. According to the survey, "53 percent of the teachers have had no astronomy, 62 percent have had no meteorology, 89 percent no oceanography and 50 percent no physical geography. Only in geology have significantly more than half received at least one semester credit.

...94 percent six or less in meteorology, 99 percent six or less in oceanography, 85 percent six or less in physical geography and 58 percent six or less credits in geology."21

On a national level earth science teachers need "encouragement and additional opportunities to reinforce their background."22 The Akron teachers who were asked to teach earth science for the first time had similar needs.

Problems of Inservice Préparation

Reno has listed eight problems that are highlighted by current inservice programs: "(1) the rapid obsolescence of subject knowledge and skills acquired by teachers in college; (2) the proliferation of educational hardware; (3) the fluid but apparently evolving state of learning and instruction theory; (4) the advent of new educational tasks such as the education of the disadvantaged; (5) the growing necessity for global awareness; (6) the acceleration


of school reorganization; (7) the increasingly evident consequences of teacher misassignment; (8) the ever more critical issue of teacher drop-out."23 These problems point to a need for the continuing education of science teachers.

Relating Inservice Programs to Desired Classroom Activity

Teachers asked to teach a science course new to them should know the what, how, and why in terms of content and teaching strategies of the new curricula materials.24 A large number of new curriculum projects are now a part of school curricula or are in advanced stages of preparation for large scale adoption.25 However, the preparation of curriculum packages may not mean that the curriculum envisioned by the writers will in fact be presented to the pupils.26

Smith reviewed educational research related to elementary and junior high school science instruction.  


25Sixth Report of the International Clearinghouse on Science and Mathematics Curricular Developments, Director of editing, J. David Lockard (University of Maryland: American Association for the Advancement of Science and the Science Teaching Center, 1968).

He suggested that the existing objectives of science include providing "knowledge, understanding, and concept development in basic science content" and that the social aspect of how one is to act upon the knowledge he possesses should not be overlooked. The science course "should reveal the nature of science as a process of inquiry", and have appeal for children. Other studies have indicated that laboratory oriented methods are preferable to deductive-demonstration methods of science teaching if more than short lived knowledge is desired.

**Assessment of Pupil Change**

The ultimate criterion of teacher effectiveness is obtaining desired changes in pupil achievement. In an attempt to refine models of teacher effectiveness criteria Mitzel included pupil gain in subject matter knowledge as part of a scheme for research in teacher effectiveness. He suggested four types of variables of concern in research dealing with teacher effectiveness. Included were (1) classroom behaviors of teachers and pupils and (2) criteria

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or standards, including "intermediate educational goals, i.e., the measurable outcomes at the end of a period of instruction as distinguished from the ultimate criterion which might be phrased as 'a better world in which to live.'"\textsuperscript{30} Gage indicated that the complex of pupil-teacher interactions in the classroom is the primary source to which one must look to account for pupil growth.\textsuperscript{31} This is not to indicate, however, that school and community environment factors should be ignored.

**The Assessment of Change in Teacher Behavior**

Teacher characteristics, background, and the style of teaching in the classroom have been found to be related to the achievement of pupils.\textsuperscript{32} A concise statement of these relationships was made by Ramsey and Howe:

> The background and philosophy of the teacher is important if a new course is being taught. Any given student will achieve more in a traditional course with a traditionally oriented teacher than he would have if the traditional teacher had taught a new course. Thus, new courses can only be successful if the teacher is adequately prepared and philosophically oriented to teach the course.\textsuperscript{33}

The statement by Ramsey and Howe is supported by findings of Schirner with respect to earth science teacher

\textsuperscript{31}Gage, *Handbook*, p. 120.
\textsuperscript{32}Ramsey and Howe, "An Analysis of Research," p. 68.
\textsuperscript{33}Ramsey and Howe, "An Analysis of Research," p. 68.
characteristics and pupil achievement. Schirner found that the style of the teacher and the type of materials he was using, ESCP or non-ESCP, had an effect on earth science pupil achievement.34

Toohey indicated that the style of teaching can make a difference in earth science pupil achievement.35 Selser36 and Bingham37 indicated that an inservice program for junior high science and mathematics teachers produced changes in the achievement of participating teachers. Further these teacher changes were related to changes in the achievement of their science pupils.

Teacher characteristic studies such as those by


Ryans and Flanders have involved analyses of teacher behaviors, but have not considered content analysis. Such investigations of a general nature not specific to science, will not be discussed in this review.

There have been some recent studies that did employ objective instruments with a science emphasis for measuring teacher behavior. Two of these studies are pertinent.

Barnes developed the Biology Laboratory Activity Checklist to measure the nature and extent of laboratory instruction in different biology classes when different curriculum materials were used. This instrument also obtains the assessment data from the teacher.

Leonard H. Kochendorfer working with Addison Lee at the University of Texas developed the Biology Classroom Activity Checklist (BCAC). This instrument provides an assessment by pupils of classroom activity with emphasis on teacher behavior. The original BCAC instrument was administered to over 1200 pupils of 64 teachers. A


reliability coefficient of .96 was obtained. Two measures of face validity gave coefficients of .84. According to Kochendorfer, "An instrument such as this should be useful in the evaluation of new curricula and in the training of teachers." In this investigation the BCAC was adapted for use with earth science teachers and pupils for the assessment of classroom activity.

Summary

The rebirth of earth science as a course offering in the public schools across the nation was discussed. The parallel need for the preparation of earth science teachers led to the consideration of inservice programs.

The literature indicated a need for the continuing education of science teachers. Inservice programs must deal with several problems including the needs of teachers for updating in terms of content knowledge and teaching strategies of the new curricula.

The assessment of pupil change and teacher change


42Kochendorfer, Research and Curriculum Development, p. 77.
with respect to the inservice program for earth science teachers was considered important. It was noted that pupil behavior change and teacher behavior change are interrelated.
CHAPTER THREE

METHODOLOGY AND OUTLINE OF THE STUDY

Introduction

A large school system planning to make curricular changes in junior high science was sought. The intent of the investigator in this study was to help initiate changes in junior high science toward pupil laboratory activity and specifically toward an earth science program incorporating both laboratory and outdoor field study experiences and to determine whether or not significant changes toward laboratory teaching could be made. The investigator hoped to facilitate the adoption of the laboratory program with strong local environmental aspects through working with the school system's junior high science teachers. The Akron City School System was ready for junior high science curriculum changes in the school years 1967-1968 and 1968-1969.

A major inservice program was developed for the summer of 1969 and the academic year 1969-1970. A laboratory oriented earth science course was adopted for the 1969-1970 school year at the eighth grade level.

This study is an evaluation of the effectiveness of
the inservice program in promoting the teaching of earth science by a laboratory approach in the junior high schools of Akron, Ohio.

Units of Statistical Analysis

For all the analyses of this study, the teacher is taken as the basic unit of the experiment, not the pupil. When pupil data are used, means of pupil scores for each teacher are the units of statistical analysis, not the individual pupil scores. The means are based on scores of all the teacher's earth science pupils present on the days the respective tests are given. When teacher data are used (e.g. scores on teacher achievement tests), each teacher's score represents a unit of statistical analysis.

Descriptions of Teacher Groups: The Study Group

Of the forty-three total CCSSP participants, there were twenty-two participants used as the study group from May 1969 through May 1970. Only participants teaching in the Akron City Schools during both the 1968-1969 school year and the 1969-1970 school year were in the group. Also those in the study group had to be teaching junior high science in the 1968-1969 school year and earth science classes in the 1969-1970 school year to allow complete data to be collected for each teacher in the study group.
Table 1 indicates the number of earth science pupils taught by the study group teachers.

The Comparison Groups

Two other groups of Akron City School teachers agreed to supply data from their science classes for evaluation purposes. The number of teachers and pupils in the comparison groups are given in Table 1. A ten teacher comparison group collected data on science classroom activity at the same time that the study group was collecting classroom activity data from their pupils in May 1969.

Table 1.—Teacher Study Group and Comparison Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Teachers</th>
<th>Number of Pupils 1968-1969</th>
<th>Number of Pupils 1969-1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Study Group</td>
<td>22</td>
<td>2155</td>
<td>2400</td>
</tr>
<tr>
<td>The May 1969 Comparison Group</td>
<td>10</td>
<td>892</td>
<td>---</td>
</tr>
<tr>
<td>The May 1970 Comparison Group</td>
<td>12</td>
<td>--</td>
<td>1130</td>
</tr>
</tbody>
</table>

All the comparison group teachers were teaching junior high science in the Akron City Schools as were the study group teachers. A twelve teacher comparison group provided data in May 1970 about their science classroom activity. These twelve teachers included only junior high science teachers who had not been involved in the inservice
program. These comparison groups were nonequivalent control groups.\textsuperscript{43}

**Comparability of the Study Group and the Two Comparison Groups**

The two comparison groups and the study group were not randomly selected. All eighth grade teachers were to be included in they chose to be in the program.\textsuperscript{44}

The teachers in the comparison groups were teaching the same types of classes, in similar settings with no known distinctions to be made between the teachers of the study group and the comparison groups except the "rejection" of the inservice program. Four of the teachers common to the two comparison groups informed the investigator that they would have been participants in the inservice program had they not committed themselves to other activities during the summer of 1969. Two of these four were in NSF Summer Institutes in 1969. They were left in the comparison group though it is worth noting that their data slightly decreased the apparent difference between the study group and the comparison group in 1970. The reasons for nonparticipation in the inservice program by other comparison group teachers are not known. The comparison groups were similar to the study group. Some


statistics to support this similarity are presented on pages 46 and 47.

Model of Data Collection

The Model for Data Collection, Figure 1, page 32, for the evaluation of the inservice program indicates the chronology of the data collection. The seven evaluation instruments used for data collection are described on pages 31, 33-36.

The pupil means by teacher or actual teacher scores from seven instruments along with eleven other measures of teacher or class characteristics were included in the analysis of the program's effectiveness.

Description of the Evaluation Instruments

The PK instrument is a modification of the Biology Classroom Activity Checklist adapted for use with earth science classes. This test was originally developed by Leonard Kochendorfer to measure biology classroom activity by assessing pupils. In this study the earth science adaptation of the BCAC gave a mean coefficient for the reliability of the test averaging .62 by the Kuder-Richardson Formula 20. These values are lower but close to values obtained using similar adaptations of the BCAC in other

---

SPRING 1969

PK
TK₁
TK₂

TA (Pre)
TS (Pre)

Treatment One

10 Weeks Summer

Class Work

TA (Post)
TS (Post)

SPRING 1970

PK
TK₁
TK₂
PA
PFS

Treatment Two

15 Saturday Inservice Meetings

FALL 1969

PA
TK₁
TK₂

Academic Year 1969-1970

Figure 1.—MODEL FOR DATA COLLECTION
(To Be Read Clockwise)

TS - Teacher's Sources of Information Test
TK₁- Teacher Measure of Classroom Activity
TK₂- Teacher Measure of What Classroom Activity Could Be
TA - Teacher Achievement
PK - Pupil Measure of Classroom Activity
PA - Pupil Achievement Test
PFS - Pupil Field Study Test
studies conducted at The Ohio State University. See Appendix F, pages 91-94 for a copy of this instrument. Leonard Kochendorfer's BCAC contains fifty-three items in seven sections, which measure different dimensions of science teaching. The seven sections in the earth science adaptation, PK, are intended to measure classroom activity in the following dimensions listed by Kochendorfer:

Section A - Role of the Teacher in the Classroom.
Section B - Student Classroom Participation.
Section C - Use of Textbook and Reference Materials.
Section D - Design and Use of Tests.
Section E - Laboratory Preparation.
Section F - Type of Laboratory Activities.
Section G - Laboratory Follow-up Activities.

TK₁ is the measure of how the teacher thought that he was teaching using the PK instruments. Directions provided to the teachers for TK₁ and TK₂ described below are on page 90.

TK₂ is the same as PK and TK₁ above, but the teacher answered the questions according to how he thought he could have been teaching if he (the teacher) could have controlled class size, purchased materials, scheduled field trips, etc. to make the class situations more favorable to his style of teaching.

PA, Pupil Achievement Test, items are from the ESCP

46 Personal communication with Dr. Robert Howe at The Ohio State University on June 4, 1970.

47 Kochendorfer, Research and Curriculum Development, p. 72.
Teacher's Guides and from the Dressel and Nelson test portfolio. The PA test has forty-two multiple choice questions.

The ESCP test items were developed during the 1964 through 1966 school years and were screened for use with the ESCP text and other materials. Items were selected prior to textbook adoptions in earth science by the Akron City Schools. Therefore the selection of items was based on two criteria: (1) Each test item selected was to measure pupil achievement of information expected to be included in an earth science course taught in Akron regardless of the text adopted. (2) Items that were rated "too easy" or "too hard" based on data supplied in the ESCP Teacher's Guide were not included.

Items selected from the test portfolio were selected on the same basis as those from the ESCP materials. However the judgment as to difficulty of an item was subjective. A KR-20 value of .67 for the Achievement Test was obtained when the achievement test was given to sixty pupils in April 1970. Based on information given in the ESCP materials, the KR-20 values obtained for this test were expected.

50Earth Science Curriculum Project, Guide, pp. 344-381.
The items used for the achievement test are on pages 113-121 Appendix H.

The Pupil Field Studies (PFS) or Local Environment Test is composed of twenty-five multiple choice items designed to test the pupil's knowledge of concepts such as techniques for sample collection, graphing of data, interpretation of graphs, and other factors. Item content was based on what the teachers' pupils should have learned from field studies. A KR-20 value of .56 was obtained in May 1970 for this test. This value is based on data from over four hundred pupils of four randomly selected study group teachers. See Appendix K on pages 124-129 for a copy of the test.

TA, Teacher Achievement Test, is a series of questions obtained from the ESCP Teacher's Guides and Dressel and Nelson's test portfolio. Items included were thought to be appropriate for the pre-post testing of teacher achievement over the 1969 Summer phase of the program. The test contains one hundred multiple choice items. Two University of Akron Faculty members teaching in the inservice program selected test items that they judged to be appropriate to the inservice program. See Appendix G pages 93-112 for the items used on this test. A KR-20 value of .90 was obtained for this test when the twenty-two study group teachers took the test in August, 1969.
TS, Teacher's Sources of Information Test, was a series of questions asking where the teacher could find information about his local environment. There were only seven questions on the test and the teacher could list as many answers as he knew. The questions used for this test are in Appendix J page 123. Additional data on teacher participants were obtained in May 1970 via a questionnaire bearing the teacher's signature. A sample questionnaire is included in Appendix I, page 122.

Subjective Observations

Numerous visits to the junior high schools in Akron, observation of pupil and teacher behavior during outdoor field studies and frequent meetings with teachers throughout the 1969-1970 school year provided much subjective information about the study group and their pupils. This subjective information is not used in this formal presentation except to note that the investigator's first hand observations do not disagree with the general statistical findings in this report. The subjective information was gained during not less than eight visits to each of the ten schools during the school years 1968-1969 and 1969-1970. First hand observations of pupils doing field studies were made eight times at different field study sites during the 1969-1970 school year.
Facilities Used in Processing Answer Sheets

Most pupil answers to tests were scored by an IBM 1230 Optical Scanner with data cards being machine punched during the scoring process. The data cards were then used to provide information for appropriate statistical analyses performed by computer facilities at the University of Akron. In the case of the Fall Pupil Achievement Test computer facilities at The Ohio State University were used. The Pupil Field Studies Test answers were scored and data cards punched by a mark sense process on an IBM 519 machine at the University of Akron. The change to the mark sense process for the last pupil test was made primarily because the IBM 1230 was not scheduled to be available June 1, 1970.

Teacher data were processed by careful hand scoring and then were punched into cards in later phases of the statistical analysis.

Introduction to the Treatment of the Data

As indicated earlier, the teacher was taken as the basic unit of the experiment, not the pupil. So when pupil data were used, means of pupil scores for each teacher were the units of statistical analysis, not the individual pupil scores. The means were based on scores of all the teacher's earth science pupils present on the days the respective tests were given. When teacher data were used
Effects of the Inservice Program
On Classroom Activity

After participation in the NSF Cooperative College-School Science inservice program, teachers were expected to be more laboratory oriented in their teaching. Several comparisons outlined in the following sections were made to determine whether or not significant change toward laboratory activity in the science classrooms of the study group teachers occurred as a result of the inservice program.

Pre-Post, Teacher Measures of Science Classroom Activity

These data were treated using analysis of variance techniques and Duncan's New Multiple Range Test (NMRT).\(^5\)

1. \(T_{K1}\) (How it was) by individual teacher

\[
M_{69} \text{ vs } 0_{69} \text{ vs } M_{70} \text{ F-Test}
\]

Duncan's NMRT was then used to isolate the differences.

2. \(T_{K2}\) (How it could have been) by individual teacher scores

\[
M_{69} \text{ vs } 0_{69} \text{ vs } M_{70} \text{ F-Test}
\]

Duncan's NMRT was applied to data from teacher scores above to isolate the significant differences.

Tests for Differences of PK Classroom Activity, Means of Means Between the Study Group vs Comparison Groups

The data analysis is based on the means of pupil scores on the classroom activity instrument, PK. F ratios were calculated using the BMD OIV, Analysis of Variance for One-Way Design.\textsuperscript{52} F ratios were determined for the following combinations with the number in parentheses representing the number of teachers per group. See Appendixes C and D for the pupil means by group, pages 88, 89.

- M69S (22) vs M69C (10)
- M70S (22) vs M70C (12)
- M69S (22) vs M70S (22)
- M69C (10) vs M70C (12)

Pupil Achievement Data, PA: September 1969 PA vs May 1970 PA

Pre and post achievement data for the pupils of the study group teachers was collected. A t-test was calculated to analyze the change in pupil achievement.

Stepwise Multiple Linear Regression Analysis

There were eighteen variables used in the regression program, BMD 02R.\textsuperscript{53} N=22 for all 18 variables. Variables 1-5 were used as dependent variables in the subprograms. The program used for the analysis was BMD 02R Step-wise Regression Revised June 26, 1969.

1. Mean of Pupil answers on PK May 1970 by teacher in the study group.
2. Test scores by teacher on TK\textsubscript{1} May 1970.
3. Test scores by teacher on TK\textsubscript{2} May 1970.
4. Mean of pupil scores by teacher on PA May 1970.
5. Mean of pupil scores by teacher on PFS May 1970.
7. Teacher test score on the TS test in August 1969.
8. Number of field trips conducted by teacher.
9. Teacher's undergraduate point average.
10. Number of different class preparations by teacher (e.g., two biology classes and three earth science classes would be two preparations).
11. The age of the school building in which the teacher taught.
12. The number of years teaching experience of the teacher.
13. Using only ESCP text. 0 = no, 1 = yes.
14. Using ESCP text and supplementing: 0 = no, 1 = yes.
15. The number of earth science classes taught each day by teacher.
16. Rank of the teacher in the study group from 5 for the lowest to 99 for the highest score on the August 1969 TA Test.
17. The percentage of Black pupils in the school in which the respective teachers taught.

\textsuperscript{53} Dixon, BMD, pp. 233-257d.
18. The percentage of pupils on Aid to Dependent Children in the school.

Pertinent results of the regression analysis are incorporated in Chapter Four, The Analysis of Data.

Summary

The population and sample teachers are discussed. Evaluation instruments used in the study are described. The evaluation design including treatments and collection of data is outlined. Statistical techniques for analyzing data are delineated.
CHAPTER FOUR

THE ANALYSIS OF THE DATA

Introduction

The inservice program was expected to produce changes in the teaching of science in the junior high schools of Akron. The adoption of two earth science textbooks, *Investigating the Earth* and *Focus on Earth Science*, and the purchase of substantial laboratory equipment by the school board and administrators effected changes. The teacher participation for ten weeks during the Summer of 1969 and Saturday meetings of the academic year phase outlined in Appendix A pages 82-85 should have produced additional changes. The major question to be answered is whether or not measurable change was produced in teacher behavior in a form or forms which can be measured statistically.

Pre-Post, Teacher Measures of Science Classroom Activity

Analyses of variance and Duncan's NMRT were used to treat the data. The teacher answered the classroom activity items based on how he believed he was teaching on TK₁ and how he thought he could have been teaching on TK₂.
TK₁ (How it was) by individual teacher

M69 vs 069 vs M70 F-Test

An F ratio of 6.338 was obtained as shown in Table 2 below. This F ratio is significant at the .01 level of probability and Duncan's NMRT was employed to isolate the differences as shown in Table 3, page 44.

<table>
<thead>
<tr>
<th></th>
<th>May 1969</th>
<th>October 1969</th>
<th>May 1970</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means</strong></td>
<td>33.41</td>
<td>41.09</td>
<td>40.86</td>
</tr>
<tr>
<td><strong>Treatments</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>840.63</td>
<td>2</td>
<td>420.32</td>
</tr>
<tr>
<td>Within Groups</td>
<td>4177.72</td>
<td>63</td>
<td>66.31</td>
</tr>
</tbody>
</table>

There is a difference at the .01 level of probability between the May 1969 TK₁ instrument data mean, 33.41, and the October 1969 TK₁ instrument data mean, 41.09, for the teachers in the study group.

There is also a difference at the .01 level of probability between the mean of May 1969 TK₁ instrument
data, 33.41, and the mean of May 1970 TK instrument data, 40.86.54

TABLE 3.— Duncan's NMRT Comparison of Means of Teacher Scores Based on TK, Administered in May 1969, October 1969 and May 1970

<table>
<thead>
<tr>
<th></th>
<th>M69</th>
<th>M70</th>
<th>069</th>
<th>Shortest Significant Ranges</th>
<th>Probability Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means</td>
<td>33.41</td>
<td>40.86</td>
<td>41.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M69-33.41 --</td>
<td>7.45</td>
<td>7.68</td>
<td></td>
<td>R2 = 6.54</td>
<td>.01</td>
</tr>
<tr>
<td>M70-40.86 -- --</td>
<td>.23</td>
<td></td>
<td>R2 = 6.82</td>
<td>.01</td>
<td></td>
</tr>
</tbody>
</table>

Null Hypotheses:

H0: uM69 = u069 is rejected at .01.
H0: uM69 = uM70 is rejected at .01.
H0: u069 = uM70 is accepted.

2. TK2 (How it could have been) by individual teacher scores. Each teacher answered the classroom activity items based on how he could have been teaching if he controlled his teaching environment.

M69 vs 069 vs M70 F-Test
An F ratio of 2.8838 was obtained as shown on Table 4, page 45. The differences were isolated by applying Duncan's NMRT as indicated in Table 5, page 45.

TABLE 4.--One-Way Three-Level Analysis of Variance for Data from Teacher Scores on TK2, How Teachers Believed They Could Have Been Teaching, Administered in May 1969, October 1969 and May 1970

<table>
<thead>
<tr>
<th></th>
<th>May 1969</th>
<th>October 1969</th>
<th>May 1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means</td>
<td>51.05</td>
<td>55.45</td>
<td>55.00</td>
</tr>
<tr>
<td>Treatments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>258.76</td>
<td>2</td>
<td>129.38</td>
</tr>
<tr>
<td>Within Groups</td>
<td>2826.41</td>
<td>63</td>
<td>44.86</td>
</tr>
</tbody>
</table>

This F ratio is significant at the .10 level of probability and Duncan's NMRT was applied.

TABLE 5.--Duncan's NMRT post hoc Comparison of Means of Teacher Scores on the TK2, Administered in May 1969, October 1969 and May 1970

<table>
<thead>
<tr>
<th></th>
<th>M69</th>
<th>M70</th>
<th>069</th>
<th>Shortest Significant Ranges</th>
<th>Probability Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means</td>
<td>51.05</td>
<td>55.00</td>
<td>55.45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M69-51.05</td>
<td>3.95</td>
<td>4.40</td>
<td>$R_2 = 3.37$</td>
<td>.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$R_2 = 4.05$</td>
<td>.05</td>
</tr>
<tr>
<td></td>
<td>M70-55.00</td>
<td>--</td>
<td>.45</td>
<td>$R_3 = 3.57$</td>
<td>.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$R_3 = 4.25$</td>
<td>.05</td>
</tr>
</tbody>
</table>

Null Hypotheses for TK2 data:

$H_0$: $u_{M69} = u_{069}$ is rejected at .05.

$H_0$: $u_{M69} = u_{M70}$ is rejected at .10.

$H_0$: $u_{069} = u_{M70}$ is retained.
Tests for Differences of PK, Classroom Activity, Means of Means Between Study Group vs the Comparison Groups

The data analysis is based on pupil mean scores on the Classroom Activity Instrument, PK. F ratios were calculated using the BMD OIV, Analysis of Variance for One-Way Design. F ratios were determined for the following combinations with the number in parenthesis representing the number of teachers per group. The NMRT was not used because the One-Way Two-Level Analysis isolates the differences directly. See Appendixes C and D, pages 88, 89 for the pupil means by group.

- M69S (22) vs M69C (10) F ratio = 1.6809
- M70S (22) vs M70C (12) F ratio = 4.1909
- M69S (22) vs M70S (22) F ratio = 2.0917
- M69C (10) vs M70C (12) F ratio = 0.0268

Null Hypotheses:

Retained or rejected based on the F ratio calculated.

H₀: \( u_{M69S} = u_{M69C} \) is accepted.

H₀: \( u_{M70S} = u_{M70C} \) is rejected at the .05 level of probability.

H₀: \( u_{M69S} = u_{M70S} \) is rejected at the .20 level of probability.  

H₀: \( u_{M69C} = u_{M70C} \) is accepted.

---

55 Dixon, BMD, pp. 486-494.

Results of Hypotheses Tested

The means of teacher scores on the TK₁ Instrument indicated that the teachers thought they were doing more laboratory oriented teaching in October 1969 and May 1970 than they had been doing during the 1968-1969 school year. Teacher scores on TK₂ indicated a change toward more inquiry in how the teachers thought they could have been teaching if they controlled more of the classroom environment factors.

There was a difference between the May 1970 mean of pupil means for the study group and the May 1970 comparison group mean of pupil means at the .05 level of probability. There was a difference at the .20 level of probability between the study group's mean of means in May 1969 and the study group's mean of means in May 1970. The difference between the study group and the comparison group in May 1970, though not large, suggests positive change in how the pupils viewed the classroom activity of study group teachers in May 1969 versus May 1970.

Summary of Null Hypotheses

1. Teacher Data, TK₁ (Was)

The null hypothesis that the three means of teacher scores on the TK₁ instrument (How they thought they were teaching) administered in May 1969, October 1969 and May 1970 indicate no significant difference was rejected at greater than .01 level of probability. Duncan's NMRT
indicated the null hypothesis, the mean of teacher scores in May 1969 (Pretreatment) shows no sample difference from the mean of teacher scores in October 1969 (Posttreatment), was rejected at greater than .01 level of probability.

Further, the null hypothesis, the May 1969 mean of teacher scores shows no sample difference from May 1970 (Posttreatment) was rejected at greater than the .01 level of probability. The null hypothesis that the two posttreatment means show no sample difference was accepted at less than .10 level of probability.

2. Teacher Data from TK2 (Could Have Been)

The null hypothesis that the three means of teacher scores on the TK2 instrument (How the teacher thought he could have been teaching) administered in May 1969, October 1969 and May 1970 show no sample difference was rejected at greater than .10 level of probability. Duncan's NMRT indicated that the null hypothesis, the mean of teacher scores in May 1969 (Pretreatment) shows no sample difference from teacher scores in October 1969 (Posttreatment) should be rejected at greater than the .05 level of probability. The null hypothesis, the May 1969 mean of teacher scores, shows no sample difference from the mean of May 1970 teacher scores was rejected at .10 level of probability. The null hypothesis that the posttreatment means show no sample difference was accepted at less than .10 level of probability.
3. Tests for Difference Between the Study Group and the Comparison Groups Using Pupil Data in May 1969 and May 1970

The null hypothesis that the mean of pupil measures of classroom activity for the study group in May 1970 shows no sample difference from the mean of pupil measures of classroom activity of the comparison group in May 1970 was rejected at greater than .05 level of probability. The null hypothesis, the mean of pupil measures of classroom activity for the May 1969 study group shows no sample difference from the mean of pupil classroom activity measures for the May 1970 study group, was rejected at greater than .20 level of probability.

The null hypothesis that the pupil measures of classroom activity between the May 1969 study group and the May 1969 comparison group were equal was accepted. The null hypothesis that the pupil measures of classroom activity between the May 1969 comparison group and the May 1970 comparison group were equal was accepted.

4. Pupil Achievement Test Data (PA): September 69 PA vs May 70 PA

Combined class means for the twenty-two study group teachers indicated a difference. A t-test calculated between means of means gave \( t = 10.39 \). This value exceeds the .001 level of probability\(^{57}\) The Fall 1969 mean was

\(^{57}\) Ferguson, Statistical Analysis, pp. 170, 407.
10.85. The May 1970 mean was 13.63. See Appendix C page 88 for a table of the actual means by teacher.

Introduction to the Interpretation of Correlation and Regression Data

The analysis of change in the pupils’ observations leads to comparisons by a combination of correlation and regression techniques. The data in Table 6 page 51 contains the list of significant correlations between how the pupils saw classroom activity in May 1970 and other variables in this study. A complete correlation matrix and verbal statement of the eighteen variables is found in Appendix B, pages 86, 87.

In Table 6, page 51 the variables indicated by c were factors that should have been affected by the inservice program. These variables all have positive correlations with the mean of pupil measures of classroom activity May 1970. However two negative correlations were community and general school environmental factors that were not directly affected by the inservice program. These negative correlations, the percentage of Black pupils in the school and the percentage of pupils on Aid to Dependent Children in the school, with the pupil measurement means of classroom activity May 1970 pointed to a problem of environmental factors that possibly suppressed the changes sought through the inservice program. The third negative correlation suggested that the laboratory oriented classroom
<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation Coefficient (against Variable 1)</th>
<th>Probabilitya</th>
</tr>
</thead>
<tbody>
<tr>
<td>b 2c</td>
<td>0.515</td>
<td>.02</td>
</tr>
<tr>
<td>b 4c</td>
<td>0.535</td>
<td>.02</td>
</tr>
<tr>
<td>5c</td>
<td>0.447</td>
<td>.05</td>
</tr>
<tr>
<td>b 6c</td>
<td>0.453</td>
<td>.05</td>
</tr>
<tr>
<td>b 7c</td>
<td>0.362</td>
<td>.10</td>
</tr>
<tr>
<td>b 10</td>
<td>-0.424</td>
<td>.05</td>
</tr>
<tr>
<td>b 13c</td>
<td>0.480</td>
<td>.05</td>
</tr>
<tr>
<td>b 17</td>
<td>-0.545</td>
<td>.01</td>
</tr>
<tr>
<td>b 18</td>
<td>-0.665</td>
<td>.01</td>
</tr>
</tbody>
</table>


brepresents variables common to this correlation table and at least one of the regression tables that follow on pages 52 and 53.

cshould be influenced by the inservice program.

Key to Variables for Correlation Tables.
4. Mean of Pupil Achievement Test scores.
5. Mean of Pupil Field Studies Test scores.
7. Teacher Scores on Sources of Local Information Test.
10. Number of different daily class preparations.
13. Using only ESCP materials.
17. The percentage of Black pupils in the school.
18. The percentage of pupils on Aid to Dependent Children in the school.
activity decreased as the number of different subject preparations by the teacher increased.

To further support the correlation data the regression analyses were calculated and Table 7 below and Table 8 on page 53 summarize the regression data.

TABLE 7.—Partial Summary of the Regression Analysis for Mean of Pupil Means of Classroom Activity
May 1970

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entereda</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18</td>
<td>0.6652</td>
<td>0.4425</td>
</tr>
<tr>
<td>2</td>
<td>16b</td>
<td>0.7280</td>
<td>0.5299</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>0.8020</td>
<td>0.6432</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>0.8311</td>
<td>0.6907</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>0.8506</td>
<td>0.7105</td>
</tr>
<tr>
<td>6</td>
<td>3b</td>
<td>0.8549</td>
<td>0.7308</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>0.8590</td>
<td>0.7380</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>0.8619</td>
<td>0.7429</td>
</tr>
</tbody>
</table>

aKey to the variables for this table is found on pages 40, 41.

bshould be influenced by the inservice program.

In all the Partial Summary Tables of the Regression Analyses in this paper only those variables accounting for a significant portion of the remaining variance will be listed. The significance level selected was that of an F ratio significant at .01 level of probability in the calculation of the amount of additional variance reduction attributed to the variable.58 The F value obtained in

58Dixon, BMD, pp. 233-257d.
the computer analysis was checked against table values at the appropriate degrees of freedom before the variable was included in the regression tables of this study.

**TABLE 8.--Partial Summary of the Regression Analysis for Mean of Pupil Means of Classroom Activity May 1970 With the Percentage of Pupils on Aid to Dependent Children Removed**

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entered&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>0.5446</td>
<td>0.2966</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>0.7047</td>
<td>0.4966</td>
</tr>
<tr>
<td>3</td>
<td>6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7715</td>
<td>0.5952</td>
</tr>
<tr>
<td>4</td>
<td>13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7946</td>
<td>0.6313</td>
</tr>
<tr>
<td>5</td>
<td>16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.8264</td>
<td>0.6829</td>
</tr>
<tr>
<td>6</td>
<td>14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.8328</td>
<td>0.6935</td>
</tr>
<tr>
<td>7</td>
<td>7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.8385</td>
<td>0.7031</td>
</tr>
</tbody>
</table>

<sup>a</sup>key to the variables for this table is found on page 40.

<sup>b</sup>should be influenced by the inservice program.

The variables that are common to the significant correlation table above and one or both of the partial summary tables obtained from the regression analysis can be noted on Table 6, page 51. Variable 2, teacher measures of classroom activity May 1970; Variable 4, mean of pupil achievement scores; Variable 6, number of academic year inservice meetings attended 1969-1970; Variable 7, teacher score on Sources of Local Information Test; and Variable 13, using only ESCP Materials are in the domain of factors that the inservice program was expected to
improve. Variable 10, the number of different daily class preparations, should be recognized by school administrators as a possible factor in reducing laboratory activity in science classrooms. Variable 17, the percentage of Black pupils and 18, the percentage of pupils on Aid to Dependent Children are definitely related in a negative fashion to classroom laboratory activity and teaching by the inquiry method.

It is understood that a strong linear relationship either in correlation or regression is not the same as finding causes for relationships that can be measured and found to be linear.59 For example in the case of the number of different daily class preparations in relation to the mean of pupil means of classroom activity in May 1970 above, several different class preparations do not necessarily cause the lower probability of laboratory procedures being used in the classroom.

It is possible that a given teacher with three different class preparations might have to travel to three or more different rooms and this required travelling causes too many practical problems in laboratory preparation. A second teacher with three preparations who has "his own" room might use a more laboratory oriented approach. In other words the number of different rooms used per day per

teacher, a variable not used in this study, might be a better predictor of the degree of laboratory activity in a science class. The high negative correlation coefficient may be in the table because of a high positive relationship between teacher "travel", or room changing, and the number of different class preparations. The "travel" might cause the reduced laboratory activity.

**Positive Relationships to Classroom Laboratory Activity-Pupil Data**

The correlation, 0.535, between higher measures by pupils of laboratory activities on the PK instrument and higher mean scores on the Pupil Achievement Test, PA, indicates a desirable relationship at the .02 level of probability. However it is not possible to claim that more laboratory oriented teaching causes higher pupil achievement. The textbook being used, percentage of pupils on Aid to Dependent Children in the school and other environmental factors not measured may have caused the desirable correlation between classroom activity and achievement.

**Negative Factors Related to Classroom Activity Pupil Data**

Variable 10, number of different daily class preparations; Variable 17, the percentage of Black pupils; and 18, the percentage of pupils on Aid to Dependent Children are significantly related in a negative fashion to the desired laboratory oriented science class activity. The complex
environmental relationship involved in the percentage of Black pupils and the percentage of pupils on Aid to Dependent Children prevent causal relationships from being precisely defined. It seems clear that if a laboratory oriented approach is to be used by teachers in schools with high percentages of pupils qualifying for Aid to Dependent Children and high percentages of Black pupils there must be something in addition to the in-service program for those teachers and pupils.

Teacher Data on What the Classroom Activity Was

A significant change at greater than the .01 level of probability was made in how the teachers thought they were teaching between May 1969 and October 1969. A similar change was noted between May 1969 and May 1970.

Table 9, page 57, Significant correlations between how the teacher thought he was teaching and the other seventeen variables of the study, includes Variables 1, pupil measures of classroom activity May 1970; 3, teacher measures of what classroom activity could have been May 1970; 4, mean of pupil achievement scores; 5, mean of Pupil Field Study Test scores; 13, using only ESCP materials; 15, number of earth science classes taught each day. These six variables are also found on one or both Partial Summary Table 10, page 58, and Partial Summary Table 11, page 59.
TABLE 9.—Significant Correlations Between How the Teacher Thought He Was Teaching and the Other Seventeen Variables of the Study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation Coefficient</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>a 1^b</td>
<td>0.515</td>
<td>.02</td>
</tr>
<tr>
<td>a 3^b</td>
<td>0.636</td>
<td>.01</td>
</tr>
<tr>
<td>a 4^b</td>
<td>0.653</td>
<td>.01</td>
</tr>
<tr>
<td>a 5^b</td>
<td>0.586</td>
<td>.01</td>
</tr>
<tr>
<td>a 13^b</td>
<td>0.601</td>
<td>.01</td>
</tr>
<tr>
<td>a 15</td>
<td>0.454</td>
<td>.05</td>
</tr>
</tbody>
</table>

^a represents variables common to this correlation table and at least one of the regression tables that follows on pages 58 and 59.

^b should be influenced by the inservice program.

Key to the variables for the correlation table above.
1. Mean of pupil measures of classroom activity May 1970.
3. Teacher measures of what classroom activity could have been May 1970.
4. Mean of Pupil Achievement Scores.
5. Mean of Pupil Field Studies Test Scores.
13. Using only ESCP materials.
15. Number of Earth Science classes taught each day.

Interpretations of Positive Correlations To How the Teacher Thought That He Was Teaching

A predictable and desirable correlation between how the teacher believed he was teaching and how the pupils saw the classroom activity, 0.515, (probability level greater than .02) and how the teacher believed he could have been teaching, 0.636, (.01) is evident from Table 9.
TABLE 10.--Partial Summary of the Regression Analysis For Dependent Variable 2, Teacher Measures of Classroom Activity, May 1970

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entered</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4b</td>
<td>0.6532</td>
<td>0.4267</td>
</tr>
<tr>
<td>2</td>
<td>3b</td>
<td>0.7432</td>
<td>0.5524</td>
</tr>
<tr>
<td>3</td>
<td>1b</td>
<td>0.7820</td>
<td>0.6115</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>0.8431</td>
<td>0.7109</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>0.8705</td>
<td>0.7578</td>
</tr>
<tr>
<td>6</td>
<td>14b</td>
<td>0.9003</td>
<td>0.8105</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>0.9209</td>
<td>0.8481</td>
</tr>
<tr>
<td>8</td>
<td>13b</td>
<td>0.9262</td>
<td>0.8578</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>0.9356</td>
<td>0.8754</td>
</tr>
<tr>
<td>10</td>
<td>5b</td>
<td>0.9572</td>
<td>0.9162</td>
</tr>
<tr>
<td>11</td>
<td>7b</td>
<td>0.9594</td>
<td>0.9204</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>0.9619</td>
<td>0.9252</td>
</tr>
<tr>
<td>13</td>
<td>14 (removed)</td>
<td>0.9619</td>
<td>0.9252</td>
</tr>
<tr>
<td>14</td>
<td>8b</td>
<td>0.9652</td>
<td>0.9316</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>0.9595</td>
<td>0.9399</td>
</tr>
<tr>
<td>16</td>
<td>14</td>
<td>0.9710</td>
<td>0.9429</td>
</tr>
</tbody>
</table>

a) Key to the variables for this table is found on page 40.

b) Should be influenced by the inservice program.

Certainly it should be possible to affect how a teacher thought he was teaching and how he could have been teaching through an inservice program. In fact the analysis of variance data reported on page 43 indicates that significant changes were produced (p < .01) in how the study group teachers believed they were teaching before the inservice program compared to how they were teaching after the inservice program. The significant positive correlations between the teacher's scores on how they thought they were teaching and pupil achievement as measured on the Pupil Achievement Test.
TABLE 11.—Partial Summary of the Regression Analysis for Dependent Variable 2, Teacher Measures of Classroom Activity with the Effects of Pupil Achievement Scores and Field Study Scores Removed

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entered(^a)</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3(^b)</td>
<td>0.6363</td>
<td>0.4049</td>
</tr>
<tr>
<td>2</td>
<td>1(^b)</td>
<td>0.7561</td>
<td>0.5717</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>0.8111</td>
<td>0.6578</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>0.8233</td>
<td>0.6799</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>0.8453</td>
<td>0.7145</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>0.8738</td>
<td>0.7635</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>0.8935</td>
<td>0.7983</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>0.9046</td>
<td>0.8145</td>
</tr>
<tr>
<td>9</td>
<td>13(^b)</td>
<td>0.9120</td>
<td>0.8317</td>
</tr>
<tr>
<td>10</td>
<td>7(^b)</td>
<td>0.9256</td>
<td>0.8578</td>
</tr>
<tr>
<td>11</td>
<td>11 (removed)</td>
<td>0.9256</td>
<td>0.8567</td>
</tr>
<tr>
<td>12</td>
<td>8(^b)</td>
<td>0.9310</td>
<td>0.8669</td>
</tr>
<tr>
<td>13</td>
<td>12</td>
<td>0.9371</td>
<td>0.8782</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>0.9397</td>
<td>0.8831</td>
</tr>
</tbody>
</table>

\(^a\) Key to the variables for this table is found on page 40.

\(^b\) Should be influenced by the inservice program.

and the Pupil Field Study Test certainly suggest that the laboratory oriented approach was beneficial to pupil achievement.

The significant positive correlation between how the teacher thought he was teaching and the selection of a laboratory oriented ESCP textbook, *Investigating the Earth*,\(^60\) is not surprising. The teachers in Akron were given the option of using the ESCP text or a more

---

conventional text, *Focus on Earth Science*. It is reasonable to assume that by choosing the ESCP text the teacher expected to teach in a more laboratory oriented approach. Those teachers using ESCP and Supplementary Materials felt the ESCP text was "not clear" or "too difficult" and their supplementary materials were really in lieu of ESCP materials and geared to a lower reading level. Then Variable 14, Using ESCP Text and Supplementing, represents a more conventional approach than a true ESCP approach.

**Interpretations of Negative Factors Related to How the Teacher Thought That He was Teaching**

There were no negative correlations at (.10 level of probability) with respect to how the teacher thought he was teaching and the other seventeen variables. However Variable 10, the number of different class preparations versus Variable 15, the number of earth science classes taught per day, had an expected negative correlation of -0.621 that is significant at greater than the (.01). It was noted on page 55 that the number of different class preparations was negatively correlated to the laboratory oriented classroom activity. Because Variable 15, number of earth science classes taught each day is positively correlated to how the teacher thought he was teaching there

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61 Margaret S. Bishop, Phyllis G. Lewis, and Richmond L. Bronaugh, *Focus on Earth Science* (Columbus, O.: Charles E. Merrill, 1969).
seems to be further evidence favoring a reduction of the number of different class preparations per teacher if a laboratory approach to earth science teaching is desired.

**Teacher Data on what the Classroom Activity Could Have Been**

The change in how the teachers believed they could have been teaching was in the desired direction, toward a more laboratory oriented approach. The change between May 1969 (followed by the summer phase of the inservice program) and October 1969 was significant at the .05 level of probability. The change between May 1969 and May 1970 was significant at the .10 level of probability. It is the investigator's opinion that the teachers had a clear image of how they wanted to teach science prior to the inservice program and that this image included more laboratory activity than they had previously included in their teaching. The inservice program did favorably affect and reinforce the study group's belief in their ability to teach laboratory oriented earth science courses.

In looking further for variables that might affect Variable 3, teacher measures of what classroom activity could have been, the statistical relationships shown on Tables 12, 13 and 14, pages 62, 63 and 64, were found.
### TABLE 12.—Significant Correlations Found Between Variable 3, How the Teacher Thought He Could Have Been Teaching, and the Other Seventeen Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation Coefficient (against Variable 3)</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>a 2b</td>
<td>0.636</td>
<td>.01</td>
</tr>
<tr>
<td>a 4b</td>
<td>0.506</td>
<td>.02</td>
</tr>
<tr>
<td>a 5b</td>
<td>0.455</td>
<td>.05</td>
</tr>
<tr>
<td>a 11</td>
<td>-0.381</td>
<td>.10</td>
</tr>
<tr>
<td>a 13</td>
<td>0.413</td>
<td>.10</td>
</tr>
<tr>
<td>a 15</td>
<td>0.370</td>
<td>.10</td>
</tr>
</tbody>
</table>

*a*represents variables common to this correlation table and at least one of the regression tables on pages 63 and 64.

*b*should be influenced by the inservice program.

**Key to the variables for the correlation table above.**

4. Mean of Pupil Achievement scores.
5. Mean of Pupil Field Study Test scores.
11. Age of school building.
15. Number of earth science classes taught each day.

### Interpretations of Positive and Negative Factors Related to How the Teacher Could Have Been Teaching

The inservice program encouraged the teacher to believe that he could teach by an inquiry method and encouraged the teacher to adopt the more laboratory oriented ESCP text. The positive correlations between teacher measures of what classroom activity could have been, $TK_1$ versus $TK_2$, when matched to the teacher choosing the ESCP materials indicate that the inservice program did encourage
the teacher to use an inquiry approach and thus select the ESCP text.

**TABLE 13.** Partial Summary of the Regression Analysis for Dependent Variable 3, How the Teacher Thought He Could Have Been Teaching and the Other Seventeen Variables

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entered&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.6363</td>
<td>0.4049</td>
</tr>
<tr>
<td>2</td>
<td>14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7056</td>
<td>0.4979</td>
</tr>
<tr>
<td>3</td>
<td>8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7581</td>
<td>0.5747</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>0.8042</td>
<td>0.6467</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>0.8407</td>
<td>0.7067</td>
</tr>
<tr>
<td>6</td>
<td>16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.8650</td>
<td>0.7483</td>
</tr>
<tr>
<td>7</td>
<td>6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.8787</td>
<td>0.7722</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>0.8950</td>
<td>0.8010</td>
</tr>
<tr>
<td>9</td>
<td>3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.9022</td>
<td>0.8139</td>
</tr>
<tr>
<td>10</td>
<td>13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.9124</td>
<td>0.8326</td>
</tr>
<tr>
<td>11</td>
<td>7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.9184</td>
<td>0.8434</td>
</tr>
</tbody>
</table>

<sup>a</sup>Key to the variables for this table is found on page 40.

<sup>b</sup>Should be affected by the inservice program.

There was no direct influence made during the inservice program to force the ESCP text onto the teachers. Both the university faculty and the teachers in the inservice program felt that the reading level of the ESCP text was too high for the average or below average eighth grade pupil. Therefore the selection of the ESCP text was based on the teacher's expectation of using a laboratory approach and minimizing the use of the vocabulary of the course materials.
TABLE 14.--Partial Summary of the Regression Analysis for Dependent Variable 3, How the Teacher Thought He Could Have Been Teaching with the Effects of Variable 2, Teacher Measures of Classroom Activity Removed

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entereda</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>0.5059</td>
<td>0.2560</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>0.6408</td>
<td>0.4106</td>
</tr>
<tr>
<td>3</td>
<td>6b</td>
<td>0.7015</td>
<td>0.4912</td>
</tr>
<tr>
<td>4</td>
<td>14b</td>
<td>0.7374</td>
<td>0.5438</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>0.7758</td>
<td>0.6018</td>
</tr>
<tr>
<td>6</td>
<td>16b</td>
<td>0.8183</td>
<td>0.6697</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>0.8444</td>
<td>0.7131</td>
</tr>
<tr>
<td>8</td>
<td>7b</td>
<td>0.8681</td>
<td>0.7537</td>
</tr>
<tr>
<td>9</td>
<td>8b</td>
<td>0.8956</td>
<td>0.8020</td>
</tr>
<tr>
<td>10</td>
<td>13b</td>
<td>0.9106</td>
<td>0.8291</td>
</tr>
<tr>
<td>11</td>
<td>15</td>
<td>0.9207</td>
<td>0.8476</td>
</tr>
</tbody>
</table>

a-key to the variables for this table is found on page 40.

b-should be affected by the inservice program.

Introduction to Achievement Data

It is appropriate to look at pupil achievement and variables that are related to the pupil achievement. The combined pupil achievement mean for the study group increased (.001 level of probability) between September 1969 and May 1970.

Interpretation of Positive Factors Related to Achievement

The following significant statistical relationships were found between Variable 4, mean scores on the Pupil Achievement Test, and the other seventeen variables
considered in this study as shown on Table 15 below and on Tables 16 and 17, pages 66 and 67.

**TABLE 15.--Significant Correlations Between Variable \(^a\), Pupil Achievement, and the other Seventeen Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation Coefficient</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>a (^1)</td>
<td>0.535</td>
<td>.02</td>
</tr>
<tr>
<td>a (^2)</td>
<td>0.653</td>
<td>.01</td>
</tr>
<tr>
<td>a (^3)</td>
<td>0.506</td>
<td>.02</td>
</tr>
<tr>
<td>a (^5)</td>
<td>0.843</td>
<td>.01</td>
</tr>
<tr>
<td>a (^6)</td>
<td>-0.633</td>
<td>.01</td>
</tr>
<tr>
<td>a (^7)</td>
<td>0.562</td>
<td>.01</td>
</tr>
<tr>
<td>a (^8)</td>
<td>0.539</td>
<td>.01</td>
</tr>
<tr>
<td>a (^9)</td>
<td>0.617</td>
<td>.01</td>
</tr>
<tr>
<td>a (^10)</td>
<td>-0.787</td>
<td>.01</td>
</tr>
</tbody>
</table>

\(^a\) represent variables common to this correlation table and at least one of the regression tables that follow on pages 66 and 67.

\(^b\) should be influenced by the inservice program.

Key to the variables for the correlation table above.
1. Mean of mean pupil measures of Classroom Activity May 1970.
5. Mean of Pupil Field Study Test Scores.
11. Age of school building.
16. Teacher Achievement Rank.
17. Percentage of Black pupils in the school.
18. Percentage of pupils on Aid to Dependent Children

The significant correlations between May 1970 pupil achievement scores and classroom activity in May 1970 as measured by the PK Instrument (.02 level of probability) and the two teacher versions, TK\(_1\) (.01) and TK\(_2\) (.02) are
TABLE 16.—Partial Summary of the Regression Analysis for Dependent Variable ¼, Pupil Achievement Means May 1970

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entereda</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>0.8428</td>
<td>0.7102</td>
</tr>
<tr>
<td>2</td>
<td>7b</td>
<td>0.9194</td>
<td>0.8453</td>
</tr>
<tr>
<td>3</td>
<td>16b</td>
<td>0.9325</td>
<td>0.8695</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>0.9363</td>
<td>0.8766</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>0.9430</td>
<td>0.8893</td>
</tr>
<tr>
<td>6</td>
<td>2b</td>
<td>0.9460</td>
<td>0.8950</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>0.9510</td>
<td>0.9044</td>
</tr>
<tr>
<td>8</td>
<td>6b</td>
<td>0.9566</td>
<td>0.9151</td>
</tr>
<tr>
<td>9</td>
<td>13b</td>
<td>0.9629</td>
<td>0.9272</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>0.9658</td>
<td>0.9328</td>
</tr>
<tr>
<td>11</td>
<td>3b</td>
<td>0.9680</td>
<td>0.9371</td>
</tr>
<tr>
<td>12</td>
<td>11</td>
<td>0.9692</td>
<td>0.9393</td>
</tr>
<tr>
<td>13</td>
<td>1b</td>
<td>0.9703</td>
<td>0.9417</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>0.9714</td>
<td>0.9436</td>
</tr>
</tbody>
</table>

a key to the variables for this table is found on page 40.

b should have been affected by the inservice program.

Reassuring. Admittedly, however, reading ability variations from one school environment to another may be the cause of the measurable positive relationship between laboratory oriented classroom activity and higher pupil achievement. Based on teacher feedback there were many pupils who had difficulty reading the Pupil Achievement Test.

Another factor relates to the selection of test items. Though test items were selected prior to the adoption of the ESCP text by the Board of Education the test items would naturally be answered more easily by pupils who had studied the ESCP text and performed many of
TABLE 17.—Partial Summary of the Regression Analysis for Variable 4, May 1970 Pupil Achievement Means with the Effects of Variable 5, Pupil Field Study Means Removed

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entered</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18</td>
<td>0.7870</td>
<td>0.6194</td>
</tr>
<tr>
<td>2</td>
<td>2b</td>
<td>0.8815</td>
<td>0.7771</td>
</tr>
<tr>
<td>3</td>
<td>6b</td>
<td>0.8963</td>
<td>0.8033</td>
</tr>
<tr>
<td>4</td>
<td>3b</td>
<td>0.9040</td>
<td>0.8172</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>0.9081</td>
<td>0.8246</td>
</tr>
<tr>
<td>6</td>
<td>14b</td>
<td>0.9124</td>
<td>0.8326</td>
</tr>
<tr>
<td>7</td>
<td>13b</td>
<td>0.9202</td>
<td>0.8467</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>0.9237</td>
<td>0.8532</td>
</tr>
<tr>
<td>9</td>
<td>7b</td>
<td>0.9290</td>
<td>0.8630</td>
</tr>
<tr>
<td>10</td>
<td>17</td>
<td>0.9355</td>
<td>0.8751</td>
</tr>
<tr>
<td>11</td>
<td>8b</td>
<td>0.9426</td>
<td>0.8885</td>
</tr>
<tr>
<td>12</td>
<td>15</td>
<td>0.9454</td>
<td>0.8938</td>
</tr>
</tbody>
</table>

superscript aKey to the variables for this table is found on page 40.

superscript bShould have been affected by the inservice program.

The laboratory activities. The ESCP items selected were judged to be suitable on two bases: (1) What might be taught in the 1969-1970 school year to Akron pupils; (2) Items selected were those for which the ESCP data indicated that about fifty per cent of the pupils studying the ESCP materials during the 1964-1966 school years answered correctly. In retrospect more attention should have been given to their "r" values. The "r" value is a correlation factor that indicates the degree to which pupils with high scores answered the item correctly versus
low scoring pupils missing the item.⁶²

Means of Pupil Achievement Test scores have a correlation coefficient of 0.843 in relation to means of scores on Pupil Field Studies Test. Both are multiple choice paper and pencil tests and the ability of a class to do well on one of the tests is obviously correlated to the ability of a class to do well on the other. Reading abilities would be a significant factor for scoring well on the PA or the PFS Tests.

Two variables, using only the ESCP text and teacher achievement, have significant positive correlations (.01 level of probability) when compared to Variable 4, mean of pupil achievement scores. They are variables that should have been influenced by the inservice program. The selection of the ESCP text alone may have accounted for pupils doing better on the achievement test. Because the teacher wanted to teach by a laboratory or inquiry approach may or may not have produced the higher achievement scores. It also seems to follow that if pupil achievement and teacher achievement are so strongly correlated then the teacher course work during the summer was worthwhile. The correlation value between pupil achievement and the teacher's undergraduate point average was 0.078. Hence the more recent achievement in course work appears to have been more

significant than grades for courses taken several years earlier.

**Interpretation of Negative Factors Related to Achievement**

The large negative correlations for the association of achievement with the age of the school building, the percentage of Black pupils in the school and the percentage of pupils qualifying for Aid to Dependent Children reflect environmental factors, lower reading levels, or other factors which depress the pupil achievement. Once again this study does not isolate the causes of these negative correlations, but as noted in Chapter Five, it seems reasonable for further study to be done to isolate the true causes and then design programs to alter the factors that suppress pupil achievement.

**Introduction to Field Study Test Data**

A major portion of the inservice program's summer phase and academic year time was spent in field work with the participants. The Pupil Field Study Test was supposed to determine whether the pupils understood graphing, random sampling, and other concepts that were needed in local study of the pupil's environment. Statistical data related to the field studies follow in Tables 18, 19, and 20 on pages 70, 71, and 72.
TABLE 18.--Significant Correlations Between Variable 5, Pupil Means on the Field Study Test and the other Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation Coefficient</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0.447</td>
<td>.05</td>
</tr>
<tr>
<td>a</td>
<td>0.586</td>
<td>.01</td>
</tr>
<tr>
<td>a</td>
<td>0.555</td>
<td>.05</td>
</tr>
<tr>
<td>a</td>
<td>0.843</td>
<td>.01</td>
</tr>
<tr>
<td>a</td>
<td>-0.646</td>
<td>.01</td>
</tr>
<tr>
<td>a</td>
<td>0.513</td>
<td>.02</td>
</tr>
<tr>
<td>a</td>
<td>-0.589</td>
<td>.01</td>
</tr>
<tr>
<td>a</td>
<td>-0.654</td>
<td>.01</td>
</tr>
</tbody>
</table>

\(^a\)represents variables common to this correlation table and at least one of the regression tables that follow on pages 71 and 72.

\(^b\)should be influenced by the inservice program.

Key to the variables for the correlation table above.
1. Mean of mean pupil measures of classroom activity May 1970.
4. Mean of Pupil Achievement scores.
11. Age of the school building.
17. The percentage of Black pupils in the schools.
18. The percentage of pupils on Aid to Dependent Children in the school.

Interpretation of Positive Factors Related to Field Studies

As would be expected from the 0.843 correlation shown in Table 18, above, between mean scores on the Pupil Achievement Test and the Pupil Field Study Test scores, the PFS correlations are nearly the same as those related to Variable 4, mean of pupil achievement scores.
TABLE 19.--Partial Summary of the Regression Analysis
For the Dependent Variable 5, Pupil Field
Study Means May 1970

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entered</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4b</td>
<td>0.8428</td>
<td>0.7102</td>
</tr>
<tr>
<td>2</td>
<td>7b</td>
<td>0.9163</td>
<td>0.8396</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>0.9286</td>
<td>0.8622</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>0.9431</td>
<td>0.8895</td>
</tr>
<tr>
<td>5</td>
<td>3b</td>
<td>0.9499</td>
<td>0.9023</td>
</tr>
<tr>
<td>6</td>
<td>14b</td>
<td>0.9545</td>
<td>0.9110</td>
</tr>
<tr>
<td>7</td>
<td>16b</td>
<td>0.9589</td>
<td>0.9194</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>0.9630</td>
<td>0.9275</td>
</tr>
<tr>
<td>9</td>
<td>8b</td>
<td>0.9650</td>
<td>0.9313</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>0.9658</td>
<td>0.9327</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>0.9587</td>
<td>0.9383</td>
</tr>
<tr>
<td>12</td>
<td>13b</td>
<td>0.9698</td>
<td>0.9405</td>
</tr>
<tr>
<td>13</td>
<td>1b</td>
<td>0.9706</td>
<td>0.9420</td>
</tr>
<tr>
<td>14</td>
<td>2b</td>
<td>0.9707</td>
<td>0.9422</td>
</tr>
</tbody>
</table>

aKey to the variables for this table is found on page 40.

bshould be influenced by the inservice program.

There are significant positive correlations between Pupil Field Study Test means, means of pupil and teacher measures of classroom activities as determined by the PK, (.05 level of probability), TK₁ (.01), and TK₂ (.05) in May 1970. Reading ability and other factors not measured in this study would have some effect on the Field Study Test scores. However the effect of a more laboratory oriented science course was quite positive for producing higher Field Study Test scores.

The data indicated that pupil achievement and field study scores were positively related to the laboratory-
TABLE 20.—Partial Summary of the Regression Analysis for Dependent Variable 5, Pupil Field Study Means with Variable 4, Pupil Achievement Means Removed

<table>
<thead>
<tr>
<th>Step Number</th>
<th>Variable Entered$^a$</th>
<th>Multiple R</th>
<th>RSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18</td>
<td>0.6536</td>
<td>0.4272</td>
</tr>
<tr>
<td>2</td>
<td>7b</td>
<td>0.7688</td>
<td>0.5911</td>
</tr>
<tr>
<td>3</td>
<td>2b</td>
<td>0.8846</td>
<td>0.7825</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>0.8938</td>
<td>0.7989</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>0.8985</td>
<td>0.8073</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>0.9027</td>
<td>0.8148</td>
</tr>
<tr>
<td>7</td>
<td>14b</td>
<td>0.9067</td>
<td>0.8221</td>
</tr>
<tr>
<td>8</td>
<td>3b</td>
<td>0.9115</td>
<td>0.8308</td>
</tr>
<tr>
<td>9</td>
<td>13b</td>
<td>0.9235</td>
<td>0.8529</td>
</tr>
<tr>
<td>10</td>
<td>8b</td>
<td>0.9321</td>
<td>0.8688</td>
</tr>
<tr>
<td>11</td>
<td>9</td>
<td>0.9368</td>
<td>0.8775</td>
</tr>
<tr>
<td>12</td>
<td>16b</td>
<td>0.9419</td>
<td>0.8872</td>
</tr>
<tr>
<td>13</td>
<td>17 (removed)</td>
<td>0.9419</td>
<td>0.8871</td>
</tr>
<tr>
<td>14</td>
<td>6b</td>
<td>0.9432</td>
<td>0.8896</td>
</tr>
</tbody>
</table>

$^a$ Key to the variables for this table is found on page 40.

$^b$ Should be influenced by the inservice program.

Oriented classroom activity. Pupil achievement was also related to how the teacher thought that he was teaching or could have been teaching. The use of ESCP materials also aided pupils in scoring well on the Field Studies Test as indicated by the positive correlation (.02 level of probability) though none of the test items were from the ESCP materials.

**Interpretation of Negative Factors Related to Field Study**

In Table 18, page 70, Variable 11, age of the school building; Variable 17, the percentage of Black pupils in
the school; and Variable 18, the percentage of pupils on Aid to Dependent Children in the school reflected negative environmental effects on the Pupil Field Studies Test scores. If individual causes for these high negative correlations could be isolated it would seem feasible to develop inservice programs to reduce the negative environmental relationships to pupil achievement.

**Additional Field Study, Variable 5, Correlations**

The teacher feedback concerning the outdoor field studies during the summer was very favorable. How much this fieldwork directly affected their earth science teaching is not directly measured in this study. However some observations regarding the significance of the efforts to encourage outdoor field study made during the inservice program might be drawn from Table 21, page 74, which is a portion of the correlation matrix given on page 87 of Appendix B.

Table 21 indicates a correlation (.10 level of probability) between the teacher's knowledge of sources of local information and the laboratory oriented classroom activity. The teacher's knowledge of sources of local information also correlates with the number of academic year inservice meetings attended (.01 level of probability), number of field trips conducted by the teacher (.05), and the teacher's undergraduate point average (.10).
TABLE 21.—Correlations of Selected Variables Related to Field Study and Teacher Achievement

<table>
<thead>
<tr>
<th>Code Letter</th>
<th>Combination of Variables</th>
<th>Correlation Coefficient</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>1 vs 7</td>
<td>0.362</td>
<td>.10</td>
</tr>
<tr>
<td>b</td>
<td>6 vs 7</td>
<td>0.628</td>
<td>.01</td>
</tr>
<tr>
<td>c</td>
<td>7 vs 8</td>
<td>0.474</td>
<td>.05</td>
</tr>
<tr>
<td>d</td>
<td>7 vs 9</td>
<td>0.398</td>
<td>.10</td>
</tr>
<tr>
<td>3</td>
<td>8 vs 10</td>
<td>0.504</td>
<td>.02</td>
</tr>
<tr>
<td>f</td>
<td>8 vs 17</td>
<td>-0.407</td>
<td>.10</td>
</tr>
<tr>
<td>g</td>
<td>13 vs 16</td>
<td>0.518</td>
<td>.02</td>
</tr>
</tbody>
</table>

Key to the variables for the correlation table above.
1. Mean of mean pupil measures of Classroom Activity May 1970.
7. Teacher score on Sources of Local Information Test.
8. Number of Field Trips conducted by teacher.
9. Teacher's undergraduate point average.
10. Number of different daily class preparations.
16. Teacher Achievement rank.
17. Percentage of Black pupils in the school.

Table 21 indicates that the number of field trips conducted by the teacher was positively correlated to the number of different daily class preparations (.02). The number of field trips conducted by the teacher was negatively correlated (.10) to the percentage of Black pupils in the school.

Teacher Achievement and the Selection of ESCP Materials

The selection of the ESCP materials by the teacher, Variable 13, is positively correlated (.02) to the teacher's
rank on the Teacher Achievement Test, Variable 16, given at the close of the summer phase in August 1969 as shown on Table 21, page 74. Nationally, ESCP materials were gener­ally adopted for ninth grade classes. The materials have been criticized for being "too difficult" by many local teachers. Perhaps the teacher who did well in the concen­trated earth science course work during the summer phase of the inservice program also expected his pupils to be able to use the "difficult" ESCP materials effectively.

**Summary**

A change toward more laboratory activity was reported based on pretreatment and posttreatment teacher data. The pretreatment and posttreatment classroom activity of the study group teachers was compared to the classroom activity of the comparison groups based on pupil data. These data indicated a change toward more laboratory-oriented teaching by the study group teachers. Data from the pre and post pupil achievement tests indicated significant change in the pupils of the study group teachers.

The correlation and regression analyses of the study variables indicated statistically significant positive relationships between pupil assessment of classroom activity and teacher assessment of classroom activity, pupil achievement, number of academic year inservice meetings attended and the use of ESCP materials. The field study
data were similar to the achievement test data.

Additional correlations indicated that the teacher knowledge of sources of local information was related to the number of academic year meetings attended, number of field trips conducted, and the teachers undergraduate point average. Teacher choice of ESCP materials was positively correlated to teacher achievement in the inservice program.
CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Variables of the Study

Correlation and regression analyses were made for eighteen variables based on study group data. The regression analysis was used to support the correlation data. The first five variables were treated as dependent variables in the regression analyses. The eighteen variables were:

1. Mean of pupil answers on PK May 1970 by teacher in the study group.
2. Test scores by teacher on TK1 May 1970.
4. Mean of pupil scores by teacher on PA May 1970.
5. Mean of pupil scores by teachers on PFS May 1970.
6. Number of academic year meetings attended by the teacher during the school year 1969-1970.
7. Teacher test scores on the TS Test in August 1969.
8. Number of field trips conducted by teacher.
9. Teacher's undergraduate point average.
10. Number of different class preparations by teacher.
11. The age of the school building in which the teacher taught.
12. The number of years teaching experience of the teacher.
13. Using only ESCP text; 0=no, 1=yes.
14. Using ESCP text and supplementing: 0=no, 1=yes.
15. The number of earth science classes taught each day by teacher.
16. Rank of the teacher in the study group from 5 for lowest to 99 for highest score on the August 1969 TA test.
17. The percentage of Black pupils in the school in which the respective teachers taught.
18. The percentage of pupils on Aid to Dependent Children in the school where the respective teachers taught.

Conclusions

The following are the major conclusions of this investigation.

Teacher Behavior Changes

The inservice program did make a difference in the teaching of science in the Akron City School System. Teachers participating in the program taught a more laboratory oriented approach to science (significant at the .05 level of probability) during the 1969-1970 school year than did the comparison group teachers.

Pupils indicated (.20) that the study group teachers taught a more laboratory oriented course during the 1969-1970 school year than they had taught during the 1968-1969 school year.

The study group teachers changed the way they thought that they were teaching toward a more laboratory oriented approach (significant at the .01 level of probability).

The study group teachers also changed the way they thought that they could have been teaching if they controlled
more classroom environment factors (significant at the .10 level of probability).

Pupil Change-Achievement

Pupils of the study group teachers made positive gains (.001) on the Pupil Achievement Test during the 1969-1970 school year.

When the dependent variable was pupil achievement, positive correlations were found between pupil achievement and pupil measures of classroom activity in May 1970, (.02 level of probability), how the teachers thought they were teaching (.01), how the teachers thought they could have been teaching (.02), pupil field studies test results (.01), teacher use of only ESCP materials (.01), and teacher achievement test results (.01). These data strongly support the effectiveness of the inservice program.

Negative correlations between pupil achievement and the age of the school building (.01), the percentage of Black pupils in the school (.01), and the percentage of pupils on Aid to Dependent Children (.01) were obtained. These negative correlations point to school and community factors that suppress pupil achievement.

Pupil Change-Field Studies

When the dependent variable was pupil field studies test results a correlation of 0.843 with pupil achievement was noted. Positive correlations with how the pupils
measured classroom activity (.05), how the teachers thought that they were teaching in May 1970 (.01), how the teachers thought that they could have been teaching (.05), pupil achievement (.01), and teacher use of only ESCP materials (.02) were also obtained for the field studies test results.

Negative correlations between pupil field studies results and the age of the school building (.01), the percentage of Black pupils in the school (.01), the percentage of pupils in the school on Aid to Dependent Children (.01) were obtained. The negative effect of some school and community environment factors on the field study achievement cannot be ignored.

Recommendations

1. Additional inservice programs are recommended. When negative school and community variables were removed from the regression analysis the four best predictors, (when used together) of higher pupil achievement were (a) how the teachers thought that they were teaching, (b) teacher achievement, as measured by the achievement test at the end of the summer phase of the inservice program (c) the pupil measures of classroom activity and (d) how the teacher thought that he could have been teaching. On this basis future programs should encourage teachers to use a laboratory oriented approach to science teaching and provide substantial improvement of the teacher's science background.
2. A major effort must be made to alter the causes of the lower pupil achievement. Changes in the school and community environment should be made to reduce the negative effect of environmental factors on pupil achievement.

3. Further study is needed in two areas:
   a. The causes of environmental factors that suppress pupil achievement should be isolated, and programs should be designed to overcome the smothering environmental effects on pupil growth.
   b. There need to be studies in other cities to determine whether inservice programs such as the one in this study could be as effective in other cities or county school systems.
APPENDIX A

DESCRIPTION OF THE 1969-1970 COOPERATIVE COLLEGE-SCHOOL SCIENCE INSERVICE PROGRAM FOR EARTH SCIENCE TEACHERS IN AKRON, OHIO

Dates, Courses, Academic Credit

The program included a ten-week summer phase from June 23 to August 29, 1969. The academic year portion of the program included fifteen meetings held throughout the 1969-1970 school year. Twelve of the fifteen academic year meetings were on Saturdays from 8:00 A.M. to 12:00. Three meetings were held on Tuesday afternoons from 3:00 P.M. to 4:00 P.M.

The course offerings included in the program were divided into two five-week sessions to fit the regular summer schedule at the University of Akron. The participants took two courses per five-week session. The choice of the courses depended on the participants background. The first five-week session courses were:
### Course Title | Quarter Hours Credit
--- | ---
1. Introductory Physical Geology | 5 undergraduate
2. Rocks and Minerals | 5 graduate or undergraduate
3. Seminar in Physical Geography | 4 graduate
4. Research Problems | 3 graduate or undergraduate

The second five week-session courses were:

- 1. Evolution and Geologic Time | 5 graduate or undergraduate
- 2. Geomorphic Processes and Their Investigation | 3 graduate or undergraduate
- 3. The teaching of Earth Science | 3 graduate or undergraduate
- 4. Research Problems | 3 graduate or undergraduate

Each participant took two courses per five-week session for a total of four courses in the ten-week summer phase. The courses were taught only to earth science program participants and were geared to meeting local needs.

Except for Introductory Physical Geology, graduate credit was earned in the courses taken by participants who had been accepted by the Graduate School of the University of Akron. About twenty-five per cent of the forty-three inservice program participants were denied admission to the Graduate School. Another twenty-five percent were accepted on a conditional basis.
Field Study Orientation of the Program

Seven days were spent on field trips in the Akron area to familiarize the teachers with the geologic setting in which they were to teach during the 1969-1970 school year. The final three days, August 27-29, 1969, of the summer phase were spent in the Appalachian Mountains where the teachers were asked to interpret structures and the results of geomorphic processes that they had studied during the summer. An additional four field trips were conducted during the 1969-1970 school year as a part of the Saturday meetings.

Monetary and Academic Support of the Inservice Program

The National Science Foundation supported the in-service program on a joint basis with cooperating schools. Each participant received a stipend of sixty dollars per week and a dependency allowance of fifteen dollars per week per dependent (limited to a total of four dependents). No monetary support was given for the academic year meetings.

The local school districts cooperated by providing equipment, textbooks, audio-visual materials, bussing for field trips, and supplies. The Akron City Schools provided approximately $50,000 in support of the new earth science program.
The University of Akron geology faculty developed courses in cooperation with the College of Education for earth science teachers. Prior to 1967-1968 there was no program for earth science undergraduate majors at the University. Dr. James Teeter, the first full-time geology faculty member to be hired, joined the faculty in the Fall of 1965.

Since most of the Akron teachers are graduates of the University of Akron there were only two teachers certified to teach earth science in the Akron City School System. Forty teachers needed extensive additions to their science background to begin teaching the earth science course adopted for the 1969-1970 school year. The university faculty members who taught in the inservice program structured their courses to meet the needs of the teacher participants.

Evaluation

The participating teachers agreed to cooperate in the evaluation of the inservice program. The evaluation of the program would not have been possible without the extensive cooperation of the teachers and school administrators.
APPENDIX B

KEY TO THE VARIABLES IN THE STUDY FOUND IN
THE CORRELATION MATRIX, PAGE 87

1. Mean of pupil answers on PK, May 1970 by
teacher in the study group.
2. Test scores by teacher on TK1, May 1970.
4. Mean of pupil scores by teacher on PA,
    May 1970.
5. Mean of pupil scores by teacher on PFS,
    May 1970.
6. Number of academic year meetings
    attended by teacher during the school year
7. Teacher test score on the TS test in
    August 1969.
8. Number of field trips conducted by
    teacher.
9. Teacher's undergraduate point average.
10. Number of different class preparations
    by teacher (e.g. two biology classes and
    three earth science classes would be two
    preparations).
11. The age of the school building in which
    the teacher taught.
12. The number of years teaching experience
    of the teacher.
13. Using only ESCP text. 0=no, 1=yes.
14. Using ESCP text and supplementing. 0=no,
    1=yes.
15. The number of earth science classes
    taught each day by teacher.
16. Rank of the teacher in the study group
    from 5 for the lowest to 99 for the
    highest score on the August 1969, TA test.
17. The percentage of Black pupils in the
    school in which the respective teachers
    taught.
18. The percentage of pupils on Aid to
    Dependent Children in the school.
### Correlation Matrix for the Eighteen Variables on Page 86

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### APPENDIX C

**PUPIL DATA, MEANS BY TEACHER OF CLASSROOM ACTIVITY, PUPIL ACHIEVEMENT AND PUPIL FIELD STUDY TEST RESULTS**

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88
APPENDIX D.

MEANS OF CLASSROOM ACTIVITY (PK TEST)
FOR COMPARISON GROUP TEACHERS

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APPENDIX E

DIRECTIONS FOR PK, TK₁, TK₂ INSTRUMENTS FOR MEASURING CLASSROOM ACTIVITY

DIRECTIONS FOR K-TEST: STUDENTS

Carefully examine the IBM answer sheets. Please call the student's attention to:

1. The answer blanks are arranged in rows from left to right not vertical columns.

2. If there are numbered alternatives, use option #1 for True. Use option #2 for False. If there are lettered options, use option "a" for True and option "b" for False.

3. Use soft lead pencils. A #2 pencil will work satisfactorily. (There will be over 3,000 students taking this test. It will be machine scored.)

DIRECTIONS FOR K-TEST: TEACHERS

1. Teachers are asked to take the K-Test twice.

2. Label the first teacher answer sheet "Version One." Answer the questions based on how you taught during this 1969-1970 school year.

3. Label the second teacher answer sheet "Version Two." Now answer the questions based on how you could be teaching if supplies, class sizes, or other factors were more conducive to your style of teaching.
APPENDIX F

ITEMS ON THE PK, TK₁, TK₂ INSTRUMENTS
FOR MEASURING CLASSROOM ACTIVITY

SAMPLE QUESTION
Checklist

1. My teacher often takes class attendance. 1.
   If the statement describes what occurs in your classroom, blacken the space under the letter T (TRUE) on the answer sheet; if it does not, blacken the space under the letter F (FALSE).

REMEMBER:
1. The purpose of the checklist is to determine how well you know what is going on in your classroom.
2. Make no marks in this booklet.
3. All statements should be answered on the answer sheet by blackening in the space under the chosen response in pencil.
4. Please do not write your name on this booklet or answer sheet.

SECTION A
1. The majority of our class time is spent listening to our teacher tell us about science.
2. My teacher doesn't like to admit his mistakes.
3. When we are with our science teacher and are arguing over possible answers in science, the teacher tells us who is right.
4. My teacher often repeats almost exactly what the textbook says.
5. My teacher often asks us to explain the meaning of certain things in the text.
6. My teacher shows us that science has almost all of the answers to questions about science.
7. My teacher asks questions that cause us to think about things that we have learned in earlier studies.
8. My teacher often asks questions that cause us to think about the evidence that is behind statements that are made in the textbook.
9. My teacher gives the answers to all our science questions.
10. My teacher takes some time in class to ask questions that aren't answered by the textbook.
SECTION B
11. My job is to copy down and memorize what the teacher tells us.
12. We students are often allowed time in class to talk among ourselves about ideas in science.
13. Over \( \frac{1}{4} \) of our class time is spent in answering orally or in writing answers to questions that are written in the textbook or study guides.
14. Classroom experiments are usually done by students rather than by the teacher.
15. We seldom or never discuss the problems faced by scientists in the discovery of a scientific principle.
16. If I don't agree with what my teacher says, he wants me to say so.
17. We often talk about the kind of evidence that is behind a scientist's conclusion.
18. It is easy to ask in class about things in nature and science that my textbook doesn't mention.
19. The teacher always tells us what should have happened when a demonstration doesn't work.

SECTION C
20. When reading the text, we are expected to learn most of the details that are stated there.
21. We frequently are required to write out definitions to word lists.
22. Our teacher has tried to teach us how to ask questions of the text.
23. The textbook and the teacher's notes are about the only sources of scientific knowledge that are discussed in class.
24. We sometimes read the original writings of scientists.
25. We are seldom or never required to outline sections of the textbook.
26. We have reading assignments in the textbook about every day.
27. The teacher provides us with information about our local surroundings that isn't in the textbook.
28. Library reading in reference books and periodicals plus lab work take more of my time than science textbook reading takes.

SECTION D
29. Our tests include many questions based on things that we have learned in the laboratory.
30. Our tests often ask us to write out definitions of terms.
31. Our tests often ask us to relate things that we have learned at different times.
32. Our tests often ask us to figure out answers to new problems.
33. Our tests often give us new data and ask us to draw conclusions from these data.
34. Our tests often ask us to put labels on drawings.
35. Many of the activities in lab help me get correct answers on tests.
36. If I learn everything in the textbook and teacher handout materials I can answer all the science test questions.

SECTION E
37. My teacher usually tells us step-by-step what we are to do in the laboratory.
38. We spend some time before every laboratory in determining the purpose of the experiment.
39. We often cannot finish our experiments because it takes so long to gather equipment.
40. The laboratory meets on a regularly scheduled basis (such as Friday).
41. We often use the laboratory to investigate a problem that comes up in class.
42. The laboratory usually comes before we talk about the specific topic in class.
43. Often our laboratory work is not related to the topic that we are studying in class.
44. We usually know the answer to a laboratory problem that we are investigating before we begin the experiment.
45. My teacher encourages me to do laboratory work that help me find answers to my own questions.

SECTION F
46. Many of the experiments that are in the laboratory manual are done by the teacher or other students while the class watches.
47. In the experiments the information that I collect is often slightly different from information collected by other students.
48. Our teacher is often busy grading papers or doing some other personal work while we are working in the laboratory.
49. During an experiment we record our data at the time we make our observations.
50. We are sometimes asked to design our own experiment to answer a question that puzzles us.
51. We often ask the teacher if we are doing the right thing in our experiments.
52. The teacher answers most of our questions about the laboratory work by asking us questions.
53. We spend less than ¼ of our time in science doing laboratory work.
54. We never have the chance to try our own ways of doing the laboratory work.

SECTION G
55. We talk about what we have observed in the laboratory within a day or two after every session.
56. After every laboratory session, we compare the data that we have collected with the data of other individuals or groups.
57. Our teacher often grades our data books for neatness.
58. We are required to copy the purpose, materials, and procedure used in our experiments from the laboratory manual.
59. We are allowed to go beyond the regular laboratory exercise and do some experimenting on our own.
60. We have a chance to analyze the conclusions that we have drawn in the laboratory.
61. The class is able to explain all unexpected data that are collected in the laboratory.
62. We are given time to evaluate our laboratory work.
63. We are encouraged by the teacher to find ways to do experiments that we think would work best.
64. The teacher often stops our lab work and tells us the answers before we are finished because we run out of time.
APPENDIX G

TEACHER ACHIEVEMENT TEST

PRETEST AND POSTTEST FOR EARTH SCIENCE PROGRAM

SUMMER PHASE—AUGUST 25, 1969

1. In which one of the following regions would frequent orographic precipitation probably be typical throughout the entire year?
   A. Western slopes of mountains in Costa Rica.
   B. Eastern slopes of mountains in southern Chile.
   C. Western slopes of mountains along the coast of southern Norway.
   D. Eastern slopes of mountains in Idaho.
   E. Northern slopes of mountains in Java.

2. In which one of the following places on September 21 are the sun's rays at local noon most nearly vertical?
   A. Montevideo, Uruguay. B. Calcutta, India.
   E. Wellington, New Zealand.

3. It is necessary to cross the equator in traveling from
   A. Jacksonville, Florida to Haifa, Palestine.
   B. Tamatave, Madagascar to Aden, Arabia.
   C. Buenos Aires, Argentina to Durban, South Africa.
   D. Manila, Philippine Islands, to Colon, Panama.
   E. Cairo, Egypt to Calcutta, India.

4. It is necessary to cross the Greenwich Meridian in traveling by the shortest route from
   A. Rome, Italy to Calcutta, India.
   B. Aden, Arabia to Tamatave, Madagascar.
   C. Paris, France to Helsinki, Finland.
   D. Belfast, Ireland to Haifa, Israel.
   E. Cairo, Egypt to Calcutta, India.

5. In which one of the following cases will solar radiation traverse the longest path through the atmosphere before striking the earth's surface at the place and time indicated?
   A. Hong Kong, China, noon on June 21.
   B. Quito, Ecuador, noon on September 21.
   C. Madrid, Spain, noon on March 21.
   D. Tamatave, Madagascar, on December 21.
   E. Singapore, Malay Peninsula, noon on September 21.
6. Assuming that the atmosphere absorbs uniformly throughout, in which one of the following cases would the amount of solar radiation received per hour per square foot of earth surface be greatest?
A. Algiers, Algeria, noon on December 21.
B. Harbin, Manchuria, noon on March 21.
C. Dublin, Ireland, noon on September 21.
D. Shanghai, China, noon on December 21.
E. Calcutta, India, noon on June 21.

7. In which one of the following cases (at the time and place mentioned) are convective thunderstorms most frequent?
A. Central Poland, from October to March.
B. Union of South Africa, April to September.
C. Northern Mongolia, from October to March.
D. Central U.S.A., from April to September.
E. Southern Argentina, from April to September.

8. In which one of the following cases (at the time and place mentioned) are hurricanes most frequent?
A. Coral Sea, in late August, September, and early October.
B. Caribbean Sea, in late January, February, and early March.
C. South China Sea, in late August, September, and early October.
D. Baltic Sea, in late February, March, and early April.
E. Bering Sea, in late August, September, and early October.

9. Which one of the following would probably be under horse-latitude control throughout the entire year?
A. Brittany peninsula of France.
B. Malay peninsula
C. coastal Southwest Africa.
D. Korean peninsula
E. Tasmania.

10. The following three statements are typical of a certain place X.
1. The prevailing winds of place X are derived from one of the great high pressure cells which is located over the ocean due east of place X.
2. On June 21 about 11 hours of daylight prevail in place X.
3. Relatively warm ocean currents flow southward along the coast of place X.
In which one of the following regions might the place X be located typically?
A. Coastal southeastern Brazil.
B. French Indo-China.
C. Coastal Southwest Africa.
D. Coastal northern Chile.
E. Coastal Palestine.
11. Which one of the following regions lies in the rain shadow of a highland, and hence receives no orographic precipitation from prevailing winds throughout the entire year?
   C. Southern coastal Chile.
   D. Coastal British Columbia.  E. Eastern Japan.

12. Which one of the following regions is characterized by a climate which is conducive to formation of lateritic soils?
   A. Southern Algeria.  B. Poland.  C. California.
   D. Borneo.  E. Northern Alaska.

13. Which one of the following regions has relatively warm ocean currents flowing along the coast?
   A. Morocco.  B. California.
   C. Coast of eastern Australia.  D. Southwest Africa.
   E. Northern Chile.

14. The climatic pattern shown at the right is typical of a certain place X. In which one of the following regions might the place be located characteristically?

<table>
<thead>
<tr>
<th></th>
<th>Temp.</th>
<th>Prec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Coastal Nigeria</td>
<td>January 55</td>
<td>5.1</td>
</tr>
<tr>
<td>B. Gibraltar</td>
<td>February 56</td>
<td>4.2</td>
</tr>
<tr>
<td>C. Northeast-coastal Argentina</td>
<td>March 57</td>
<td>4.8</td>
</tr>
<tr>
<td>D. Central Florida</td>
<td>April 61</td>
<td>2.7</td>
</tr>
<tr>
<td>E. Oklahoma</td>
<td>May 65</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>June 70</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>July 73</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>August 75</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>September 72</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>October 67</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>November 60</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>December 56</td>
<td>5.5</td>
</tr>
</tbody>
</table>

15. The climatic pattern at the right is typical of a certain place X. In which one of the following regions might the place X be located characteristically?

<table>
<thead>
<tr>
<th></th>
<th>Temp.</th>
<th>Prec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. West-coastal Nicaragua</td>
<td>January 28</td>
<td>3.6</td>
</tr>
<tr>
<td>B. Southeastern Australia</td>
<td>February 29</td>
<td>3.4</td>
</tr>
<tr>
<td>C. Coastal Georgia</td>
<td>March 36</td>
<td>3.6</td>
</tr>
<tr>
<td>D. Massachusetts</td>
<td>April 46</td>
<td>3.3</td>
</tr>
<tr>
<td>E. Coastal Washington</td>
<td>May 57</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>June 66</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>July 72</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>August 70</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>September 63</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>October 54</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>November 42</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>December 32</td>
<td>3.4</td>
</tr>
</tbody>
</table>
16. On March 21 there are twelve hours of daylight and twelve hours of night
A. only at the North Pole.
B. only at the 66.5° S. latitude.
C. only at the equator.
D. only at 23.5° S. latitude.
E. everywhere on earth.

17. The edge of the zone of the sun's illumination on the earth is a great circle
A. only at the summer solstice.
B. only at the equinoxes.
C. only at perihelion.
D. at any time.
E. at none of the above times.

18. The factor having the greatest bearing upon the seasonal change in the temperate latitudes is
A. the distance to the sun is about 3 million miles less at one time of year than at any other time.
B. There is much more land surface in the northern hemisphere than in the southern.
C. The sunspots vary in magnitude in a regular cycle.
D. The earth's axis is inclined 23½ degrees to the ecliptic.
E. The equinoxes precess.

19. In which one of the following regions would frequent convectional precipitations probably be typical throughout the entire year?
A. Florida.
B. South Island, New Zealand.
C. Sumatra.
D. West-coastal peninsular India.
E. Korea.

20. Which of the following pairs is most useful in determining a rock's origin?
A. Color and shape.
B. Size and weight.
C. Density and hardness.
D. Composition and texture.

21. Which of the following would change if a piece of granite were moved to a different planet?
A. Its mass.
B. Its volume.
C. Its weight.
D. Its density.

22. Which of the following is a vector quantity?
A. Magnetism
B. Temperature.
C. Rock composition
D. Atmospheric pressure.

23. What percentage by volume of the earth's crust is made up of oxygen?
A. Less than 25
B. About 50
C. About 75
D. More than 90.
24. How many degrees farther north is A than B?
   A. 20 B. 40 C. 50 D. 70
25. What is the latitude at position A?
   A. 20 degrees N. B. 40 degrees N.
   C. 50 degrees N. D. 60 degrees N.
26. What gas is most effective in reducing heat loss from the earth by absorbing reradiated heat energy?
   A. Argon B. Oxygen
   C. Nitrogen D. Carbon dioxide
   Questions 27 and 28 are based on the following data.

<table>
<thead>
<tr>
<th></th>
<th>Mass</th>
<th>Radius</th>
<th>Distance from Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Planet X</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Planet Y</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

27. If the gravitational force on the earth's surface is one unit, what would it be on Planet X?
   A. \( \frac{1}{2} \) unit B. \( \frac{1}{3} \) unit C. 2 units
   D. 4 units
28. If the gravitational forces on the earth's surface is one unit, what would it be on Planet Y?
   A. \( \frac{1}{4} \) unit B. \( \frac{1}{5} \) unit C. 2 units
   D. 4 units
   Questions 29 and 30 are based on the diagram that follows

29. What two assumptions are made when the circumference of the earth is determined by measuring the angle \( B \) and the distance \( D \) as shown in the diagram?
A. The sun's rays are essentially parallel at this distance and the sun is $2 \times 10^6$ km from the earth.
B. The earth is round and its axis is tilted $23\frac{1}{2}$ degrees to the plane of its orbit.
C. The earth is a sphere and the sun's rays are essentially parallel at this distance.
D. The earth is a known distance from the sun and it revolves around the sun.

30. What would be the circumference of a planet if the angle B were 10 degrees and the distance D were 161 km?
A. 580 km  B. 1450 km  C. 2900 km  D. 5800 km

31. Which of the following is evidence that the earth's crust has undergone great changes during its history?
A. The constant pounding of ocean waves on the coastlines.
B. The occurrence of a large number of earthquakes each year.
C. The continued flowing of vast amounts of river water into the sea.
D. The presence of marine fossils in the rocks making up high mountains.

32. Which of the following processes gives off rather than uses energy?
A. Melting of ice  B. Heating of water  C. Freezing of water  D. Evaporation of water

33. Water moves slowly through a clay stratum because
A. Capillarity is not operating.
B. The pores are not interconnected.
C. The total pore space is very small.
D. The pore spaces are very small in size.

34. If the lowest temperature reading at a station on a given day was $5^\circ C$ and the highest reading in the afternoon was $15^\circ C$, the daily mean temperature would be
A. $3^\circ C$  B. $5^\circ C$  C. $10^\circ C$  D. $20^\circ C$.

35. A rock with a high percentage of open spaces has high
A. porosity  B. base flow  C. capillarity  D. permeability

36. The statement, "the core of the earth is metallic," is
A. a fact  B. a principle  C. an hypothesis  D. an observation.
37. What characteristic of metamorphic rocks provides a clue that they were formed deep within the earth's crust?
A. The absence of elements commonly found on the earth's surface.
B. They frequently include bits of material from the earth's core.
C. The minerals are those that form under high temperature and pressure.
D. They have marked bedding, a characteristic not developed at a shallow depth.

38. What is the first indication that a distant earthquake has occurred?
A. An atmospheric wave. B. A P wave in the interior C. A tidal wave in the ocean D. A surface wave on the land.

39. What is the basic cause for earth materials being moved to lower elevations?
A. Water B. Gravity C. Erosion D. Weathering

40. The crust beneath the ocean basins is composed of
A. granitic type rocks B. basaltic type rocks C. sedimentary rocks D. metamorphic rocks

41. Why are scientists so uncertain about processes going on at the crust-mantle interface?
A. all the evidence is indirect. B. S waves do not penetrate the crust. C. Most earthquakes originate in the mantle. D. Only a few holes have been drilled into the crust.

42. When a piece of rock is crushed to clay-sized particles, one result is
A. a decrease in the surface area. B. a decrease in the volume of the rock material. C. an increase in the surface area. D. an increase in the volume of the rock material.

43. What is granite?
A. A common mineral that makes up a large part of the crust. B. An igneous rock type that is a major constituent of lavas. C. A common igneous rock that cooled relatively slowly and is made up mostly of feldspar and quartz. D. A common igneous rock that cooled at the surface and is composed mostly of feldspar and pyroxene.
44. Studies of which of the following give the most information about the deep crust?
A. Heat flow, lava, drill cores.
B. Fossils, magma composition, mineralogy.
C. Gravity, drill cores, mineralogy, fossils.
D. Seismic waves, gravity, heat flow, volcanism.

45. What does the fact that gravity is lower than expected over mountain ranges suggest about their structure?
A. Mountain ranges must have high density roots.
B. Mantle rocks must be nearer the surface beneath mountains.
C. The cores of mountains have been uplifted during geologic history.
D. Low-density rock must extend to greater depths beneath mountains than elsewhere.

Question 46 and 47 are based on the following information and diagrams.
The liquid in container A is distilled water. All the hydrometers are identical.

46. Which one of the beakers contains a liquid denser than water? A. B B. C C. D D. F
47. If all the liquids were identical except for color, which one of the hydrometers would contain the least mass?
A. B B. C C. F D. A and D

48. Geologic time is divided into "chapter"s on the basis of
C. The amount of rock deformation.
D. The thickness of the sedimentary beds.

49. What is the age relationship of early man to dinosaurs?
A. Early man appeared just after the dinosaurs died out.
B. Early man and the dinosaurs lived at the same time but in different places.
C. The dinosaurs became extinct at least one billion years before man appeared.
D. The dinosaurs became extinct millions of years before the first man evolved.
50. Evidence obtained through study of sedimentary rocks provides information concerning the
   A. absolute age of the earth.
   B. environment at the time of deposition.
   C. direction of forces causing metamorphism.
   D. composition of the earth's original crust.

51. On what basis do scientists conclude that fossil corals required a warm, shallow-water environment?
   A. Radiocarbon temperature determinations.
   B. The geographic distribution of fossil corals.
   C. Most modern corals live in this type of environment.
   D. The composition of the rocks in which fossil corals are formed.

52. During the geologic history of North America, which of the following processes has probably been responsible for moving the most material the greatest distance?
   A. Wind action
   B. Wave Erosion
   C. Stream erosion
   D. Glacial erosion.

Question 53-57 are based on the graphs at the given space, which are based on measurement of 1000 individuals in each case.

53. Which of the graphs was drawn for a fossil group whose length-to-width ratio was roughly the same for all individuals even though a large variety of sizes occurred?
   A. A  B. B  C. C  D. D

54. Which of the graphs most likely was drawn for a group whose size changed little with age?
   A. A  B. B  C. C  D. D
55. Which two graphs were most likely drawn for groups composed of single species?
A. A and B  B. A and C  C. B and D  D. C and D

56. Which of the graphs shows a pattern of increase in size with age?
A. A  B. B  C. C  D. D

57. Which of the graphs shows the least constant relationship of width to length?
A. A  B. D  C. C  D. D

58. Why does man seek to establish ABSOLUTE dates for geologic events?
A. To predict the rise and fall of sea level.
B. To predict catastrophic geologic events of the future.
C. To determine the rates of natural processes.
D. To prove that the earth is five billion years old.

59. Which of the following is evidence of multiple glaciations?
A. Ancient forests covered by glacial till.
B. River valleys buried deeply in glacial till.
C. Striations on bedrock buried by glacial till.
D. Glacial till overlying soils developed on glacial till.

60. If the half-life of an element if 500 years, what part of it will remain after 2000 years.
A. 1/16  B. 1/8  C. 1/4  D. 1/2

61. Which of the following explains why the C\textsuperscript{14} method of dating is limited to objects younger than about 35,000 years?
A. The short half-life of C\textsuperscript{14}.
B. The organic matter decays too rapidly.
C. The radioactive decay of C\textsuperscript{14} slows down.
D. Older objects are usually buried too deeply.

62. Which of the following would probably be the most help in correlating two sets of rock beds that are more than 160 km apart?
A. The general type of rock.
B. The fossils found in the rocks.
C. The age of the underlying beds.
D. The relative elevations of the strata.
Questions 63-67 are based on the following diagram.

63. What is the age relationship of rock units P and K?
   A. P is younger than K.
   B. P is older than K.
   C. P and K are the same age.
   D. There is no evidence bearing on the relationship.

64. What geologic features does the line XY in the cross section represent?
   A. The strike of XY.
   B. The dip of Unit G.
   C. A bedding plane.
   D. an unconformity.

65. What is recorded by the feature represented by the line XY?
   D. Rapid deposition.

66. What is the relative age of the fault?
   A. Younger than W and older than M.
   B. Younger than Z and older than B.
   C. Younger than all of the rock units.
   D. Older than all of the rock units.

67. The presence of the baked zone in Unit K indicates that the basalt (M)
   A. is buried lava flow.
   B. is older than the limestone (K).
   C. is younger than the limestone (K).
   D. was hot when the limestone (K) was deposited.

68. If two kinds of fossils are found in a sedimentary bed, and one type is known to have lived during the Paleozoic and Mesozoic while the other lived in the Mesozoic and Cenozoic what is the age of the bed?
   A. Cenozoic. B. Mesozoic.
   C. Mesozoic and Cenozoic. D. Paleozoic and Cenozoic.
69. Why have erosional and depositional processes NOT completely reduced the surface of the earth to a level surface?
   A. Sea level keeps changing.
   B. Crustal movement opposes them.
   C. There has not been enough time.
   D. Runoff makes up such a small part of the hydrologic cycle.

70. The belief that a mountain range will someday rise on the present site of the Gulf of Mexico coastal plain is based on evidence that
   A. This region is now experiencing accumulation of great thicknesses of sediment.
   B. Modern seismic and gravity studies suggest that basement rocks are being steadily uplifted.
   C. Periodic uplift has extended the area into the Gulf and suggests the start of mountain building.
   D. Mountain building has generally proceeded from north to south in the Appalachians and the Gulf is next in line.

71. In the study of ancient climates, what basic assumption is made regarding the use of fossil evidence?
   A. Ancient organisms had much wider environmental tolerances than modern species.
   B. Specialization has gradually led to greater tolerances in modern forms of life.
   C. Fossil forms lived in environments similar to those occupied by their modern counterparts.
   D. The amount of C\textsuperscript{14} present in fossils is dependent on temperature as well as time.

72. Which of the following is the best statement of uniformity of process?
   A. The basic laws of nature do not change with time.
   B. The earth and all its features are undergoing constant change.
   C. Although earth processes produce change, their intensity is constant.
   D. The surface of the earth is being gradually reduced to a level plain.

73. What was Hutton's major contribution to earth science?
   A. The dipolarity of water.
   B. The discovery of oxygen.
   C. The idea of uniformitarianism.
   D. The universal law of gravitation.
74. Generally speaking, the material immediately beneath a coal seam is an underclay which is characterized as
A. representing an old regolith.
B. being an unconformity.
C. being largely sandstone.
D. being largely limestone.

75. Which one of these statements is false?
A. All rocks of the earth are composed of minerals.
B. Minerals in the earth show a great range of chemical composition.
C. Minerals can be identified through a study of their physical properties.
D. All chemical alterations in minerals result from diastropic forces.

76. A rock had the following characteristics: stratified and non-calcareous, composition largely kaolin, low permeability, easily broken into thin plates, and minute pore spaces. The rock would most likely be
A. limestone. B. coal. C. shale.
D. conglomerate. E. sandstone.

77. Sedimentary deposits of clay or mud after being subjected to pressure change to layers of
A. conglomerate. B. sandstone. C. shale.
D. limestone. E. chert.

78. Igneous rocks with crystals which are easily seen
A. were formed at or near the surface of the lithosphere.
B. are generally found in a lava flow.
C. are always metamorphic.
D. cooled from molten magma at a very slow rate.
E. have structures known as foliation.

79. Crystallization or recrystallization in metamorphic rocks producing alignment of minerals into bands is known as
A. Colluvial deposition. B. bedding.
C. paludal deposition. D. foliation.
E. crenulation.

80. Slate and shale differ chiefly
A. in appearance. B. in general structure.
C. in geologic processes to which they have been subjected. D. as to the geologic period of time in which they were formed.
E. as to whether formed under marine or continental conditions.
81. Sedimentary rocks are geologically important because of all of the following except
A. the extent of foliation shows the magnitude of the pressured under which they were formed.
B. they show from their attitude something of the extent of the movement of the earth's crust.
C. their structures furnish clues to the process involved in their origin.
D. they indicate the age of the strata from their contained fossils.
E. sedimentary processes concentrate many minerals.

82. Which of the following geological conditions is not a prerequisite for an oil field?
A. the presence of a suitable trap.
B. the presence of source beds.
C. bedrock must be exposed at the surface.
D. lack of regional metamorphism.
E. marine sedimentary rocks must be present in the geologic column.

83. Suppose you were given two specimens of granite, one of them definitely a result of long-time transport by stream; the other definitely had been dragged along in the bottom of the ice sheet and left when the ice melted. They are about the same size, about as large as your fist. You could tell the difference between the two because
A. the stream pebble would have a brown coating on its surface while the ice-borne one would show fresh rock.
B. the ice-borne pebble would probably show signs of weathering by solution while the stream pebble would show none.
C. the stream pebble would probably be somewhat heavier having absorbed water during its transport while the ice-borne pebble would have all water squeezed out by weight of the ice.
D. the stream pebble would be well rounded while the ice-borne one would be subangular and might show striae.
E. the difference in appearance would not permit any distinction whatsoever to be made.

84. In a Chicago quarry the walls are thick horizontal layers of a pale gray rock which contains many tiny shells of marine animals. It dissolves slowly in water containing carbon dioxide. It is probably
A. limestone.  B. granite.  C. basalt.
D. sandstone.  E. shale.
85. A coarse gravel with rounded edges, cemented together to make a rock indicates
   A. that heat and pressure have altered pre-existing rock.
   B. that slow-flowing water deposited the material.
   C. that water flowing out of high mountains from what may have been a cool climate deposited the material, probably under water.
   D. that a volcano produced the material.
   E. that a glacier produced the material.

86. Metamorphic rock in general indicates
   A. that heat and pressure have altered pre-existing rock.
   B. that slow-flowing water deposited the material.
   C. that water flowing out of high mountains from what may have been a cool climate deposited the material, probably under water.
   D. that a volcano produced the material.
   E. that a glacier produced the material.

87. It is thought by some people that the center of the earth is composed of molten material because
   A. direct P waves are not recorded by seismographs situated half way around the earth from the epicenter.
   B. the speed of earthquake waves increases when those waves reach a depth of about 10 miles or more below the surface.
   C. P and S waves travel the chord of the arc while L waves do not.
   D. direct S waves are not recorded on seismographs at a distance of a little more than a third of the way around the earth from the epicenter.

88. The direction of motion of the ice sheet is best indicated by
   A. kettle holes.
   B. kame terraces.
   C. sheep rocks (roches moutonnees).
   D. varved clays.
   E. eskers.

89. All but one of the following are due to a combination of structure and stream erosion. Which one is the exception?
   A. Hogbacks.
   B. Mesas.
   C. Cuestas.
   D. Waterfalls.
   E. Floodplains.

90. Which one of the following statements is correct?
   A. A cuesta can be formed only by the action of stream erosion on tilted layers of rock of different resistance.
   B. Pediments are the piles of debris left at the base of mountains where streams deposit their load of debris upon the plains.
C. Barchans usually have a small oasis with palm trees growing between the tips of the dunes.

D. Mesas are usually very small in size, say about 200 feet in diameter.

E. None of the above.

Below are listed various stages of the nitrogen cycle. The stages are not listed, however, in the order in which they occur in nature. You are to arrange them in that order.

1. Conversion of plant organic nitrogen compounds by herbivorous animals into nitrogen compounds present in their tissues.
2. Absorption of nitrogen compounds, present in the topsoil, through the roots of the plants.
3. Introduction of uncombined nitrogen into the topsoil, either by rainfall or by aeration.
4. Return to the atmosphere of nitrogen contained in tissues of putrefying dead animals.
5. Fixation by micro-organisms of the uncombined nitrogen in the soil into nitrogen compounds.
6. Utilization by plants of the nitrogen compounds absorbed through the roots.

91. The correct order is
   A. 5 2 4 1 3 6   B. 3 5 2 6 1 4   C. 6 1 4 2 5 3
   D. 3 5 2 4 1 6   E. 5 3 2 6 1 4

92. Four of the following refer to the same stage in the geologic development of a region. Which one does not?
   A. The uplands consist of broad areas.
   B. Major streams meander.
   C. Flood plains are well developed.
   D. The land surface is thoroughly dissected with a maximum of slope land.
   E. Drainage is well established.

93. The difference between a valley which is formed by a glacier and one which was formed by running water is
   A. The former is always V-shaped while the latter is always U-shaped.
   B. Parallel scratches often occur in the rock of the former.
   C. Hanging valleys are often tributaries of the former.
   D. All of the above.
   E. Both B and C of the above.
94. Which of the following characteristics would enable you to recognize the deposits of a continental ice sheet?
A. Sediments unsorted with respect to size.
B. Sediments containing many different types of rock, spread over a large area.
C. Sediments having an irregular, hilly, undrained topography.
D. All of the above. E. None of the above.

95. The difference between a moraine and an esker?
A. The former is formed by glacial action while the latter is not.
B. The former is formed along the sides or ends of glaciers while the latter is formed beneath a glacier.
C. The former is formed at the end of a glacier, the latter at the head of a glacial valley.
D. The latter is the outwash plains which protrude from the former.
E. The former contains rocks while the latter does not.

96. One difference between an old and winding stream and one that has been rejuvenated?
A. The former is characterized by meanders while the latter is not.
B. The former stream flows faster than the latter.
C. The former has tributaries while the latter does not.
D. The latter may have entrenched meanders.
E. The latter has none of the characteristics of a youthful stream.

97. On a topographic map it is usually possible to determine the difference between topography due primarily to wind action and that formed by development of caverns because
A. The hollows resulting from wind action would always be circular due to the eddying action of the wind, while hollows due to cavern development would be irregular in shape.
B. The hollows resulting from wind action would be apt to be deeper than those resulting from cavern development.
C. The hollows resulting from cavern development generally occur in any kind of rocks while those due to wind action would only occur in types of rocks which are softer and more easily eroded.
D. The hollows due to cavern development would be apt to be irregular in shape and arranged along lines, while those due to wind action would have no particular arrangement.
E. None of the above conditions would show the difference.
98. Artesian wells in North Dakota derive their supplies of water from a certain sandstone aquifer. All the following statements but one show why the artesian pressure in wells tapping this aquifer would be apt to differ from place to place. Which statement does not apply?
A. Variations in porosity of the aquifer.
B. Variations in permeability of the aquifer.
C. More fractures occur in the capping material in some places than in others.
D. More wells are located in some areas than in other areas.
E. Wells in places with less elevation above the main rivers would have the least artesian pressure.

99. In the study of archeology much information concerning the habits and manner of life of early people may be derived from excavations and hence the discoveries of utensils and fragments of tools, etc. In the United States and Europe which of the following would you consider to be least productive in the yield of such materials, provided you had the time and money to carry on the excavations?
A. Eskers. B. Cave deposits.
C. Flood plain deposits. D. Loess deposits.
E. Peat bogs.

100. Of all the sedimentary deposits now existing on the earth's crust, by far the greatest volume was formed by
A. fresh-water deposition. B. wind deposition.
C. glacial deposition. D. marine deposition.
E. some other means than listed above.
APPENDIX H

PUPIL ACHIEVEMENT TEST

PRETEST AND POSTTEST FOR THE EARTH SCIENCE PROGRAM

Directions: Carefully read the question and select the best answer from the alternatives. Use a soft lead pencil to darken the appropriate blank on the answer sheet. DO NOT WRITE ON THIS TEST BOOKLET. Be careful not to mark the answer sheet unnecessarily, and be sure to completely erase all changed answers.

Questions 1 and 2 are based on the following data.

<table>
<thead>
<tr>
<th></th>
<th>Mass</th>
<th>Radius</th>
<th>Distance from Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Planet X</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Planet Y</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

1. If the gravitational force on the earth's surface is one unit, what would it be on Planet X?
   1. 1/4 unit.  2. 1/2 unit.  3. 2 units.  4. 4 units.

2. If the gravitational forces on the earth's surface is one unit, what would it be on Planet Y?
   1. 1/4 unit.  2. 1/2 unit.  3. 2 units.  4. 4 units.

Questions 3 through 6 are based on the graphs in the space below. The graphs are based on measurement of 1000 individuals in each case.
3. Which of the graphs was drawn for a fossil group whose length-to-width ratio was roughly the same for all individuals even though a large variety of sizes occurred?

4. Which of the graphs most likely was drawn for a group whose size changed little with age?

5. Which two graphs were most likely drawn for groups composed of a single species?

6. Which of the graphs shows the least constant relationship of width to length?

7. The velocity of a star toward or away from the earth can be detected by
   1. photographing it at two different times.
   2. determining its right ascension at intervals of a year.
   3. measuring variations in the angle of parallax.
   4. measuring the diameter of the star from time to time.
   5. comparing its spectra with spectra obtained in the laboratory.

Questions 8 and 9 are based on the following information and diagrams.
The liquid in container A is distilled water. All the hydrometers are identical.

8. Which one of the beakers contains a liquid denser than the water?

9. If all the liquids were identical except for color, which of the hydrometers would contain the least mass?

10. Which of the following pairs is most useful in determining a rock's origin?
     1. color and shape  2. size and weight
     3. density and hardness  4. composition and texture.
11. Which of the following is evidence that the earth's crust has undergone great changes during its history?
1. The constant pounding of ocean waves on the coastlines.
2. The occurrence of a large number of earthquakes each year.
3. The continued flowing of vast amounts of river water into the sea.
4. The presence of marine fossils in the rocks making up the high mountains.

12. What characteristic of metamorphic rocks provides a clue that they were formed deep within the earth's crust?
1. The absence of elements commonly found on the earth's surface.
2. They frequently include bits of materials from the earth's core.
3. The minerals are those that form under high temperature and pressure.
4. They have marked bedding, a characteristic not developed at a shallow depth.

13. When a piece of rock is crushed to clay-sized particles, one result is
1. a decrease in the surface area.
2. a decrease in the volume of the rock material.
3. an increase in the surface area.
4. an increase in the volume of the rock material.

14. Studies of which of the following give the most information about the deep crust?
2. Fossils, magma composition, mineralogy.
4. Seismic waves, gravity, heat flow, volcanism.

15. Which of the following is evidence of multiple glaciations?
1. Ancient forests covered by glacial till.
2. River valleys buried deeply in glacial till.
3. Striations on bedrock buried by glacial till.
4. Glacial till overlying soils developed on glacial till.
Questions 16 through 20 are based on the following diagram.

16. What is the age relationship of rock units P and K?
   1. P is younger than K  2. P is older than K
   3. P and K are the same age
   4. There is no evidence bearing on the relationship.

17. What geologic features does the line XY in the cross section represent?
   1. The strike of XY  2. The dip of Unit G.

18. What is recorded by the feature represented by the line XY?
   1. Erosion  2. Faulting  3. Slow deposition
   4. Rapid deposition.

19. What is the relative age of the fault?
   1. Younger than W and older than M.
   2. Younger than Z and older than B.
   3. Younger than all of the rock units.
   4. Older than all of the rock units.

20. The presence of the baked zone in Unit K indicates that the basalt (M) is buried lava flow.
   2. is older than the limestone (K).
   3. is younger than the limestone (K).
   4. was hot when the limestone (K) was deposited.

21. If two kinds of fossils are found in a sedimentary bed, and one type is known to have lived during the Paleozoic and Mesozoic while the other lived in the Mesozoic and Cenozoic what is the age of the bed?
22. Which of the following characteristics would enable you to recognize the deposits of a continental ice sheet?
1. Sediments unsorted with respect to size.
2. Sediments containing many different types of rock, spread over a large area.
4. All of the above. 5. None of the above.

23. The belief that a mountain range will someday rise on the present site of the Gulf of Mexico coastal plain is based on evidence that
1. This region is now experiencing accumulation of great thicknesses of sediment.
2. Modern seismic and gravity studies suggest that basement rocks are being steadily uplifted.
3. Periodic uplift has extended the area into the Gulf and suggests the start of mountain building.
4. Mountain building has generally proceeded from north to south in the Appalachians and the Gulf Coast is next in line.

24. Artesian wells in North Dakota derive their supplies of water from a certain sandstone aquifer. All the following statements but one show why the artesian pressure in wells tapping this aquifer would be apt to differ from place to place. Which statement does not apply?
1. Variations in porosity of the aquifer.
2. Variations in permeability of the aquifer.
3. More fractures occur in the capping material in some places than in others.
4. More wells are located in some areas than in other areas.
5. Wells in places with less elevation above the main rivers would have the least artesian pressure.

25. In the study of archeology much information concerning the habits and manner of life of early people may be derived from excavations and hence the discoveries of utensils and fragments of tools, etc. In the United States and Europe which of the following would you consider to be least productive in the yield of such materials, provided you had the time and money to carry on the excavations?
26. What would be the circumference of a planet if the angle B were 10 degrees and the distance D were 161 km.
   1. 580 km  2. 1450 km  3. 2900 km  4. 5800 km

27. Four of the following refer to the same stage in the geologic development of a region. Which one does not?
   1. The uplands consist of broad areas.
   2. Major streams meander.
   3. Flood plains are well developed.
   4. The land surface is thoroughly dissected with a maximum of slope land.
   5. Drainage is well established.

28. All but one of the following are due to a combination of structure and stream erosion. Which one is the exception?
   4. waterfalls  5. floodplains

29. Which of the following geological conditions is not a prerequisite for an oil field?
   1. the presence of a suitable trap.
   2. the presence of source beds.
   3. bedrock must be exposed at the surface.
   4. lack of regional metamorphism.
   5. marine sedimentary rocks must be present in the geologic column.

30. On March 21 there are twelve hours of daylight and twelve hours of night.
   1. only at the North Pole.
   2. only at the 66.5° S. latitude.
   3. only at the equator.
   4. only at 23.5° S. latitude  5. everywhere on earth.
31. The latitude of city X is $42.5^\circ$ N. An observer in city X notes that a star has a constant altitude of 42.5°. The star is
4. Sirius 5. The Sun
32. The presence or absence of certain elements in a star is generally determined from
1. The velocity of light from the star.
2. The temperature of the star.
3. The dark and bright line spectra.
4. A sample of the star (e.g. a meteorite from the particular star).
5. A different type of information than listed here.
33. The most permanent points of reference for locating position on the earth's surface are the
1. courses of rivers. 2. shore lines of oceans.
3. location of mountain ranges
4. boundaries of continents
5. positions of stars and planets.
34. In measuring the circumference of the earth by the method of Erathosthenes, one observer notes that a certain star is directly overhead at the same time that another observer in a distant location
1. notes that the star is at its zenith.
2. measures the angle between the star and the horizon.
3. measures the angle between the star and the North Star.
4. measures the angle between the lines from both observers to the star.
5. measures the angle between the star and his zenith.
35. Which of the following would you never expect to see at midnight.
36. Which one of these is the smallest quantity?
1. The astronomical unit (mean radius of the earth's orbit)
2. The distance to the nearest star outside of the solar system.
3. $5.88 \times 10^{12}$ miles.
4. The parsec ($19,000,000,000,000$ miles).
5. The light year.
37. If an equal amount of rain falls upon one square mile of each of the following areas, which one will deliver the greatest quantity of water to the natural reservoir in the ground, i.e., as ground water beneath the ground water table?

38. With respect to the drawing on the right, how would you interpret this section of rocks?
1. Deposits laid down in regressing sea.
2. A regression followed by a transgression of the sea without metamorphism in the lower zone.
3. Deposits of Pennsylvanian sandstone and slate overlain by Permian limestone.
4. Deposits of marine sedimentary rocks intruded by non-marine shales.
5. Deposits laid down in a transgressing sea.

39. The most logical explanation of the formation of ox-bow lakes is
1. the persistence of lagoons upon the emergence of shorelines.
2. the straightening out (cutting through) of an old meandering river thereby leaving remnants of the old meanders.
3. underground springs oozing towards the surface.
4. geologic changes in climate causing a formerly rainy region to become relatively dry.
5. the melting of glaciers.

40. The water table generally
1. is found only in regions of heavy rainfall.
2. follows the contour of the land.
3. falls during rainfall because of increased weight.
4. is found in regions covered mostly with the sloping sides of hills.
5. has all of the above as its characteristics.
41. Which one of these is not characteristic of a youthful stage of stream development?
1. The land surface is thoroughly dissected and there is a maximum amount of slope land.
2. Down-cutting is dominant because the streams are not fully loaded.
3. The valleys are V-shaped with bottoms only as wide as the channels.
4. The streams have high gradients and relatively straight courses.
5. Rapids and falls are relatively common.

42. One of the conditions listed below favors the development of strong shore currents. Which one?
1. Winds which blow in an off-shore direction.
2. Winds which blow nearly straight on-shore.
3. Winds which blow long and steadily and diagonally towards the shore.
4. Winds which blow first from one direction and then from another direction.
5. A regular shore line.
APPENDIX I

SPECIFIC INFORMATION FOR THE CCSS
NSF EARTH SCIENCE PROGRAM

1. Number of classes of earth science that you are now teaching.  

2. Total number of preparations for different subjects, e.g. (Math and earth science = 2).  

3. Number of years teaching experience.  

4. Undergraduate point average.  

5. Undergraduate major.  

6. Highest degree presently held.  

7. How many Academic Year Meetings of the CCSSP in earth science did you attend? (Saturdays and Tuesdays 3:00 p.m. meetings about earth science)  

8. How many field trips did you conduct during this school year including those scheduled yet this spring?  

9. What earth science textbook are you using?  

Teacher's Signature

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APPENDIX J

SOURCES OF EARTH SCIENCE INFORMATION TEST

Name______________________
August 25, 1969

Where would you seek information on the following topics with respect to local problems? (Assume that the information sought would answer questions about local conditions). State the best sources as precisely as you can.

1. Recommendations concerning soil use.

2. Weather Data.


4. Interesting celestial objects to be viewed on a given night.

5. Maps, air photos.

6. The geologic history of local landforms.

7. To what references would you direct a student who had collected several fossils in Ohio so that he might identify the fossils?
APPENDIX K

EARTH SCIENCE ENVIRONMENT TEST (PPS)

DIRECTIONS: The following questions are based on the environment in the Akron area as it might be seen by an eighth grade student in earth science. The questions are not from a textbook. The questions really ask you to figure out the answers. Take your time. Be sure to use a soft #2 lead pencil. Mark only in the correct answer blank. Do not write on the test booklet. Over two thousand other students will also take the test this week. Good luck.

![Block diagram of a landscape. Keys to symbols.]

1. The relative age of the trees, valley, waterfalls and bedrock is
   Oldest to Youngest
   A. 4,5,1,2,3     B. 5,4,2,3,1  
   C. 3,2,1,4,5     D. 1,2,3,4,5

2. A local landfill (or dump where garbage and industrial waste is buried each day) must be especially concerned about
   A. The amount of rain and snow each year  
   B. rain water percolating through the refuse and into the ground water.  
   C. the weight of the garbage brought to the landfill.  
   D. the lack of public objection to landfills.

3. An Akron area landfill operation includes covering the waste with a thick cover of earth to prevent rats and flies from living in the waste. One problem in keeping the waste covered is
   A. the average wind direction  
   B. underground springs  
   C. erosion by runoff water  
   D. expansion of the waste on warm days.
In Figure 2 the top Layer A is glacial till. Layer B is shale. Layer C is a sandstone. Layer D is a limestone. Notice the irregular contact between Layer C and Layer D.

4. The irregular contact between C and D, that is the uneven surface of limestone D represented by the double line, was probably caused by
   A. burrowing animals such as ground hogs.
   B. glaciers in the last million years.
   C. erosion over a long period of time.
   D. faulting that took only a few minutes.

5. Boulders in the glacial till are crystalline rocks such as granite and gneiss. These boulders were
   A. from the Akron area bedrock.
   B. durable and transported long distances.
   C. of sedimentary origin.
   D. flat with sharp edges.

In examining the pebbles from Layer A of Figure 2 the following percentages of different pebbles were calculated from collected samples:
   Shale - 40% - sh
   Sandstone - 40% - ss
   Crystalline Rocks - 15% - x-rx

6. Which graph below is a correct way to graph the pebble percentages?

   A. %
   
   B. %
   
   C. %
   
   D. %

   sh ss x-rx ls
   sh ss x-rx ls
   sh ss x-rx ls
   sh ss x-rx ls
A few miles from the area shown in Figure 2 another pebble count was made in a second collecting area and the graph of the results is shown in Figure 3 below.

Figure 3

7. One reason for the apparent increase in the percentage of crystalline rocks in the second collecting area (Figure 3) might be
   A. an abundance of shale at the area in Figure 2 diluted by the percentage of crystalline pebbles.
   B. the collector of the pebbles was attracted by the looks of the crystalline pebbles.
   C. crystalline pebbles are more durable during glacial transport than the shale.
   D. all of the above.

8. Examine the information in number 7 and the graph in question 7, Figure 3. Which type of pebble decreased in relative abundance from the information in 6 to the graph given with 7 (Figure 3)?

9. In glaciated Akron a one-word description of soils formed in poorly drained areas could be

10. Locally very well-drained and sandy soils are found
    A. on kames. B. on floodplains.
    C. in depressions. D. all of the above.

11. Acid put on soil samples in northern Summit County taken 24" to 36" below the surface will cause "fizzing," "bubbling," or effervescence. The fizzing is caused by the action of the acid on
    A. calcium carbonate (the principle mineral in limestone).
    B. quartz (the principle mineral in local sandstones)
    C. clays (the very fine particles in till)
    D. none of the above.

12. Acid put on soil samples from southern Summit County generally will not "fizz" unless the samples are taken from depths of 48" or more. The reason samples that fizz are found at greater depths in southern Summit County than in northern Summit County is because the soil parent material
    A. in the northern portion of the county is younger.
    B. the soils in the southern portion are more permeable.
    C. rain water slowing leaches the parent material.
    D. all of the above.
Soil profiles develop slowly. The profile diagrammed in Figure 4 has different percentages of quartz by weight shown.

13. Note the information given with Figure 4. The higher percentage, 85%, of quartz in the A horizon is there because
A. local bedrock is exposed.
B. the wind doesn't erode the quartz particles.
C. quartz particles are resistant to weathering.
D. none of the above.

14. The B horizon has less quartz particles than A and C horizons (75% compared to 85% and 80%). A reason for the lower percentage of quartz in the B horizon might be
A. a shortage of quartz as the layers were deposited
B. the local presence of coal in the B horizon.
C. clay minerals collect in the B horizon and dilute the quartz.
D. none of the above.

15. The meander length to channel width ratio would be
A. 1/10  B. 10/1  C. 9 = 90  D. 90 x 9

16. Many studies of meander length to channel width ratios of different size streams indicate that
A. the bigger streams have bigger ratios.
B. the average ratios are nearly constant.
C. small streams have bigger ratios.
D. the current velocities make a difference in ratios.

17. In the treatment of sewage one thing that is usually added before the water is released into streams is
A. clay  B. oxygen  C. sand  D. natural gas

Large size holes in sieve A.
Medium size holes in sieve B.
Small holes in Sieve C.
Bottom pan catches fine particles.
On the bottom of page 127 is a graph of the size analysis of particles taken from a stream channel. The size analysis is based on the weight of particles by percentage of the whole sample caught in sieves and the bottom pan.

18. From the information given by the graph (Figure 6) and from the descriptive statements the Stream X was
   A. slow moving. B. fast flowing.
   C. a "muddy" bottomed stream. D. very large.

The graphs below pertain to channel bottom samples taken from stream Y and Z. See Figure 6 for description of sieve sizes.

19. The sample from Stream channel Y indicates that Stream Y flows
   A. more swiftly than Stream X (Figure 6).
   B. more slowly than Stream X (Figure 6).
   C. at the same velocity as Stream Z (Figure 8).
   D. none of the above.

20. The sample from Stream channel Z indicates that the Stream Z channel bottom material is
   A. composed mainly of quartz.
   B. poorly sorted
   C. very "muddy"
   D. from a deep river

21. When moist soil can be worked by your fingers into a thin "ribbon" or narrow layer without crumbling the soil has
   A. a lot of clay in it. B. a lot or iron in it.
   C. a lot of humus in it.
   D. a lot of fertilizer in it.

22. When many tree trunks bend the same way near the ground, the slope that the trees are planted on is probably

23. One reason why there are many dips or low places in highways is
   A. bulldozers used to build the road were too small.
   B. cars are too heavy.
   C. some soils won't support traffic loads
   D. underground river.
24. A student in the Akron area has carefully used a compass in a field study. After he has recorded several compass readings his teacher tells him that the compass readings must all be corrected by the same amount because
A. the compass was broken.
B. the steel in factory buildings in Akron diverted the compass needle.
C. the compass was not held properly.
D. the magnetic north pole is not the true geographic north pole.

25. If you were asked to report what kind of pebbles of a certain size could be found in an operating sand and gravel quarry you wouldn't break every pebble and identify what kind of rock it was. To save time you could select a few pebbles and identify them. Which way suggested below would be the best way to collect 100 representative pebbles?
A. Scoop up a bucket full of the pebbles from the edge of the quarry.
B. Pick up one hundred pebbles at different places in the quarry where the pebbles seem to "stand out".
C. Pick up the first ten pebbles that you come to in ten different places in the quarry.
D. Get the bulldozer operator to make a fresh cut to uncover unweathered pebbles and pick up any one hundred of the uncovered pebbles.
SELECTED BIBLIOGRAPHY

BOOKS


ARTICLES AND PERIODICALS


UNPUBLISHED DISSERTATIONS


PAMPHLET


REPORTS


PERSONAL COMMUNICATION

Personal Communication with Dr. Robert Howe at The Ohio State University on June 4, 1970.