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A GUIDE FOR CURRICULUM EVALUATION:

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By

Delbert Walter Mueller

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ABSTRACT

A GUIDE FOR CURRICULUM EVALUATION:

A DESCRIPTIVE STUDY OF THE IMPLEMENTATION OF THE EARTH SCIENCE CURRICULUM PROJECT FOR THE CARMAN SCHOOL DISTRICT, FLINT, MICHIGAN, 1970-1971

By

Delbert Walter Mueller

THE PROBLEM

Educators, working in local areas have long searched for practical processes and useful techniques to assist them in anticipating consequences, isolating problems, and assessing changes when implementing curricular innovations.

The purpose of this study was to develop a set of procedures which could serve as a guide to local school district personnel as they attempted to assess the impact of new curricular programs. This guide was to be sufficiently versatile for adaptation by most school districts over a variety of school subjects.

While this study attempted to present a plan useful for measuring outcomes over a variety of new curricula, it focused attention on a single curriculum introduction in a particular school system; the implementation of the Earth Science Curriculum Project (ESCP) in the Carman School District, Flint, Michigan.

THE STUDY

Evaluation of ESCP was divided into two parts. Part one used three pre- and post-tests, Attitude Toward Science, Achievement of Science Process Skills, and Achievement of Earth Science Knowledge, and three variables related to student's sex, grade point average in science from the previous year, and teacher-classroom differences, to identify strengths and weakness during the first year of implementation. Part two used descriptive instruments to diagnostically determine why such differences existed and suggest possible remedial action. The following survey instruments were used in the study: Teacher-logs, Science Process Rating Scale, Teacher and Student Questionnaires, and Academic Background of Teachers.

FINDINGS

Analysis of student scores from the fall and spring tests showed significant gains in achievement of science process skills and earth science knowledge, and a deterioration of attitude toward science. Students with a high grade point average in science during the previous year showed greater gains than low GPA students when considering earth science knowledge. Students in classes where teachers had strong earth science backgrounds also showed greater gains in knowledge. Deterioration of attitude toward science appeared to be directly related to overemphasis of textbook teaching and limited use of laboratory sessions, as well as an inability on the part of teachers to effectively instruct within a material-centered inquiry approach to learning.

SET OF PROCEDURES TO GUIDE FUTURE EVALUATIONS

Faculty should collectively determine the following:

a. Identify areas that manifest outstanding characteristics of the program to be evaluated.

b. Identify characteristics that are most useful for differentiating between students.

c. Identify kinds of information to be gathered through survey instruments, with priority given those that help the evaluator decide why certain differences existed and how improvements could be made.

PLAN FOR ACTION

In order to facilitate planning for a curriculum evaluation as described in this study, the following outline is suggested:

1. Identify the discipline to be evaluated.
2. Select areas of interest which best demonstrate outstanding characteristics of the curriculum program.
3. Choose variables which appear to show promise as identifiers of specific problems and strengths within areas of interest.
4. Develop a test program representative of the above conditions.

5. Prepare measures to be used in each of the areas of interest.
6. List the kinds of information that might be helpful to diagnostically interpret result of the test program.
7. Develop the various kinds of survey instruments necessary for gathering the required information listed under point six.
8. Administer the test and survey instruments according to an agreed calendar.
9. Record and analyze results from the tests.
10. Tabulate and analyze results from the survey instruments.
11. Interpret results from the tests with the aid of the survey instruments.
12. Present recommendations for change.

ACKNOWLEDGEMENTS

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CHAPTER I

THE PROBLEM

Curricula and Culture

Education, in its broadest sense, refers to the entire social process by which individuals acquire the ways, beliefs, and standards of society. What a school is and professes to teach is shaped by these characteristics. However, the school is also an agency for affecting change in the social system. While the relationship between education and society is important during stable times, it assumes profound importance during periods of social change. It then becomes the task of the teaching profession to keep school curricula current, and when desirable, to shape the educational program in such a way as to influence the form and direction of the society's development.

Each society is confronted with the problem of inducting immature members into its culture. To this end a sequence of potential expriences is set up in the schools. This set of experiences may be referred to as curriculum. The curriculum, then, is an outgrowth of culture, that part of man's environment which he himself has made.

Smith, Stanley, and Shores[1] place elements of a culture into three categories. The first of these is called universals; those aspects that are universally distributed among the adult population. These may involve kinds of food, clothing, language, moral and religious standards, political and economic beliefs.

Some elements may be found among only part of the adult population. These are called specialties. They consist principally of vocational callings demanding technical knowledges and skills, and positioning of individuals into various social classes.

Finally there are those cultural elements, alternatives, that embrace all the ways of obtaining results which depart from generally accepted techniques and procedures. They represent those elements about which an individual can exercise choice. Alternatives may enter a culture by way of invention from within or diffusion from without.

When a culture is quite stable, alternatives are generally rather few, and if accepted, are absorbed by either the universals or the specialties. Thus the school is little effected. On the other hand, when a society's fundamental associations are breaking down, when there is vast scientific and technological change bringing about an increased ratio of alternatives, the demands made upon the school become

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[1]Othanel B. Smith, William O. Stanley, and J. Harlan Shores, Fundamental Curriculum Development (Yonkers-on Hudson, New York: World Book Company, 1950), pp. 6-8.

correspondingly more taxing, and failure to meet them may be fraught with social, economic, and political disaster.

During the early period of American history, its people were rooted in self-sufficient, isolated communities, characterized by neighborlines and intimate associations. During the last one-hundred years, however, this way of life has been rapidly disappearing largely as the result of advancement in science and technology.

> One of the chief characteristics of modern civilization is its expanding conquest of nature. Modern man is exploring and subduing nature ceaselessly and successfully, uncovering new knowledge and creating new techniques and machines at an accelerating pace. He has also discovered the method of discovery ... so that he need not depend upon chance discoveries and inventions, but can deliberately bring them about. As the method of discovery is deliberately applied to nature, new knowledge, professional information and techniques, mechanical inventions, and commercial gadgets of all descriptions accumulate at an accelerating rate.... It is not surprising, therefore, that students of history agree that the present phase of social evolution is marked by scientific and technological progress unequaled in recorded history.[2]

Such changes, must of necessity force educators to review the curricula in their schools. All programs, including science, must be evaluated for their contribution to building a new synthesis of the various cultural elements.

Need and Purpose of Study

During recent years exciting and challenging experiments were conducted in an attempt to develop new science curricula.

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[2]Smith, op. cit., pp. 27-28.

These efforts seemed destined to change the total structure of K-12 science. Multiple circumstances dictated that change was inevitable.

> The children today live in a new world of science, and it's getting 'newer' every day; there are new discoveries, new medicines, new ways of doing things, new kinds of jobs. One has the impression that we are living in a very dynamic time of history.[3]

An examination of figures on employment and on career choices of high school and college graduates over the past fifty years showed that development of and interest in science had grown to a great extent.[4] Our civilization produced new knowledge faster than it could be either communicated or consumed. There was more to any one aspect of science than a single person could learn in a lifetime.

> How (then) can a ... school curriculum be designed that is up-to-date, where the amount of scientific knowledge doubles in the time it takes a child to progress from kindergarten to high school? What kind of instruction is needed for today's children, who before middle age will have access to eight times as much knowledge as there is currently?[5]

The "explosion of science knowledge" was not simply adding more and more details to a stable basic outline. Research was constantly reexamining basic definitions, assumptions, principles, and relationship. This research

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[3]Paul D. Hurd and James J. Gallagher, New Directions in Elementary Science Teaching (Belmont, California: Wadsworth Publishing Company, Inc., 1968), p. 2.

[4]Ralph W. Tyler, "Forces Redirecting Science Teaching," The Science Teacher, XXIX (October, 1962), p. 23.

[5]Hurd and Gallagher, loc. cit.

frequently required a reconstruction of the basic ideas as well as addition of details.[6]

In view of these circumstances certain pertinent questions needed to be asked.

> Since the child is in class for only a relatively short time period, what should we choose to teach from all the science that is known? How should it be taught and under what instructional conditions? However one looks at these questions, it becomes apparent that the traditional ... school science curricula are seldom adequate in concept or purpose to help children meet the demands of our modern scientific-technological-industrial society. Without new approaches to ... science teaching, we run the danger of having children become strangers within their own culture.[7]

It was this need for new approaches to science teaching that required educators to constantly reevaluate programs currently in use, and when advisable, to seek new curricular approaches for implementation within the school program.

However, curriculum selection and implementation was fraught with certain hazzards. Many related facets of the social, economic, and educational enterprise needed to be considered when choosing particular modes for advancing attitudes, skills, and content understandings. If, through miscalculation or insufficient research, a program proved to be other than beneficial to the target population, considerations such as financial investment and academic quality, as well as student and parent resentment, often became major sources of concern. It then became necessary for the

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[6]Tyler, op. cit., pp. 23-24.

[7]Hurd and Gallagher, loc. cit.

educational community to again reevaluate its efforts and provide proper corrective measures.

Another concern related to the kind and focus of evaluation. In the past much curriculum evaluation has "consisted of unsystematic judgments of the goodness of something by authors, publishers, school superintendents or principals, teachers, parents, school boards, lay committees, and professors of education and of subject matter."[8]

More recently there has been increasing concern that such decisions should be based on a variety of research measures producing the best evidence that can be made available. In the past curriculum research has rarely served as a basis for changing education. The prime consumers of these efforts have been other researchers. This logically has had little impact at the local level. The major direction of local evaluation research needed to be applied rather than basic.

According to Scriven[9] evaluation may be classified as formative or summative. Formative evaluation purports to assist during the development of new materials and methods, while summative is concerned with the period after the

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[8]Hulda Grobman, Evaluation Activities of Curriculum Projects: A Starting Point (Chicago: Rand McNally and Company, 1968), p. 1.

[9]Michael Scriven, "The Methodology of Evaluation," as found in Ralph W. Tyler, Robert Gagné, and Michael Scriven, Perspectives of Curriculum Evaluation, AERA Monograph Series on Curriculum Evaluation, No. 1 (Chicago: Rand McNally and Company, 1967), pp. 39-83.

materials are completed. The purpose of the latter may be to compare results with those of other curricula, or to look at the program and see how it is effecting the target population. The focus often shifts to data needed for revising and supplementing materials to meet specific needs within the local community.

In the past much of the summative evaluation work has been done by outside investigators. However, the school could not afford to depend entirely on outside studies for help in those areas in which it needed information. Curriculum projects generally focused their evaluation on the materials themselves; on whether the materials were valid in the sense of accuracy, as well as, in implementing the intent of the authors. Thus evaluation looked at the performance of the students in some national sample to ascertain whether new skills, attitudes, and behaviors had been attained. As a result projects remained largely uninformed about what was happening to their materials after books were sold.[10] Given the above, plus the millions spent on materials development, it seemed necessary to ask questions and make observations relative to what happened in the local school district after a new curriculum project was adopted.

Grobman[11] contended that while many major curriculum projects were presently available and certainly their

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[10] <u>Ibid</u>., p. 29.

[11] Grobman, <u>op. cit</u>., p. 30.

developers were concerned about the use of their materials, they had not made sufficient effort to investigate this aspect of their work. She stated:

> They have not fulfilled their mandate to improve education in their respective subject areas if they have made improvement possible but such improvement is not effected. The existence of better materials is only part of the job. Reporting that students in experimental classrooms perform in a noteworthy manner is not enough. Data on sales of materials are indicative of adoption, but do not indicate the reasons for adoption, who tends to adopt the materials, whether the change in materials persists or is temporary, what appear to be the significant factors in such adoptions, and whether adoption of materials results in the intended changes in teaching and learning. Without such information, the evaluation is incomplete.[12]

Assuming the need for more complete evaluation, the question still arose as to how this should be done, and who should accept responsibility for evaluation after the material has been purchased by the local school district. One answer to these questions was offered when the National Educational Association recommended that "procedures and instruments for evaluating pupil progress must be specifically geared to the school's goals and to the curriculum sequence in use in the school."[13]

The NEA further stated that school systems should consider curriculum evaluation an integral part of the school program.

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[12] Ibid., p. 30.

[13] Schools for the Sixties. A report of the Project on Instruction National Education Association (New York: McGraw-Hill Book Company, Inc., 1963), p. 68.

> School systems should allocate an appropriate proportion of their annual operating budgets--not less than one percent--for the support of research, experimentation, and innovation. Adequate time should be provided for each staff member to participate in curriculum planning, research, evaluation, and other activities designed to improve the instructional program.[14]

However, the NEA admitted that adequate measuring instruments were not currently available for such evaluation. They warned against attempting to evaluate the effectiveness of patterns of organization using traditional methods. They encouraged the development of new instruments appropriate for measuring the effectiveness of the new organizational patterns of instruction.[15]

In November, 1956, a grant to produce materials for a new high school physics course marked the beginning of the National Science Foundation's course content improvement program. In the fifteen years that have elapsed since the original grant the NSF has contributed more than $100,000,000 to support major curriculum project primarily in science and mathematics. Several private organizations, and more recently, the United States Office of Education, have contributed funds for similar purposes. Thousands and perhaps millions, of man-hours have been invested in these efforts.[16]

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[14] Ibid., p. 22.

[15] Ibid., pp. 68-69.

[16] Wayne W. Welch, "The Need for Evaluating National Curriculum Projects," Phi Delta Kappan, XLIX, No. 9 (May 1968), p. 530.

Of the forty-six science curriculum projects reported by Lockard (1968),[17] thirty-five indicated some form of evaluation. Since these studies were generally carried out on a national scale, few efforts were made to look at local conditions. National programs, with their lack of attention to district curricular problems, emphasized need for a careful, local assessment. Curriculum planning must, by its very nature, ultimately be a school and district responsibility.

The NEA concurred that:

> Local school faculties should have the freedom and authority to make decisions about what to teach--within state and local requirements--and how to teach. Final instructional decisions should be made by the teacher, taking into consideration recommendations from appropriate local, state, and national groups representing the teaching profession, academic scholars, and the public.[18]

Therefore, each school system should determine its strengths and weaknesses, speculate intelligently about the possible consequences of using a current curriculum development, and plan for careful evaluation of the project when introduced into the school. While the local community must address itself to questions relating to sponsorship and development of the program considered, questions relating to appropriateness

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[17] J. David Lockard (editor), Sixth Report of the International Clearinghouse on Science and Mathematics Curricula Developments (College Park: University of Maryland, 1968).

[18] Schools for the Sixties, op. cit., p. 17.

for the target population and adaptibility within the total curriculum must take precedence.

One, therefore, needs to determine the proper direction and mode of educational travel before beginning the journey. Answers must be sought for questions relating to local, as well as, national goals and objectives. A school district needs to be appraised of the mores and values imbedded into the hearts of community's citizenry. The administration must carefully consider future skills and learnings necessary for community growth. Faculty must address itself to learning theory as it relates to effective changes in attitudes, skills, and understandings. Only after careful consideration of the above criteria can the educational establishment hope to know where the student presently is, where it intends to lead him, and how it expects to successfully bring about the desired changes.

However, many school districts could not be expected to initiate such an evaluation study on their own. Even more difficult would be a proposition that new designs be constructed for assessment of each separate subject. Therefore, it became apparent to this writer that there was a need for development of evaluation guides for local use. Construction of a single guide for evaluation which would be adaptable over a variety of curriculum programs might prove to be most useful. It became the objective of this research to develop such a guide.

Previous studies that considered local conditions usually focused attention to one particular curriculum with no consideration for broader application. Since this investigation was especially concerned with those studies designed to develop an evaluation guide applicable to a variety of school curricular programs, the Education Resources Information Center (ERIC) was consulted. A search of the literature from 1966-1971 showed no studies designed to produce a simple statement of procedures applicable to the typical school district level.

Statement of the Problem

Educators, working at the local level have long searched for a simple yet thorough formula to assist them in the task of anticipating consequences when implementing curricular change. They have sought useful techniques to help them isolate problems and assess changes derived from the new programs.

It therefore became the expressed purpose of this study to develop a set of procedures which could serve as a guide to local school districts as they attempted to assess the impact of new curricular programs. This guide was to be sufficiently versatile for adaptation by most school districts over a variety of school subjects.

While this study attempted to present a plan useful for measuring outcomes over a variety of new curricula, it focused attention to a single curriculum introduction in a particular school system; the implementation of the Earth Science

Curriculum Project in the Carman, School District, Flint, Michigan.

Background of the Study

In the summer of 1967 representatives from the Carman School District, Flint, Michigan, requested that the Science and Mathematics Teaching Center, Michigan State University (MSU), East Lansing, Michigan, assist them in selecting and implementing science curricula for grade levels K-12. This cooperative venture developed into a three part program. Part one was concerned with elementary science (K-6), two with junior high (7-9), and three with senior high (10-12). It was agreed that elementary science should receive priority. Science--A Process Approach (SAPA)[19] was chosen as the elementary program to be implemented at levels K-2 in the fall of 1968. Subsequent grade levels would be added each year until the curriculum was complete.

That aspect of the total program which related directly to this study was identified under part two. It was an eighteen month effort beginning in the summer of 1970, specifically designed to assist in selection of an earth science curriculum for eighth grade students of the District, and to provide re-training for teachers to enable them to adequately teach the program. The earth science curriculum

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[19] Science--A Process Approach. An elementary school science program developed by the Commission on Science Education of the American Association for the Advancement of Science. Produced commercially by Xerox Corp., N. Y.

chosen was the Earth Science Curriculum Project (ESCP).[20]

Beginning in September, 1970, a follow-up program with regular visits was arranged with the Carman earth science teachers. Opportunities were granted for discussion and planning of lessons, special assistance with content problems, equipment, instructional aids, and testing.

Discussion of Variables

As stated above, the participants of the 1970 summer institute had established as their major goal the selection and placement of an earth science program for the Carman District. Subsequently the participants, as well as the administration, showed a desire to develop an evaluation procedure for the adopted eighth-grade earth science program during its first year of implementation.

A major concern expressed related to the grade placement of the program. ESCP was a rather sophisticated approach to teaching earth science and might possibly be better implemented at a higher level. Perhaps a two track junior high school program with ESCP included in the sequence designed for high achievers would be warranted.

Another concern involved changes when considering sex. Some evidence had been gathered to suggest that males perform better than females in science programs (Chapter II, page 73).

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[20] Earth Science Curriculum Project. A secondary earth science program developed by the American Geological Institute. Produced commercially by Houghton Mifflin Company, Boston.

A third question considered teacher variables. Certain studies showed a relationship between teacher and/or teaching approaches and student success (Chapter II, pages 78 and 79).

It was decided that an attempt to evaluate ESCP with Carman grade eight students could best be determined through use of measures in student attitude toward science, student achievement in science process skills, and science knowledge, as well as through the use of survey instruments. ESCP used a textbook, but emphasized the laboratory-inquiry approach to teaching. It therefore allowed for manipulation of materials and investigation by the learner. It encouraged independent inquiry and a degree of open ended research.

It has been theorized by many educators that an approach to learning which involved the learner directly with investigation would generate enthusiasm, raise attitude levels toward the subject, and generally produce a happier, more congenial classroom situation.[21] Thus it could be argued that a science classroom in which children were manipulating objects, asking questions and attempting to find answers through their own investigations would tend to produce students with a positive attitude towards science. It was, therefore, proposed that attitudes should improve as a result

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[21]William Kessen, "Statement of Purposes and Objectives of Science Education in the Elementary School," Journal of Research in Science Teaching, II, Issue 1 (1964), p. 4.

of an activity-oriented classroom. Of related interest was observation of whether attitude levels changed as instructors changed teaching approaches.

As students seek answers to questions through investigation they need to use certain process skills. One could conceive numerous lists of such processes. Since SAPA had become a part of the school district's science sequence K-6, it seemed appropriate to relate these future incoming competencies to the present earth science program. The thirteen processes as taught in SAPA are listed in Table 1.1.[22]

These skills are used by both scientist and non-scientist. It is held that all individuals should have a working acquaintance with these thirteen processes, be he layman or scientist.[23] Interest was therefore focused on student change over these processes.

The end product of scientific investigation is organized information which leads to understanding and encourages prediction and further investigation. ESCP was designed to emphasize content. While it was true that attitudes and processes are important considerations in a science program, it can not be denied that the product of science must receive major consideration. One could argue that product becomes increasingly important as children proceeded to higher grade

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[22]American Association for the Advancement of Science, Science--A Process Approach, Commentary for Teachers (New York: Xerox Corporation, 1970), p. 10.

[23]Kessen, loc. cit.

TABLE 1.1*

THE SCIENCE PROCESSES, SCIENCE--A PROCESS APPROACH

Eight Basic Processes
Observing
Using space/time relationships
Classifying
Using numbers
Measuring
Communicating
Predicting
Inferring
Five Integrated Processes
Formulating hypotheses
Defining operationally
Controlling variables
Interpreting data
Experimenting

*A more complete treatment of these processes is found in Chapter II, pages 86 to 90.

levels. There is prevalent opinion that recognizes the primacy of process during the primary and intermediate grade levels and the primacy of content during higher grade levels.[24] It was therefore of interest to observe student change in content understanding.

As stated previously, evaluation of ESCP at the Carman School District was designed as a guide to test the hypothesis

[24]Robert M. Gagné, "The Learning Requirements for Inquiry," Journal of Research in Science Teaching, I, Issue 2 (1963), p. 152.

that a single evaluation technique could be developed which would incorporate into its body those major factors necessary for adaptation by many school districts over a variety of school subjects. In order to facilitate understanding of this plan the study addressed itself to several specific concerns. Questions answered are presented in order of treatment and do not imply a hierarchial sequence.

Questions to be Answered

Questions relating to ESCP at Carman School District:

1. What special problems faced the Carman District during the evaluation year?
2. Did students show improvement in attitude toward science, understanding of science process skills, and science knowledge?
3. How did seventh-year grade point average in science relate to change as indicated by these three measures?
4. How did sex relate to changes as indicated by the above criteria?
5. Was there a difference between classrooms as determined by the above criteria?
6. How did eighth-grade science students at Carman School District compare to a national sample taken for the year 1964-1965?
7. What percent of classtime was used for laboratory investigations?

8. Was there a relationship between student attitude toward science and teaching approach?
9. To what degree did ESCP emphasize individually the processes of science and how did this correlate with ESCP objectives?
10. What information was found relative to ESCP as the eighth-grade science program?
11. How did the teacher-classroom variable effect learning?
12. What recommendations for improvement of ESCP were presented to the Carman School District?

Question relating to the development of a model evaluation instrument:

13. How was the ESCP study at the Carman School District employed as a guide for other curriculum evaluation?

Definition of Terms

1. Curriculum: A set of materials or planned experiences designed to accomplish certain stated or implied objectives. In particular a discipline or subject area; such as biology or mathematics, also a multidiscipline area such as earth science or social science.
2. New curricular program: A set of classroom materials for students and teacher which have stated aims and goals different from what has been considered traditional curricula and which propose teaching approaches unusual to that traditionally espoused.

3. Evaluation: Information gathered for the purpose of making decisions, in particular the collection and use of information concerning changes in pupil behavior to make decisions about an educational program.
4. Set of procedures: A sequence of planned steps forming a course of action to be followed when evaluating a curriculum.
5. Guide: An orderly, systematic plan for assessing curriculum. The manner or mode of procedure.

Limitations of the Study

1. The study was limited to ESCP as taught in the Carman School District, Flint, Michigan, and inferences to a larger population are confined to selection of populations that closely resemble the Carman School District.

2. While there are several student educational goals that pertain to the effectiveness of ESCP as an innovative teaching approach, this study was limited to those effects which pertained to attitude toward science, understanding of science processes, and competence in earth science knowledge.

3. Evaluation was confined entirely to seven, eighth-grade science classrooms teaching ESCP during the 1970-1971 school year in one school district. No attempt was made to compare pupil changes as measured in this study with pupils not participating in ESCP during 1970-1971.

4. The investigation was also limited in that no evaluation of science attitudes such as open-mindedness and curiosity was contemplated or carried out.

5. The selection of the student as the unit of analysis reduced the validity of this study since there necessarily was interaction between students within each classroom.

Organization of the Thesis

The need and purpose of the study, statement of problem, background, discussion of variables, questions to be answered, definition of terms, and limitations were presented in Chapter I. Chapter II was divided into four parts. In part one historical and theoretical development in curricular thought and practice leading to a discussion of ESCP were presented. Part two presented a discussion of curriculum evaluation. A review of literature relative to ESCP was offered in part three. The fourth part was reserved for a discussion of science process skills. The design of the analytical and descriptive phases of this study were presented in Chapter III. Chapter IV contained the results and analysis of the data. Conclusions of this study and recommendations for further investigations were reported in Chapter V.

CHAPTER II

REVIEW OF LITERATURE RELATED TO SCIENCE CURRICULUM DEVELOPMENT

Studies presented in this chapter have been divided into four parts. Part one deals directly with a review of curriculum development. Subjects treated are the history of curriculum thought and practice, the development of science curricula, a theory for science curriculum development, a history of earth science, and background information to Earth Science Curriculum Project (ESCP).

Part two presents a discussion of curriculum evaluation. A review of literature related to ESCP is developed in part three. Part four presents discussion and definition of the thirteen science process skills as employed in Science--A Process Approach (SAPA).

History of Curriculum Thought and Practice

Innovators of the past decade had attempted to solve difficult problems of curriculum planning and development with little attention to the historical dimensions of these problems.[1] Kliebard[2] maintained that this ahistorical stance

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[1]Arno A. Bellack, "History of Curriculum Thought and Practice," Review of Educational Research, XXXIX, No. 3 (1969), p. 283.

[2]Herbert Kliebard, "The Curriculum Field in Retrospect," Technology and the Curriculum (New York: Teachers College Press, 1968a), p. 96.

resulted in a tendency for curriculum reformers to repeat the rallying cries and slogans of former days and left each generation to discover anew the persistent and perplexing problems that characterized the field. However, interest in the contributions that history might make to the study of curriculum had begun to develop.

Perhaps the first major contribution to curriculum development was the study reported by the Committee of Ten in 1892 when it attempted to establish an organized curriculum for the secondary schools.[3] The report this committee presented effected curriculum development well into the twentieth century.

The emergence of curriculum as a field of professional work and study during the twentieth century was explored by Seguel, Caswell, and Kliebard. Seguel[4] examined certain aspects of developing thought about curriculum problems from the turn of the century to the late 1930's. She concluded that this period could be characterized by four persistent interests on the part of the emerging group of specialists: (1) the nature of knowledge, (2) the nature of the knowing process, (3) the professional status of the new specialty of curriculum making, and (4) procedures for introducing new curriculum insights into educational practice on a broad scale.

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[3]National Education Association, Report on the Committee of Ten on Secondary School Studies (Washington, D.C.: G.P.O., 1893).

[4]Mary Louise Seguel, The Curriculum Field, Its Formative Years (New York: Teachers College Press, 1966).

Caswell[5] identified three continuing, central concerns of curriculum specialists during the 1920's and 1930's: (1) assuring sound sequence or continuity in curriculum, (2) establishing consistent relationships between general goals of education and specific objectives that guide teaching, and (3) designing curricula that provide a reasonable balance of emphasis among the various areas of study.

Kliebard[6] saw the predominant influence of the 1920's a "social efficiency." The key idea was that school subjects were to be judged by the criterion of social utility. This movement incorporated two closely related dichotomies: (1) the dichotomy of school subject--the academic and the practical, and (2) the dichotomy of school population--college preparatory and non-college preparatory.

Foshay[7] summarized the events discussed above when he identified the 1890 to 1930 period as the subject centered curriculum, and the period from 1930 to 1950 as the child-in-society or the child-centered curriculum.

Emergence of the 1950's brought about change of an evolutionary and revolutionary nature. Initial leadership and

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[5]H. L. Caswell, "Emergence of the Curriculum as a Field of Professional Work and Study," Precedents and Promises in the Curriculum Field (New York: Teachers College Press, 1966), pp. 1-11.

[6]Kliebard, op. cit., p. 75.

[7]Arthur W. Foshay, "Changing Interpretations of Elementary Curriculum," The American School Journal, Thirteenth Yearbook of the John Dewey Society (New York: Harper and Brothers, 1953), p. 17.

funding came from sources outside the educational establishment. The movement took on a nationalistic character. Goodlad[8] listed six major forces influencing this curriculum-reform movement: (1) World War II and its immediate aftermath revealed extensive mathematical and scientific illiteracy among high school graduates; (2) the cold war and the shock of Sputnik focused national priorities toward subject disciplines; (3) interest in college education mushroomed; (4) new cultural values merged stressing uncertainty, adaptibility, and cultivation of rationality; (5) the knowledge explosion ruled out traditional approaches to curriculum planning; and (6) there emerged a growing preoccupation for structures and strategies of the subject fields.

Goodlad described the movement of the 1950's and 1960's as a subject-centered curriculum development. The ends and means of schooling were derived from the nature of man's organized bodies of knowledge. The curriculum was planned by academic specialist. Students were encouraged to think like these scholars. The word "structure" replaced "the whole child" of the previous era.

It would appear at first glance that the cycle had been completed. It would seem that the movement which began with subject-centered curriculum, advanced to child-centered curriculum, and now has retreated to subject-centered again.

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[8]John I. Goodlad, "The Curriculum," Rational Planning in Curriculum and Instruction (Washington, D.C.: National Education Association, Center of Study for Education, 1967), pp. 5-10.

As will be shown later in the chapter this is only partly true.

Learning Theory

To better understand the differences that separate the subject-centered curriculum of the first quarter century from this third quarter century one needed to examine certain characteristics of learning theory.

> All theories of learning rest on a concept of man and behavior. Historically there have been essentially two concepts of man. One postulates a mind endowed with certain capabilities--such faculties as reasoning, remembering, imagining, which grow with exercise. The second concept postulates that man is an energy system--a system of dynamic forces--attempting to maintain a balance or an equalibrium in response to other energy systems with which he interacts through his sense organs. This energy system encompasses his entire being; it includes his responses to stimuli, his motivation, feelings, and rational processes.[9]

The first concept of man produced a learning theory often referred to as the theory of mental discipline or faculty psychology. It held that the mind inherently contained all the attributes, or faculties, and that the task of education was to bring them forth by the exercise of acquiring knowledge.[10] An outgrowth of this theory was the development of the serial and the saltatory theories.

> The serial theory postulated that mental abilities appear in serial order, and develop one after another as the child matures. The saltatory theory states that

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[9]Hilda Taba, Curriculum Development, Theory and Practice (New York: Harcourt, Brace and World, Inc., 1962), p. 79.

[10]Ibid., p. 80.

> the development of mental abilities is relatively rapid and is characterized by sudden and relatively abrupt (saltatory) changes.... Taken together, they maintain that certain mental processes, such as memory and observation, begin their development early in life, develop rapidly, and approach a maximum before other mental traits appear. Reasoning, a more complex ability, develops later.[11]

The early school years were therefore considered preliminary for later, more intellectual learning. Practice and drill were important at all levels for their disciplinary value. Transfer was assumed automatic and universal.[12]

This concept reigned supreme in the United States until the end of the century. As late as 1892 it was believed that there were three primary ways for developing the mind: (1) the study of languages was recommended for cultivating powers of discrimination; (2) the study of mathematics strengthened the logical faculty by reasoning from point to point; and (3) the study of history was promoted to ripen the process of judgment.[13]

A second concept of man had produced at least two more theories of learning and behavior. The first of these, the associationist or behaviorest theory, assumed man to be a

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[11] A Program for Teaching Science, National Society for the Study of Education, Thirty-first Yearbook, Part I (Chicago: University of Chicago Press, 1932), p. 4.

[12] Taba, loc. cit.

[13] Report on the Committee of Ten on Secondary School Studies, op. cit., p. 168.

collection of responses to specific stimuli. Shulman[14] described the epistemology of this philosophy as one in which the child began as a blank slate. Human development was described as the cumulative effect of experience. What was learned was the function of the imprint that experience made upon this blank slate. Learning was therefore thought of additively and connectively; what was learned was something that was added and connected to what was learned before.

This theory promoted learning by trial and error, and conditioning took precedence over the higher mental functions. Motives were controlled from without by conditioning, reward, and punishment. Practice was important and transfer was limited.[15,16] Skinner,[17] a leading proponent of this theory, believed that a science of behavior needed to be built only on what was observable. He would not consider such unobservable behaviors as purpose, thought, and insight.

Another set of theories, common in current literature, had been referred to variously as genetic psychology and

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[14]Lee S. Shulman, "Psychology," Mathematics Education, Sixty-ninth Yearbook of the National Society for the Study of Education (Chicago: University of Chicago Press, 1970), p. 45.

[15]Morris L. Biggs, Learning Theories for Teachers (New York: Harper and Row, 1964), pp. 55, 79-81, 258-259.

[16]Ernest R. Hilgard, Theories of Learning (New York: Appleton-Century-Croft, Inc., 1948), pp. 15-47.

[17]B. F. Skinner, Science and Human Behavior (New York: The Macmillan Company, 1953), pp. 87-90.

field theories.[18] While differing, these theories held to a common assumption that cognitive processes--insight, intelligence, and organization--were fundamental characteristics of human response, present in even the simplest perceptions of the environment. Taba[19] further explained this point of view by stating that human actions are marked by quality of intelligence and capacity to perceive and create relationships. Man, as an adaptive creature, organized each subsequent response in light of his prior experience. In each perception the object or event was seen differently, because the cognitive structure had been reorganized by each prior perception. Therefore man was not passive in the face of external stimuli but became an active agent who created his own "phenomenal" world. For man, learning was essentially an active process of selecting and organizing.

Bruner[20] exemplified one aspect of these theories. For Bruner learning involved an internal process. First there was acquisition of new information. Then followed transformation. Here the learner took this new information and found some match between it and models, templates, or ideas already in his mind. This total information was now reorganized,

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[18]Tom C. Venable, Philosophical Foundation of the Curriculum (Chicago: Rand McNally and Company, 1967), pp. 76-84.

[19]Taba, op. cit., pp. 80-81.

[20]Jerome S. Bruner, The Process of Education (New York: Random House, 1960), pp. 48, 49.

ordered, reassembled, and reevaluated. When learning one accepted new knowledge, put it together with the old, then analyzed, organized, assembled, and evaluated the new totality of knowledge possessed. Shulman[21] interpreted this to mean that rarely was something discovered that was outside the learner. Instead this discovery involved the internal reorganization of previously known ideas in order to establish a better fit between those ideas and regularities of an encounter to which the learner had to accommodate.

No single person has better epitomizes the present state of genetic psychology than has Jean Piaget. Piaget[22] has addressed himself to learning theory as it relates directly to curriculum implementation when he encouraged schools to allow children to do their own learning. He has chided the schools by suggesting that what they do is ineffective. One doesn't further understanding in a child by simply talking to him.

> Good pedogogy must involve presenting the child with situations in which he himself experiments in the broadest sense of the term--trying things out to see what happens, manipulating things, manipulating symbols, posing questions and seeking his own answers, reconciling what he finds at one time with what he finds at

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[21]Lee S. Shulman, "Psychological Controversies in the Teaching of Science and Mathematics," The Science Teacher, XXXV (September, 1968), p. 35.

[22]Eleanor Duckworth, "Piaget Rediscovered," Journal of Research in Science Teaching, II, Issue 3 (1964), p. 172.

another, and comparing his findings with those of other children.[23]

According to Piaget, "teaching means creating situations where structures can be discovered; it does not mean transmitting structures which may be assimilated as nothing other than the verbal level."[24]

Transfer of Learning

Bigge[25] defined transfer of learning as that which occurred "when a person's learning in one situation influences his learning and performance in other situations." The theories presented in the previous discussion generated three principle ideas of how transfer of learning took place.

The first theory presented an idea that transfer resulted automatically from the study of certain subjects. Mathematics, science, language, and history fell into this category.[26,27] This theory remained alive for many years. Griswold[28] (1954) proposed the study of liberal arts as a means for developing intellectual and spiritual powers in men.

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[23] Ibid., pp. 172, 173.

[24] Ibid., a direct quote from Piaget, p. 174.

[25] Morris L. Bigge, Learning Theories for Teachers (New York: Harper and Row, 1964), p. 243.

[26] Ibid., pp. 249-254.

[27] Report on the Committee of Ten on Secondary School Studies, op. cit., p. 168.

[28] A. W. Griswold, "What We Don't Know Will Hurt Us," Harper's (July, 1954), pp. 76-82.

Following the turn of the century the concept of unlimited transfer was challenged by Thorndike and others.[29] They showed that improvement in a single mental function rarely brought about equal improvement in any other function, no matter how similar. Further studies suggested that transfer was possible only if there were identical elements in the content involved or in the process of training.[30] During later periods other researchers substantiated the belief that gains on mental tests could not be attributed to a single subject and school subjects, as such, had no disciplinary value. These and other studies challenging transfer, influenced education tremendously. The more abstract subjects, such as Latin and ancient history, were eliminated, and practical subjects were introduced in which knowledge and skill were offered as near to the context in which they were to be used as possible.[31]

Taba[32] reported that certain inconsistencies were observed. Certain types of learning such as attitudes showed a fairly strong transfer, while areas such as arithmetic

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[29]E. L. Thorndike and R. S. Woodworth, "The Influence of Improvement in One Mental Function Upon the Effeciency of Other Functions," Psychologic Review, VIII (1901), pp. 247-261, 384-395, 553-564.

[30]E. L. Thorndike, The Principles of Teaching (New York: A. G. Seiler, 1906), p. 244.

[31]Dorothy M. Fraser, Current Curriculum Studies in Academic Subjects (Washington, D.C.: National Education Association, June, 1962), p. 1.

[32]Taba, op. cit., pp. 125, 126.

skills showed very little transfer. These inconsistencies generated a third theory of transfer. It stated that transfer occurred not by means of specific identical elements, but through generalization either of the content or of the methods employed in learning the content.

Judd[33] demonstrated that practice combined with concept understanding produced more effective transfer than practice alone. He reached the conclusion that one was able to use something learned in a given situation in another situation if he was capable of discerning what principles were involved.

Shulman[34] concurred that when more attention was paid to principles underlying specific processes or generalizations combining otherwise unrelated facts, transfer was more assured and learning more stimulating and productive. He held that transfer became greater when what was learned was rendered meaningful to the learner; that it articulated clearly with what the learner already knew, and was made to fit into his organization or structure of knowledge.

Shulman[35] further stated that the most stable objects of instruction concepts, principles, and general strategies, should become a matrix or network into which facts were

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[33]C. H. Judd, "The Relation of Special Training to General Intelligence," Educational Review, XXXVI (1908), pp. 28-42.

[34]Lee S. Shulman, "Elements of a Cognitive Psychology of Instruction for Higher Education," Journal of Medical Education, ILV, No. 11 (November, 1970), p. 95.

[35]Ibid., p. 96.

embedded. When facts were hung on a conceptual scaffolding, the likelihood of forgetting was less and the possibility of transfer increased. However, to optimize transfer these principles must be practiced well, in a wide variety of conditions.

Taba[36] concluded that transfer took place only if there was some aid both in abstracting and applying the principle and developing the method and the "set" for doing so. She suggested that curriculum needed to be organized so that the principles of a subject stand out. Content should be "programmed" in a manner which enabled a student to discover generalizations and incorporate them into his thinking.

There was also evidence to support Bruner's[37] belief that principles which the student himself discovered were understood more clearly, retained longer, and more easily retrievable.

In summary, then, this argument maintained that the main road to adequate transfer lay with the understanding of fundamental principles or concepts.

> To understand something as a specific instance of a more general case--which is what understanding a fundamental principle or structure means--is to have learned not only a specific thing but also a model for understanding other things like it that one may encounter.[38]

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[36]Taba, op. cit., pp. 125-126.

[37]Jerome S. Bruner, "The Act of Discovery," Harvard Educational Review, XXXI, No. 1 (1961), pp. 21-32.

[38]Bruner, The Process of Education, op. cit., p. 25.

Parker and Rubin[39] presented a proposition that "process--the cluster of diverse procedures which surround the acquisition and utilization of knowledge was ... the highest form of content and the most appropriate base for curriculum change."[40] They argued that since we knew little about how people learn, and that they learn in different ways and at different rates, conceptualization of process as the life blood of content presented a point of view in which process and content would not remain a dichotomy.[41]

Cross-application, a term used to propose an instructional gambit which would circumvent the limitations of the ordinary concept of transfer, would receive first priority in the educational process. The learner would be given more than a mere exposure.

> He must grasp the nature of the process and how he got it; he must know where it has been used in the past and grasp where it might be used in the future; and he must know how to use it in diverse contexts, to modify it as circumstances demand, to fit it to his purposes, and to assess its results.[42]

This position stated that it was desirable for the learner to be schooled in what might be called the cognitive art of transfer which should have priority in the scheme of the

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[39]The major part of the following presentation is taken from Cecil J. Parker and Louis J. Rubin, Process As Content (Chicago: Rand McNally and Company, 1966).

[40]*Ibid*., p. 1.

[41]*Ibid*., p. 2.

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

school.[43] Such a statement was in general agreement with theories which favored exposing the student to the structure of a subject, and saw considerable merit in proposals for discovery learning, both as a learned process and as an epistemological scheme.[44]

Shulman[45] elaborated on the merits of discovery when he stated that the probability of effective transfer increased when learning conditions simulated an actual application setting, and when it was so structured that the learner was called upon to discover a principle for himself.

> For the student, this means relinquishment of habits of passivity, docile learning, and dependence on teacher and textbook, in favor of an active learning in which lecture and textbook cease to be authoritative sources of information to be learned and become materials to be dissected, analyzed. For, in one form or another, the materials of such a classroom are not statements of truth but reports of inquiry. Hence, the student's attention is not on something said but on something done. The oral and written material presented him still, inevitably, are sayings. But the student's attention is not on statements as statements--words and assertions to be learned--but on what the words and assertions are about: the thought and the actions of a scientist which have gone into making of a piece of scientific research.[46]

The task, therefore, which confronted the curriculum worker involved the following four steps:

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[43] Ibid., p. 13.

[44] Ibid., p. 47.

[45] Shulman, "Elements of a Cognitive Psychology," op. cit., p. 96.

[46] Joseph J. Schwab and Paul F. Brandwein, "The Teaching of Science as Inquiry," The Teaching of Science (Cambridge, Massachusetts: Howard University Press, 1962), pp. 65-66.

1. A retooling of subject matter to illustrate base structure, and to insure that knowledge which generates knowledge takes priority over knowledge which does not;

2. an examination of the working methods of the intellectual practitioner, the biologist, the historian, the political scientist, for the significant processes of their craft, and the use of these processes in our classroom instruction;

3. the utilization of the evidence gathered from a penetrating study of people doing things, as they go about the business of life, in reordering the curriculum; and

4. a deliberate effort to school the child in conditions for cross-application of the processes he has mastered--the ways and means of putting them to good use elsewhere.[47]

The Development of Science Curricula

In order to understand the revolution that led to today's concept of science education it was essential to trace the events leading up to the present situation. From the early colonial days until the mid-eighteenth century, virtually no science was included in the school curriculum. What little science was taught began at the university level and emphasized surveying and natural history. With the development of the academy in the middle and late 1700's, science was brought into the secondary schools. The academies developed into college preparatory schools in which science courses emphasized physics, earth science, and astronomy. The advent of the public school around 1820 caused little change. High schools were mainly preparatory schools for college bound students in search of a profession. The college faculty

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[47]Parker and Rubins, op. cit., p. 48.

dominated the high school science curriculum through development of textbooks and standard entrance requirements.[48] Not until the post-Civil War period did laboratory experimentation become a part of high school instruction.[49]

The theory of faculty psychology, which was predominant during the latter part of the nineteenth century, increased the popularity of science in education circles since it was held that the mind, like a muscle, could be improved through constant use and rigorous training. Science was championed as an excellent course for training the mind and so considered part of a general education.[50]

The dominant goals of any elementary school science prior to 1860 were to transmit factual knowledge and to show the presence of God in nature.[51] About this time the Pestalozzian method with emphasis on object teaching received nearly universal acceptance in this country. Krusi sighted the following excerpt as typical of object teaching:

> ... to place objects before the (children) in which they are interested, and which tend to cultivate their preceptive faculties; and, at the same time, lead them to

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[48]A Half Century of Sqience and Mathematics Teaching (Oak Park, Illinois: Central Association of Science and Mathematics Teachers, Inc., 1950), p. 92.

[49]Eugene C. Lee, New Development in Science Teaching (Belmont, California: Wadsworth Publishing Company, Inc., 1967), p. 1.

[50]Ibid., p. 92.

[51]Ronald D. Anderson and others, Developing Children's Thinking Through Science (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1970), p. 17.

> name the object, to describe its parts, and to state the relation of these parts. Thus, language also is cultivated; and from the observation of a single object, the pupil is led to compare it with other, and the first steps of classification are taken.... These lessons are designed specially to cultivate the perceptive faculty ... they must be considered fundamental.... Object Lessons in form lead directly to Drawing, Writing, and Geometry; in sound and form to Language, including Reading, Speaking, and Spelling; in place to Geography; and in animals, plants, minerals, etc. ... to Natural History.[52]

However, this emphasis was again gradually replaced with a nature study movement. Like object study, nature study was based on the principles of faculty psychology and on the alledged serial development of traits.

Ranger stated that "the aim of nature study as an instructional process is to put the child in sympathy with his surroundings--with his own life.... Nature study contributes much to right civic and moral training. It inspires kindness to God's creatures.... It tends to adapt the child to his threefold environment, nature, man, God."[53]

A sequence of science courses for the secondary school was established in 1892, when the Committee of Ten proposed the following sequence of courses for the secondary school:

Freshman: Physical Geography
Sophomore: Biology
Junior: Physics
Senior: Chemistry.[54]

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[52]Herman Krusi, Pestalozzi: His Life, Work and Influence (Cincinnati: Wilson, Hinkle and Company, 1875), pp. 162-164.

[53]Walter E. Ranger, "The Nature Study Movement," Education, XXIV (April 1904), p. 502.

[54]Hans O. Andersen, Readings in Science Education for the Secondary School (New York: The Macmillan Company, 1969), p. 276.

With the establishment of the junior high school in the early 1900's science education became more practical and less formalized. Because of the ever-increasing enrollments an effort was made to provide a more general background in science, particularly for those whose formal education terminated with high school or earlier.[55] Goals were shifted from attention to proficiency in subject matter to development of happy and effective citizens. This shift was demonstrated by a listing of seven cardinal principles of education for secondary schools:

1. healthful living,
2. worthy home membership,
3. worthy use of leisure time,
4. command of judgmental processes,
5. vocational effectiveness,
6. earnest citizenship, and
7. ethical character.[56]

In 1920 science teaching was interpreted in light of these aims so as to contribute to the cardinal aims rather than reproduce in the minds of the students organized knowledge of the specific sciences.[57] Representative of this new thinking in the high school curriculum was replacement of physical geography with general science at the ninth grade

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[55]Lee, op. cit., p. 2.

[56]Commission on the Reorganization of Secondary Education, "Cardinal Principles of Secondary Education," Bulletin of the United States Bureau of Education (Washington: National Education Association, No. 35, 1918).

[57]Commission on the Reorganization of Secondary Education, "Report of the Subcommittee in the Teaching of Science," No. 36 (1920).

level.[58]

> (In 1927) a thesis was written at Columbia (University) which came at a time when the situation was ripe for change. It represented the most prestigious institution in professional education and was to have, perhaps, the most far-reaching influence of elementary science of any single event in the history of the field.[59]

This work, which became a major contributing factor to a development of social utility and a child-centered interpretation of science education was the work of Gerald Craig.[60] His research determined a science curriculum for the elementary school. The products of this study, later embodied in a series of eight textbooks for the elementary school marked the rise of a true general science curriculum for the schools.[61]

The Thirty-first Yearbook[62] further related aims of science in the elementary schools (grades 1-6) to those in junior high schools and the senior high school. The curriculum provided for a continuous development of both physical and biological concepts through the first twelve grades.

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[58]Hans O. Anderson, op. cit., p. 278.

[59]Herbert A. Smith, "Historical Background of Elementary Science," Journal of Research in Science Teaching, Issue 3 (1963), pp. 200-205, 233.

[60]Gerald S. Craig, "Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School" (New York: Bureau of Publication, Teachers College, Columbia University, 1927).

[61]Gerald S. Craig and others, Science for You, Book I-VIII (Boston: Ginn and Company, 1932).

[62]A Program for Teaching Science, op. cit.

1947 saw the publication of Science in American Schools.[63] This issue was designed to emphasize the importance of scientific knowledge during World War II, and to point up the impact of science on future society. The writers outlined the basic areas of elementary science and summarized the patterns of secondary school science teaching. Of interest was an attempt to categorize the objectives of science teaching into functional information, concepts, and understandings; and developmental skills, attitudes, interests, and appreciations.

The Fifty-ninth Yearbook of the National Society for the Study of Education was indicative of the present state of science teaching.[64] It advocated a genuine revolution in science education. Both the conventional approaches to science teaching and the traditional subject matter areas were subject to revision or were discarded. Of the many factors contributing to the revisions, probably the three most important were; the change in philosophy of science education, the willingness of scientists and educators to pool their talents, and new sources of money.[65]

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[63] Science in American Schools, National Society for the Study of Education, Forty-sixth Yearbook, Part I (Chicago: University of Chicago Press, 1947).

[64] Rethinking Science Education, National Society for the Study of Education, Fifty-ninth Yearbook, Part I (Chicago: University of Chicago Press, 1947).

[65] Lee, op. cit., p. 3.

The reform movement which began in the mid-1950's achieved fruition in the form of the "alphabet soup" high school and elementary courses such as BSCS, Biological Science Curriculum Study; PSSC, Physical Science Study Committee; ESCP, Earth Science Curriculum Project; SCIS, Science Curriculum Improvement Study; AAAS: SAPA; American Association for the Advancement of Science: Science--A Process Approach; and a host of others.

> Whereas previous texts and materials were written by educators, the new curricular packages were developed by writing teams in which practicing scientists played a dominant role. The content was not simply updated; it was reorganized around the basic concepts of inquiry and structure.
>
> Students were engaged in laboratory work which was generally investigative rather than verificational. They were to infer from their own data rather than memorize a rhetoric of conclusions. They were to study the reasoning of scientists in the evolution of scientific concepts rather than commit to memory the associated names and dates. The processes and not just the products of science were emphasized.[56]

The science course was to represent genuine science as seen by the practicing scientist today, and be given unity by a few overarching themes.

During 1962 and 1963 the National Science Teachers Association prepared a list of seven conceptual schemes and five "major items in the processes of science" proported to guide future curriculum efforts.

Seven Major Conceptual Schemes:

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[56]Thomas R. Tanner, "The Science Curriculum: Unfinished Business for an Unfinished Country," Phi Delta Kappan, L, No. 7 (March 1970), p. 353.

I. All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.

II. Matter exists in the form of units which can be classified in hierarchies of organizational levels.

III. The behavior of matter in the universe can be described on a statistical basis.

IV. Units of matter interact. The bases of all ordinary interactions are electromagnetic, gravitational, and nuclear forces.

V. All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

VI. One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid, and gaseous.

VII. All matter exists in time and space, and since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

Five Major Items in the Process of Science:

I. Science proceeds on the assumption, based on centuries of experience, that the universe is not capricious.

II. Scientific knowledge is based on observations of samples of matter that are accessible to public investigation in contrast to purely private inspection.

III. Science proceeds in a piecemeal manner, even though it also aims at achieving a systematic and comprehensive understanding of various sectors or aspects of nature.

IV. Science is not, and will probably never be, a finished enterprise, and there remains very much more to be discovered about how things in the universe behave and how they are interrelated.

V. Measurement is an important feature of most branches of modern science because the formulation as well as the establishment of laws are facilitated through the development of quantitative distinctions.[67]

These concerns were re-enforced by the issuance of science goals as expressed in the NSTA position statement on <u>School Science Education for the 70's</u>.[68] These, then, were a suggested set of conceptual schemes and processes intended to permeate the entire science experience of students throughout their school lives. It was not recommended that one accept them blindly as the only worthwhile conceptual schemes. Glass, referring to these schemes, stated "they may indeed supply an admirable basis for the organization of the study of physics, and possibly also of chemistry--although here I begin to have some doubt; but as a basis for organizing the study of the biological sciences they are not helpful--they are positively harmful."[69] In rebuttal, Shamos, one of those who prepared the statements, accused Glass, a biologist, of "disciplinary bias."[70]

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[67] <u>Theory Into Action ... in Science Curriculum Development</u> (Washington, D.C.: National Science Teachers Association, 1964), pp. 20, 21.

[68] <u>School Science Education for the 70's</u> (Washington, D.C.: National Science Teachers Association, 1970).

[69] Bentley Glass, "Theory into Action--A Critique," <u>The Science Teacher</u>, XXXII (May, 1965), p. 29.

[70] M. H. Shamos, "The Role of Major Conceptual Schemes in Science Education," <u>The Science Teacher</u>, XXXIII, No. 1 (1966), pp. 27-30.

Developing a Theory for Science Curriculum Improvement

> Science curricula are not permanent nor should they necessarily have a long life. They are constantly disrupted by a changing society, by their own inadequacies, and by new developments within the disciplines they represent.[71]

When the science curriculum reform of the fifties was examined, it was found most pressures came from scientists. Practically none of these professionals was of the opinion that the pre-1960 science courses were the very best that could be devised. They criticized previous practice as repair of curriculum breakdowns by correcting the isolated defects. Thus critics of the schools whose training was in science became the educational philosophers of the new curricula.

Since the new science philosopher was a specialist in his field, an emphasis was placed on teaching of science in high school as a reflection of its nature as it was known to scientists. This was one of the reasons the reform movement was labeled a "discipline-centered approach."

> One characteristic of a discipline is the conceptual structure identifying the knowledge of which it is composed. Disciplines also have particular modes of inquiry, special ways of gathering information and processing it into data. These inquiry processes are not exactly the same for all sciences.... The scientist's point of view on curriculum development is quite clear: a high school course should be a mirror image of a science discipline, with regard to both its conceptual structure and its pattern of inquiry.[72]

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[71] Paul DeHart Hurd, New Directions in Teaching Secondary School Science (Chicago: Rand McNally Company, 1969), p. 12.

[72] Ibid., p. 16.

Hill, when writing about elementary science, stated that:

> The purpose of learning is to assist boys and girls to build skills and concepts which will enable them to cope more effectually this year, this month, this day of their lives with objects, forces, and events which comprise their environment. The science skills--observation, measurement, classification, inference, and so on--can be translated into immediate behavior by the child as he attempts to understand the phenomena of science encountered in his environment.[73]

Those involved in curriculum reform were faced with the question, "What does it take to provide a valid picture of science that might have lasting purpose for the learner?" Part of the answer was supplied by considering the substantive side of science. This included the great conceptual schemes of science as related to knowledge, "those major generalizations which appear to be best suited to the environmental information input at the present time and which seem to have the greatest power of assimilation of incoming information."[74] A more definitive explanation for conceptual scheme is: Conceptual schemes are structural systems in science that accommodate a great many concepts or processes in an organized manner.

A major part of the curriculum reformer's position consisted of having young people understand the conceptual components of the various disciplines of science.

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[73]Katherine E. Hill, "Science for Children--Why?" Science and Children, III, No. 8 (May, 1966), p. 11.

[74]J. W. George Ivany, "Psychological Aspects of Structure of Science," Science Teacher, XXXIII, No. 5 (May, 1966), p. 37.

> The very nature of a discipline is that it is an organization of knowledge, and its significant concepts, principles, conceptual schemes, laws and theories can be identified.[75]

An important aspect of the new science was its development around the "structure of science." Structure referred to the conceptual organization of knowledge and inquiry processes that gave rise to it.

> Knowledge has a structure, a hierarchy, in which some of what is known is more significant than the rest.... The task of the curriculum maker ... is to give the student a grasp of this underlying structure so that he may be saved from ... clutter.[76]

> The structure of knowledge can aid in the construction of a curriculum because it can guide the organization of knowledge for learning.[77]

> When a sufficient number of connections have been established between concepts and reality and among different concepts, we have a curriculum structure. The web of concepts and connections must fit into some kind of coherent pattern.[78]

The task was one of converting the more powerful ideas of science into optimal units of instruction which a beginner could learn and which at the same time were meaningful units in terms of science. Bruner suggested that "we should cut

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[75]Hurd, op. cit., p. 38.

[76]Jerome S. Bruner, "Liberal Education for All Youths," The Science Teacher, XXXII, No. 8 (November, 1965), p. 20.

[77]Ronald J. Raven, "Toward a Philosophical Basis for Selecting Science Curriculum Content," Science Education, LIV, No. 2 (1970), p. 97.

[78]Ibid., p. 103.

down drastically on the coverage in what we teach to any one child and concentrate instead upon a multiple choice to a few basic ideas, attitudes, and skills in order that we keep alive a sustained satisfaction in mastery."[79]

One means for implementing this idea was to select a small number of significant conceptual schemes, use these to give coherence and unity to a course, and then select supporting concepts for each of the schemes. The concepts selected for teaching were those with the greatest potential for explaining and inferring. The new science courses, therefore, represented a conceptual system with a predesigned set of sequential learning materials serving to give a logical and coherent structure to the course in terms of a particular scientific discipline.[80]

Equally important to the curriculum reformers was the methodical characteristics of science. These were the processes giving rise to the concepts of science and the means by which they were corroborated.

> The processes of inquiry help us to learn how the knowledge of science is obtained. Its parameters and probabilities, and what it means today.... For each of the sciences there are methods of inquiry and investigation by which the field is organized, discoveries made, problems attacked, and the accumulated knowledge brought into order through models and theories. In considering subject matter for science courses it is essential to choose topics that exemplify scientific methods of inquiry and allow the exercise of them.... The inquiry skills best suited for teaching science are those which

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[79]Bruner, "Liberal Education for All Youths," _loc_. _cit_.

[80]Hurd, _op_. _cit_., pp. 72, 73.

> are generalizable and widely applicable for both learning and problem solving.[81]

Gagné held that processes should be taught at all levels of the education endeavor since they were so important for an adult human to have even if he never studied much science in a formal way.[82] He declared that such processes could not be learned as abstractions, but must be learned as one deals with content. As Gagné looked at the spectrum of science education from kindergarten through twelfth grade, he stated:

> ... it is perfectly evident that it [curriculum] must contain more and more high organized substance as it goes along. ... however one decides to _begin_ the learning of science, there comes a time during these grades when one wants the students to learn in some detail the organized theoretical structures of the sciences, physics, chemistry, biology, etc., or at least some portions of them.[83]

Gagné held that "systematic 'content' learning" should begin at seventh grade.[84]

Atkin stated that processes are best learned in a variety of purposeful context in which the learner is aiming toward broader cognitive goals. He concluded that the best way to

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[81] _Ibid_., pp. 39, 40.

[82] Robert M. Gagné, "Process in Science for the Elementary Grades." Reprint from the proceeding of the Sixteenth Annual Convention of the National Science Teachers Association, Washington, D.C., _Elementary Education for the Seventies_, edited by William W. Joyce, Robert Oana, and W. Robert Houston (New York: Holt, Rinehart and Winston, Inc., 1970), p. 169.

[83] _Ibid_., p. 167.

[84] _Ibid_., p. 169.

teach process skills was not to aim at them directly, but rather to use the processes of science while seeking to build principles of science content.[85]

Hurd,[86] while thinking of the processes of science as components of conceptual schemes, stated that this meant there were certain skills and values which undergird the scientific enterprise regardless of the discipline. He believed science could be distinguished from other subjects in school more by its methodologies than its subject matter. He concluded that it was just as feasible, and possibly more worthy, to construct the curriculum hierarchy around inquiry processes than upon a pattern of concept. However, as concepts and processes go hand in hand it would be pedogogically sound to plan the systematic organization of the curriculum around both.

In such a curricular structure one would undertake a major effort to develop a conceptual interdependence representing a valid picture of the discipline involved. Concepts and processes would exist as part of a reference pattern and conceptual scheme, so an integrated web would develop in which any fragment of knowledge, or skill, had relevance to the total design.

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[85]J. Myron Atkin, "'Process' in Science Education." Reprint from the proceedings of the Sixteenth Annual Convention of the National Science Teachers Association, Washington, D. C., <u>Elementary Education for the Seventies</u>, <u>op</u>. <u>cit</u>., p. 164.

[86]Hurd, <u>op</u>. <u>cit</u>., pp. 78, 79.

Hurd described certain advantages to the use of conceptual schemes in curriculum development.

1. They represented the major long-term goals of instruction and helped provide the vertical organization of the curriculum;
2. A student's understanding of a conceptual scheme would increase as he advanced from one science to another;
3. Conceptional schemes provided an excellent criteria for selection of concepts and inquiry skills;
4. Conceptual schemes provided a framework and map for effective science teaching but did not prescribe the path;
5. Conceptual schemes represented the most stable unit of scientific knowledge; and
6. They had a cumulative quality, taking on added meaning with new discoveries.[87]

History of Earth Science

> Earth science today is experiencing a growth unmatched by any of the other sciences taught in the secondary schools of the nation. This growth has been attributed primarily to dissatisfaction of students with general science in the junior and senior high schools. This dissatisfaction, in turn, is traced to improved elementary science curricula which make ninth grade general science seem redundant to the student. Nation wide, the increase in earth science has generally been at the expense of secondary general science.[88]

The first public high school of the nation, established in Boston in 1821, gave as its avowed purpose (to) "qualify youths to fill usefully and respectfully many of those stations,

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[87]Hurd, op. cit., pp. 89, 90.

[88]James R. Orgren, "Earth Science: Then and Now," Journal of Geological Education, XVII, No. 5 (December, 1969), p. 179.

both public and private, in which he may be placed."[89] The United States, in those early years as a new nation, was just beginning to feel the initial impact of nation goals and ambitions. It was natural, for a nation with advancing frontiers, that subjects useful to surveyors, geographers, geologists, and astronomers were included in the curricula.[90] Since this was the period in which "mental discipline" formed the basis for learning theory, subjects were also chosen on the basis of their contribution to imposing such discipline.

During the latter 1800's the laboratory method began to gain acceptance as the only proper way to teach science. Since field studies, as a laboratory method for high schools, never caught on, geology and astronomy were set into the category of lecture subjects. Their replacement by physics became inevitable.[91]

However, physical geography had been established in the ninth grade curriculum and remained as part of the recommendation of the Committee of Ten.[92] Various attempts were made to change the previous concept of physical geography as

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[89]John Elbert Stout, The Development of High School Curricula in the North-Central States from 1860-1918 (Chicago: University of Chicago Press, 1921), p. 322.

[90]Orgren, op. cit., p. 180.

[91]Stout, op. cit., p. 161.

[92]Report of the Committee of Ten on Secondary School Studies, op. cit.

"place" or "sailor geography" to a casual study.[93,94] The Committee of Ten gave this kind of physical geography its prestigeous support.[95] Teachers of that era were too weak in the sciences to teach the new curriculum as designed, and so, by 1910 geography had degenerated to nothing more than memorization of a different kind; land forms rather than places.

Recognition of the work of Dewey[96,97] and others focused attention of curriculum builders on the school's responsibility to develop the power of critical thinking and not merely memory. In science this was interpreted as less emphasis on what was to be learned and more stress on how one achieved scientific knowledge. Physical geography stood in an especially vulnerable position due to its grade placement and its intrinsic weaknesses. A general science was promoted as an ideal introduction to high school science. It promised to examine topics in biology, chemistry, physics--all the sciences. It promised to be more concerned with the method

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[93]Zonia Bober, "The Scope of Geography," Journal of Geography, IV (1905), pp. 386-396.

[94]R. H. Whitbeck, "Thirty Years of Geography in the United States," Journal of Geography, XX, No. 4 (1921), p. 124.

[95]Ibid., p. 124.

[96]John Dewey, Experience and Education (London: Collier-Macmillan, 1938).

[97]Arthur G. Wirth, John Dewey as Educator (New York: John Wiley and Sons, Inc., 1966), pp. 72-87.

of science and place much less attention to lists of facts to be memorized.[98] The movement caught on and gained prominence as the ninth grade science offering in the nation's high schools through the first half of the twentieth century.

The turning point in the revival of earth science began in 1949 when the New York Department of Education inagurated an earth science course for gifted students. This course, which was originally designed to compensate for individual differences with respect to student science interests and aptitudes, proved so successful that the plan was soon adopted by schools throughout the state.[99] The introduction of an earth science course in Pennsylvania marked the beginning of widespread expansion of such courses across the nation.[100]

Heller[101] stated that decisions to include earth science in the curriculum had been based on three primary considerations: (1) With the advent of the space age, it was deemed important that all future citizens increase their understanding of the earth on which they lived and the realm of space to which their lives would be increasingly oriented. (2) With the increase in science teaching in the elementary grades it

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[98]Whitbeck, op. cit., p. 182.

[99]William H. Matthews III, "Current Status of Earth Science in Secondary Schools," Journal of Geological Education, XII, No. 2 (June, 1964), p. 60.

[100]Ibid., p. 60.

[101]Robert L. Heller, "The Earth Science Curriculum Project," Journal of Geological Education, XII, No. 2 (June, 1964), p. 65.

should become possible to complete general science work in grades seven and eight. (3) With the growing need for well-trained geologists, meterologists, astronomers, and oceanographers, it was vital to introduce these fields to potential future scientists while they were still in secondary school.

An analysis of traditional courses in physical and historical geology showed two major weaknesses: (1) These courses emphasized the descriptive and taxonomic aspects of subject matter and generally failed to emphasize concepts, principles, and the challenge of unsolved problems; and (2) there was a general failure to present stimulating and provocative exercises for the laboratory.[102]

Heller[103] stated a further observation that related to utilization of earth science in the curriculum.

> In the process of rediscovering the secondary school, biologists, chemists, and physicists also discovered earth science.... Scientists and educators recognized ... that earth science could serve most effectively to demonstrate the interrelationship of all science.

Namowitz[104] showed how chemistry, physics, climatology, oceanography, astronomy, and meteorology were integrated by

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[102]Roy J. Chalmer, "Let's Teach Geology as the Science of the Earth," Journal of Geological Education, XIV, No. 1 (January, 1964), p. 48.

[103]Heller, "ESCP," loc. cit.

[104]Samuel N. Namowitz, "The Traditional Approach to Earth Science," Journal of Geological Education, XVI, No. 5 (December, 1968), p. 172.

the concept of earth science. "Earth science is by any approach interdisciplinary, else it would not be earth science."

Holmes[105] regarded the geologic sciences as the area through which the other physical sciences could most effectively serve the social sciences, the arts, and the humanities.

Background to Earth Science Curriculum Project (ESCP)

Confronted with the almost explosive development of earth science as a secondary school science course, the American Geological Institute, through its Educational Committee, decided, in 1958, that up-to-date resource materials had to be developed for use in these courses.[106] After considerable editorial revision, Geology and Earth Science Sourcebook for Elementary and Secondary Schools was published in 1962.[107]

Advisability for development of an entirely new program was also seen. Need was generated by surveys that predicted a rapid growth in earth science course offerings between 1962 and 1970. It was estimated that the number of

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[105] Chauncey D. Holmes, "Geology and Liberal Education," Journal of Geological Education, XVII, No. 4 (October, 1969), p. 144.

[106] "History of ESCP," ESCP Newsletter, NL-1 (1963), p. 2.

[107] Robert L. Heller, Geology and Earth Science Sourcebook for Elementary and Secondary Schools (New York: Holt, Rinehart and Winston, Inc., 1962).

students enrolled in an earth science course would grow from 190,000 in 1962-1963 to as much as 1,000,000 by 1970.[108]

A proposal to initiate a major course-content improvement program was approved by the Executive Committee of the American Geological Institute (AGI) in 1962 and submitted to the National Science Foundation. Funds to support the initial phase of the project, called the Earth Science Curriculum Project (ESCP), were granted by the Foundation in 1963.[109] The project had its headquarters at the University of Colorado, Boulder, Colorado, and was under the direction of Robert L. Heller, on leave from the University of Minnesota, Duluth.

The authors[110] held that there was no distinct discipline known as earth science, but rather, there were a number of fields of science that had come to focus on particular aspects of the natural earth, its processes, and its environments. They stated that despite specialization, many threads, both in subject matter and method of investigation, continued to bind the several fields together. The cementing agent was the earth itself. Using the seven conceptual schemes

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[108] Robert C. Stevenson, "The Earth Science Curriculum Project, Its Organization, Objectives, and Philosophy," The Science Teacher, XXXI, No. 2 (1964), p. 21.

[109] Robert L. Heller, "Earth Science Curriculum Project," op. cit., p. 64.

[110] Earth Science Curriculum Project, Teacher's Guide--Investigating the Earth, Part 1 and 2 (Boston: Houghton Mifflin Company, 1967), p. 3.

prepared by the National Science Teachers Association (1966)[111] as a guide, the Committee presented a diagram picturing a continuum of basic concepts and principles that encompassed the entire realm of science.[112] (See Table 2.1, page 60).

The first version with a student text, laboratory manual, and teacher's guide was completed in the summer of 1964 during an eight week writing conference by forty-one earth scientists (astronomers, geologists, geophysicists, meteorologists, oceanographers, physical geographers, and soil scientists), science educators, and secondary school teachers.[113] The preliminary materials were field tested in over 400 trial classrooms, evaluated and revised twice during the two year period 1964-1965. In the spring of 1967 the first commercial version of ESCP's Investigating the Earth became available. This version presented a student text and laboratory manual combined into a single volume, and a two volume teacher guide with unit and final tests.[114]

This experience orientated science course emphasized inquiry, discovery, and interpretation of student-obtained data.[115] Stressed throughout the materials were the

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[111]See page 44 for listing of Seven Major Conceptual Schemes.

[112]ESCP, Teacher's Guide, op. cit., p. 2.

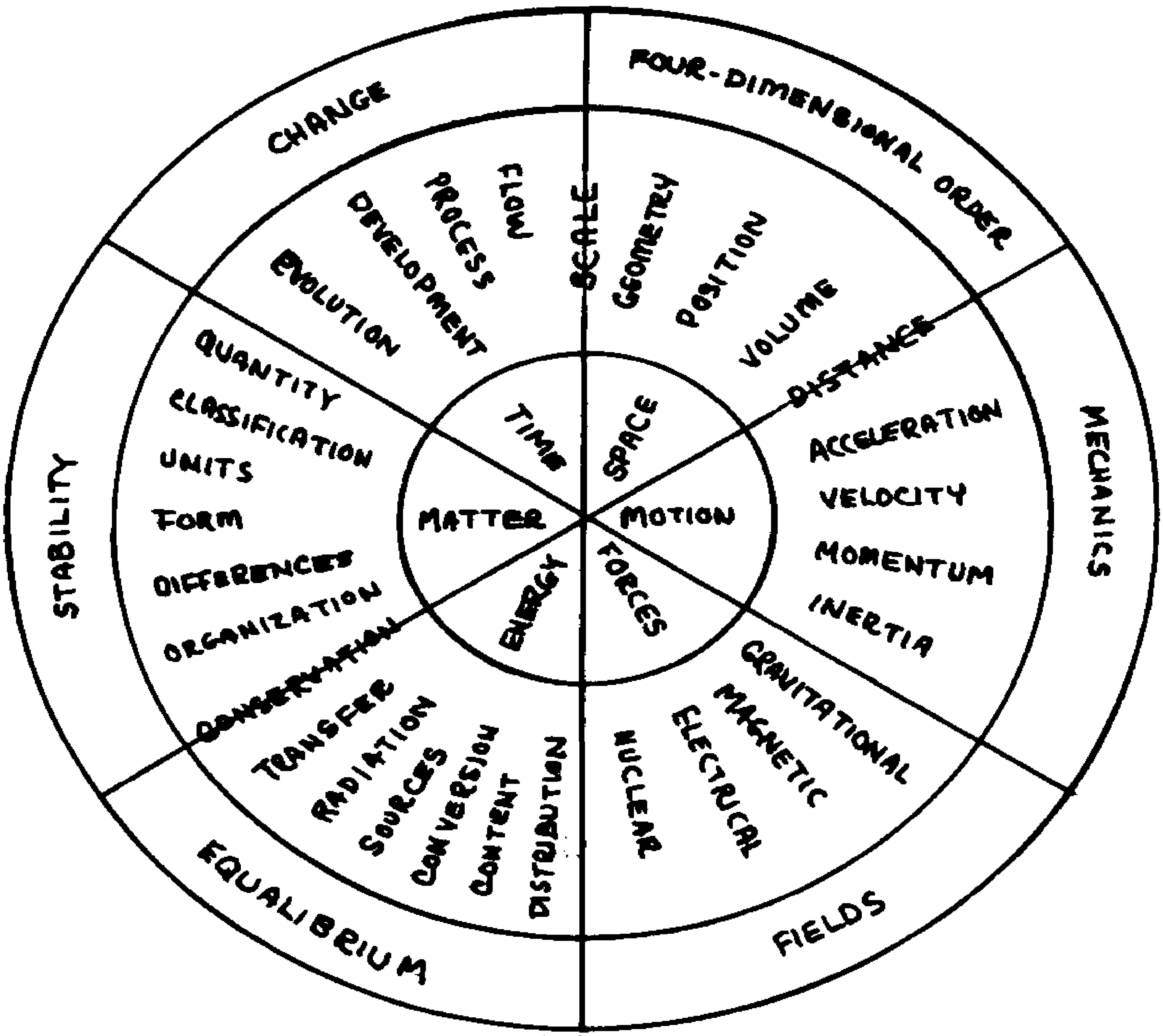
[113]Earth Science Curriculum Project, Investigating the Earth, Text (Boston: Houghton Mifflin Company, 1967).

[114]ESCP, Teacher's Guide, op. cit.

[115]Ibid., p. 3.

TABLE 2.1

MAJOR CONCEPTS OF EARTH SCIENCE



The inner circle of this diagram shows that major concepts of earth science relate to matter, energy, forces, motion, space, and time. The second circle embraces the principles related to each of the concepts. On the rim of the diagram appear the generalizations derived from the principles in the second circle. The goal of Investigating the Earth is to help the student attain some understanding of these concepts, principles, and generalizations.

importance of time, the incompleteness of evidence, the difficulties of experimental verification, the necessity for speculative and tentative conclusions, and unsolved problems in earth science.[116]

The general objective as it related to this study was the development of up-to-date teaching resource materials for use in secondary school earth science programs.[117] The major elements in the framework of the final version were the hydrological cycle and the petrogenic cycle. The concept of an interface was the prelude to the theme of the hydrologic cycle. In the rock cycle students were taught that a wide range of processes are at work.[118]

The writers incorporated into this framework the following basic themes as unifying threads:

Behavioral Themes

(1) Science as inquiry. Experimentation and intuition are important in the earth science, but observation of nature is the true basis of all knowledge.
(2) Comprehension of scale. Earth scientists must think to scale, although illustrations of natural phenomena usually involve enlargements or reduction.
(3) Prediction. Prediction of future events, processes, and relationships is a goal of most scientific inquiries.

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[116]Robert L. Heller, "The Earth Science Curriculum Project--A Report of Progress," Journal of Research in Science Teaching, II, Issue 4 (December, 1964), p. 330.

[117]"Objectives and Philosophy of ESCP," ESCP Newsletter, NL-1 (October, 1963), p. 5.

[118]Richard S. Lewis, "ESCP Moves Ahead," Geotimes, IX, No. 2 (September, 1964), p. 16.

Conceptual Themes

(4) Universality of change. The earth is a dynamic planet; nothing about it is static, nothing really endures.
(5) Flow as energy. Universality of change in earth materials is a consequence of the redistribution of energy, and the 'running down' of the energy level of the system.
(6) Adaptation to environmental change. The goal is equilibrium, a state of balance between opposing forces in an environment.
(7) Conservation of mass and energy. The processes and changes observable on the earth obey all the basic laws of the physical universe.
(8) Significance of components and their relationships in space and time. Understanding any aspect of the earth requires consideration of the physical and chemical nature of the components and their relationships in space and time.
(9) Uniformitarianism. The past can be interpreted only if one understands the present.

Historical Theme

(10) Presentation. Presentation of principles and concepts should reflect the historical development of earth science.[119,120]

Behavioral schemes (1), (2), and (3) were considered the major process schemes and (4) through (9) the major subject matter schemes.[121]

The 594 page student text was organized into four major units and twenty-six chapters. A detailed listing of the contents is shown in Appendix A, page 193.

As stated previously, laboratory investigations were included in the body of the student text. Investigations were grouped into three categories: (1) Those in which the student

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[119]Heller, "The Earth Science Curriculum Project," op. cit., p. 67.

[120]ESCP, Teachers Guide, op. cit., pp. 3, 4.

[121]Hurd, op. cit., pp. 79, 85.

investigated processes or materials of the natural world directly; (2) those of a more abstract nature in which the student investigated natural materials and processes through the use of laboratory equipment and instruments; and (3) those in which he employed modules and/or data that were provided by the teacher.[122]

The Teacher's Guide emphasized the need for laboratory time in which students work together in small groups collecting data, analyzing results, interpreting it, predicting and inferring. Major stress was given for adequate laboratory equipment as well as need to visit the field for on-the-spot investigations.[123]

As a convenience for teachers, laboratory kits were developed for many of the investigations. A variety of enrichment materials such as a Reference Series, Field Guide Series, pamphlets, and audio visual aids were made available to supplement the course.[124]

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[122]ESCP, Teacher's Guide, op. cit., p. 6.

[123]Shirley A. Brehm, "General Content of the Earth Science Program and Where It Fits into the Curriculum," mimeographed working paper prepared for Earth Science Committee, Earth Science Education in Michigan (Michigan State University, January, 1971), p. 7.

[124]For listings and source see: ESCP, Teacher's Guide, op. cit., pp. 343, 344.

A Discussion of Curriculum Evaluation

> Curriculum developers and educators are tempted to de-emphasize evaluation because of the complex and sometimes ill-defined methodological problems present. To do so is a tragic mistake indeed. If tight methodology is impossible, in a given instance, it does not follow that evaluation attempts should be virtually abandoned. Evaluation is a secondary activity in the development of curricula, but still one which needs to receive a major share of attention ... stakes are high.[125]

Stufflebeam defined evaluation as "the process of delineating, obtaining, and providing useful information for judging decision alternatives."[126] Wiley presented a narrower focus when he stated that "evaluation consists of the collection and use of information concerning changes in pupil behavior to make decisions about an educational program."[127]

Mehrens[128] identified two kinds of evaluation when considering the educational process--curriculum evaluation and student evaluation. The basic distinction between these two was the decisions which were to be made. Curriculum evaluation was considerably broader than student evaluation.

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[125] J. Stanley Ahmann, "Aspects of Curriculum Evaluation: A Synopsis," as found in Ralph W. Tyler, Robert M. Gagné, and Michael Scriven, Perspectives of Curriculum Evaluation, op. cit., p. 89.

[126] Daniel L Stufflebeam et al., Educational Evaluation and Decision Making (Bloomington, Indiana: Phi Delta Kappan, Inc., 1971), p. xxv.

[127] M. C. Wittrock, and David E. Wiley, Evaluation of Instruction (New York: Holt, Rinehart and Winston, Inc., 1970), p. 261.

[128] From a personal interview with William A. Mehrens, Professor of Education, Michigan State University, East Lansing, Michigan, March, 1972.

When considering student progress toward goals one was concerned with student evaluation. Curriculum evaluation related to such things as why the students goals were, or were not, achieved; the evaluation of the goals themselves; the need to be particularly alert to unintended outcomes; the impact the curriculum has on others than the students; obtaining measures of cost effectiveness; and others.

A discussion of curriculum evaluation might well center on the question of choice of strategies. A common distinction usually separates evaluation goals from evaluation roles. Goals aré attempts to answer certain types of questions with regard to educational instruments. These questions may concern the degree to which one instructional instrument performs better than another, or how well it performs with regard to specified criteria.

Evaluation roles are quite variable. The role might be to contribute to the process of the development of a curriculum or to the self-improvement of a teacher; or it might be aimed at the determination of the over-all quality of an instructional instrument.[129]

Perhaps the best way to examine and illustrate evaluation roles is through further subdivision. As stated in Chapter I, Scriven[130] categorized curriculum evaluation roles as formative and summative. Formative evaluation provided a means

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[129]Ahmann, as found in Tyler _et al_., _op_. _cit_., p. 87.

[130]Scriven, as found in Tyler et al., _op_. _cit_., pp. 39-83.

of obtaining information that could be used to improve the course during its development. It took place at an intermediate stage of development and permitted intelligent changes to be made. Deficiencies and strengths of the intermediate versions were identified, and appropriate adjustments made.

Summative evaluation provided a basis for decisions about curriculum adoption and effective use. Devisions were made with regard to replacement of one curriculum by another and acceptance or rejection of such elements as textbooks, course of study, and the like.

Scriven[131] also described two basically different approaches to both formative and summative evaluation. The first involved an appraisal of the instructional instrument itself--the content, goals, materials use, teaching approaches, etc. He called it intrinsic evaluation. The criteria were usually not operationally orientated. The second approach proceeded to examine the effect of the teaching instrument on the pupil, and it usually specified these rather operationally. It involved an appraisal of differences between pre- and post-tests, between experimental and control groups, etc., on a number of critical parameters. This latter aspect was called pay-off evaluation.

It appeared that intrinsic evaluation involved much subjective judgment while pay-off evaluation tended to be more objective. The two approaches considered different types of data and their limitations and advantages were not the same.

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[131] Ibid., pp. 53-54.

At least four specific means of evaluating student progress in the new programs have been used in the past: 1. Observations of whether or not the students for whom the material was intended appeared to be progressing successfully; 2. both causual and systematic questioning of students involved in the programs; 3. periodic examination of students by tests designed to cover the new material; and 4. comparative testing of students in the new and old programs with traditional and specially designed tests.[132]

Evaluation must of necessity be an on-going process. The job is not finished when the program is published. Those who purchase the materials need to assess its effects on a long-term basis with the local population. It is at the local level where curricular programs succeed or fail.

Ahmann summarized the concern of responsible curriculum evaluators when he stated:

> All evaluation is relative, perhaps to a larger degree than the unsophisticated wish to acknowledge. Rather than emphasizing the search for one 'final decision' with respect to a curriculum we should, perhaps, concentrate more heavily on the 'try-out' type of study where measurement sophistication is less significant. For the time being, the local school official should pay less attention to 'universal' summative evaluation and more attention to 'local' summative evaluation. Good evaluation of his curriculum can take place on 'home ground' in spite of its many unique--and probably unmeasured--factors. These are worthy studies indeed.[133]

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[132]John I. Goodlad, Renata Van Stoephasius, and M. Francis Klein, The Changing School Curriculum (New York: The Fund for the Advancement of Education, 1966), pp. 98-99.

[133]Ahmann, as found in Tyler et al., op. cit., p. 89.

Review of Literature Related to ESCP

Since the first instructional materials produced by ESCP were introduced into classrooms, ten major research studies and several surveys were conducted. Six of the studies dealt with student achievement, two were analysis of the content, and two discussed textbook readability. Four surveys were reported. Two dealt with student questionnaires; one with a survey of grade placement for earth science, and the latter was a teacher questionnaire.

The Psychological Corporation Study. The first instructional materials produced for ESCP were introduced into secondary school classrooms during the fall of 1964. These preliminary materials were officially tested by the Psychological Corporation during the 1964-1965 school year.[134] Approximately 6,500 ESCP students in high schools and junior high schools participated in the first year evaluation. In addition 2,500 students in conventional earth science classes were included in the study as a comparison, or control group.

The basic design of the study included:

1. Comparison of the end-of-course earth science achievement level of ESCP and control classes.

2. Comparison of students' (both ESCP and control) understanding of science principles and methods at the beginning and end of the school year.

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[134] Earth Science Curriculum Project Evaluation Program End-of-Year Report (New York: The Psychological Corporation, October, 1965).

3. Comparison of science knowledge and ESCP achievement among grade levels between boys and girls.[135]

Careful attention was given to student academic ability and previous science knowledge. The ESCP students ranged from grades 8 through 12. All students in the control group were in the 9th grade. Test scores were studies for ESCP students by grade (three grade groupings: 8, 9, and 10-12) and sex, and the control group by sex.

Table 2.2 shows the selection of students chosen for the experiment.

TABLE 2.2*

SELECTION OF STUDENTS--ESCP EVALUATION PROGRAM
END-OF-YEAR REPORT, 1964-1965

Grade	Experiment Group		Control Group	
	Male	Female	Male	Female
8	711	699		
9	1950	1587	1247	896
10-12	365	230		

*ESCP Evaluation Program End-of-Year Report, op. cit., p. 2.

After tests were administered raw scores were adjusted to hold constant any differences which existed in academic ability or prior science knowledge to provide a better

[135]*Ibid*., p. 1.

estimation of the effects of the curriculum.[136] At the beginning of the school years, all students in ESCP and control classes were administered the Verbal Reasoning (VR) and Numerical Ability (NA) tests from the Differential Aptitude Tests (DAT) published by the Psychological Corporation. These measures were followed by administration of Part I and II of a Test of Science Knowledge (TOSK), tests designed specifically for this ESCP evaluation program. TOSK I was constructed to measure knowledge of basic factual information from all areas of general science. TOSK II was designed to measure understanding of scientific principles and methods. At the end of the school year, Part II of the Test of Science Knowledge was readministered in conjunction with the ESCP Comprehensive Final, a test included in the ESCP teacher's manual. The ESCP Final provided comparisons for achievement between the ESCP and control groups, while the science test (TOSK II) provided the beginning and end-of-year measures of understanding of science, and both tests provided grade and sex comparisons.[137]

Findings of the Study

1. Both ESCP and control group students were about ten to fifteen percentile points above national norms in mean academic ability when compared to national student samples as

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[136] Ibid., p. 2.

[137] Ibid., p. 1.

measured by DAT (VR) and DAT (NR). Specifically, the mean of ninth grade students was at the sixty-fifth percentile, the grade eight mean at the seventieth percentile, and the mean for grade ten through twelve was at the sixty-fifth percentile.[138]

2. All groups had a greater science understanding at the end of the year than at the beginning as measured by TOSK II.[139]

3. The ninth grade ESCP experimental group had a greater increase in science knowledge during the year than did the ninth grade control group when measured at the .001 level. Table 2.3 shows the results of the TOSK II tests.

TABLE 2.3*

MEAN GAIN FROM PRE-TOSK II TO POST-TOSK II WHEN ADJUSTED FOR ABILITY

	Experimental Group			Control Group
Grade	8	9	10-12	9
Boys	4.57	5.18	4.28	3.44
Girls	4.36	4.46	4.94	3.53
Average	4.47	4.82	4.88	3.49

*<u>ESCP Evaluation Program End-of-Year Report</u>, op. cit., p. 16

[138] Ibid., p. 2.

[139] Ibid., p. 16.

Since TOSK II was not designed specifically to test ESCP achievement, this difference represented a definite advantage for the ESCP group. However, one needed to temper this difference with the researchers' warning that systematic bias such as better teachers and laboratory facilities for the ESCP group may have influenced the results.[140]

4. Of major interest was the comparison of achievement between the experimental ninth grade and the control ninth grade groups on the ESCP Comprehensive Final. The comparison discussed below was based upon the mean scores adjusted for academic ability level. Table 2.4 showed that the experimental group mean was significantly higher than the control group mean at the .001 level.[141]

TABLE 2.4*

RESULT OF ESCP COMPREHENSIVE FINAL

	Number of students	Mean	Standard Deviation
Experimental Group	3537	27.46	6.48
Control Group	2170	23.29	4.88
Difference between Means = 4.17			

*<u>ESCP Evaluation Program End-of-Year Report</u>, <u>op</u>. <u>cit</u>., p. 2.

[140] <u>Ibid</u>., p. 4.

[141] <u>Ibid</u>., p. 5.

When the comparison was made with an additional adjustment for prior science knowledge the experimental group still outperformed the control group. The authors again cautioned the reader by stating a difference between pupils in the Comprehensive Final was not surprising since the examination was written to test achievement of ESCP students.[142]

5. Boys consistently had greater understandings of science and greater earth science achievement than did girls. The largest difference occurred at grade nine.[143]

6. As grade level increased from eight to ten through twelve, students in the higher grades had more science knowledge and earth science achievement than did those in grades below them.

7. ESCP ninth graders made the greatest score gains, while the control group showed least for all groups tested.[144]

Of significance to this study were the results for eighth grade students on the Comprehensive Final (see Table 2.5, page 74).

Champlin and Hassard Study. Champlin and Hassard, instructors at Lexington High School, Lexington, Massachusetts, conducted a similar study the following year.[145] Lexington

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[142] Ibid., p. 5.

[143] Ibid., p. 7.

[144] Robert F. Champlin, "A Review of Research Related to ESCP," Journal of Geological Education, XVIII, No. 1 (January 1970), pp. 31-39.

[145] Robert F. Champlin and John Russell Hassard, "A Comparative Study of Two Earth Science Courses" (unpublished Master's dissertation, Boston University, 1966).

TABLE 2.5*

MEAN AND STANDARD DEVIATION OF SCORES ON THE COMPREHENSIVE FINAL FOR EIGHTH-GRADE STUDENTS

	Mean	Standard Deviation
Male	27.94	8.63
Female	26.28	7.76

*Earth Science Curriculum Project Evaluation Program End-of-Year Report, op. cit., p. 11.

had previously been included in one of the fifteen trial centers by the national committee developing these new materials.

The experimental group used ESCP materials (N=84) while the control group studied from an earth science course that had been established in the school five years previously (N=94). The latter group spent about fifty percent of their class time in laboratory situations while the ESCP group was involved in laboratory investigations seventy-five percent of the time. A testing schedule was initiated that followed the 1964-1965 national trial period.

When scores were compared for the pre- and post-TOSK II, the ESCP group showed a gain of 7.35 while the conventional group demonstrated an improvement of 7.57. Even though both groups showed a significant gain, the post-TOSK II indicated a significant difference in favor of the conventional group when measured at the .05 level of probability (30.68 and 33.03).

TABLE 2.6*

RESULTS OF TOSK II--CHAMPLIN AND HASSARD STUDY

	ESCP			Conventional		
	Pre	Post	Gain	Pre	Post	Gain
Mean	23.33	30.68	7.35	25.46	33.03	7.57
S.D.	7.36	8.37		7.23	6.56	

*Champlin and Hassard, op. cit., pp. 15 and 21.

An interesting contrast was observed when the ESCP Comprehensive Final results were compared. This measure indicated a significant difference in favor of the ESCP group at the .01 probability level.

TABLE 2.7*

RESULTS OF ESCP COMPREHENSIVE FINAL

	ESCP	Conventional
Mean	30.63	26.15
S.D.	7.56	6.31

*Champlin and Hassard, op. cit., p. 21.

The above evidence seemed to report no certain advantage for either program. While the TOSK II measure indicated an advantage for the control group, the Comprehensive Final demonstrated an advantage for the ESCP group. This latter observation was especially open to question when one considered that the Comprehensive Final was written specifically for ESCP students. It could logically have been expected that such a test would favor ESCP students.

Paull, Larson, and Vanden Avond Study. A recent study by Paull, Larson, and Vanden Avond[146] attempted to evaluate the potential effect of secondary school earth science education on student achievement in college geology courses. Students in ninth grade general science, earth science, and ESCP were pre- and post-tested with TOSK I and II. Both ESCP and the non-ESCP earth science were elective courses while general science was considered a remedial program. The same tests were administered to a group of pre-geology college students and geology graduate students for purposes of comparison.[147]

The study suggested that ESCP was a better course than general science or non-ESCP earth science for strengthening science backgrounds of students in secondary schools. Although students entering the different courses had variable science backgrounds and TOSK means were different for each class, improvement in scores was most dramatic for ESCP students.

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[146] R. A. Paull, A. C. Larson, and Richard Venden Avond, "Predicting the Effect of ESCP on Introductory College Geology Course," Journal of Geological Education, XXVII, No. 2 (1969), pp. 47-53.

[147] Champlin, op. cit., p. 34.

TABLE 2.8*

COMPARISON OF TOSK SCORES--PAULL, LARSON, AND VANDEN AVOND STUDY

	General Science	Non-ESCP	ESCP
Pre-TOSK Mean	60.4	67.9	70.0
Post-TOSK Mean	64.1	71.8	83.0
Gain	3.7	3.9	13.0

*Paull _et_ _al_., _op_. _cit_., p. 51.

In all cases improvement in the total TOSK score was distributed quite equally between improvement in TOSK I (factual) and TOSK II (principles). When results were compared to students entering college geology, it was found that ESCP students with high school biology, physics, and chemistry still ahead of them were already close to the pre-geology college students' science ability level.

TABLE 2.9*

COMPARISON OF POST-TOSK SCORES BETWEEN ESCP STUDENTS AND COLLEGE STUDENTS

	ESCP	Pre-Geology College Students	Geology Graduate Students
Mean	83.0	90.2	101.4

*Paull _et_ _al_., _op_. _cit_., p. 50.

A comparison between pre-geology college student scores and those attained by eleven high ability ESCP students showed that the latter's post-TOSK mean score of 94.8 ranked favorably with mean score of 90.2 for the former.

A final consideration relevant to this paper involved a study relating to teacher quality. When two teachers were considered, the first with a biology orientated background, two years of teaching experience of which one was with ESCP, and the second with fifteen years experience, two with ESCP, and a master's degree in earth science, the first teacher's students scored a mean of 77.1 on post-TOSK while a score of 82.9 was recorded for the latter. Even though no statistical significance was reported the authors suggested that this confirmed a common observation that students who studied under well qualified teachers would be better prepared for college geology than those who did not.[148]

Other Studies Related to ESCP. Shirner and Sargent conducted investigations of the effects of teacher variable. Shirner[149] found that a student having a direct teacher with traditional teaching beliefs had an advantage in a non-ESCP course. On the other hand, a student with an indirect teacher with non-traditional teaching beliefs had an advantage in an

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[148]Paull *et al.*, *op. cit.*, p. 52.

[149]Silas Shirner, "A Comparison of Student Outcomes in Various Earth Science Courses Taught by Seventeen Iowa Teachers, A Paper Presented at the National Association for Research in Science Teaching Conference (Chicago, 1968).

ESCP course and was at a disadvantage in a non-ESCP course. Non-ESCP students having a direct and traditional teacher scored significantly higher than ESCP students who had direct and traditional teachers. This suggested to Shirner that matching the right teacher to the right curriculum was extremely important.

Sargent[150] conducted a study in which he compared ESCP students of permissive teachers with students of authoritarian teachers. The findings indicated that student achievement was not strongly related to these two variables. However, when Sargent compared students of teachers with thirteen to twenty semester hours in education to those who had zero to twelve hours he found significant differences favoring the former.

Mooney[151] found that ESCP could replace a half year earth science-half year physics course and produce the same achievement.

Two content analysis studies were reported. Sonnier[152] investigated how the conceptual content in college level

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[150]Earl Alvin Sargent, "A Study to Determine Certain Characteristics of Earth Science Curriculum Project Teachers and Students in Permissive and Authoritarian Classrooms Which Lead to Greater Academic Achievement in These Students" (Ann Arbor, Michigan: University Microfilms, 1966).

[151]E. W Mooney, "The Earth Science Curriculum Project for Ninth Grade," Pilot Studies (Richmond, Virginia: Division of Educational Research, State Department of Education, 1968).

[152]Isadore L. Sonnier, "A Study of the Number of Selected Ideas in Astronomy Found in Earth Science Curriculum Project Materials Being Taught in College and University Courses" (Ann Arbor, Michigan: University Microfilms, 1966).

astronomy courses compared with conceptual content in the ESCP astronomy unit. His study showed that the content of formal college astronomy courses presented sufficient subject matter background for earth science teachers.

Smith[153] selected "The Universe and Its Origin" from the preliminary version of the ESCP text for his study because it seemed to involve a great many concepts. Smith's analysis, while subjective, was both detailed and thoughtful. He concluded that the unit contained a heavy explicit concept load and a much greater implicit concept load. He stated that it was "almost certainly projecting a level of sophistication to junior high school students which extremely few of them would possess."[154]

Smith also reported that the material was not concept-oriented, but descriptive and narrative in style at a rather sophisticated level. He concluded that the material was not well organized, lacked concept continuity, assumed unrealistic background, and had surprising omissions.

Kline[155] reported the reading level of the preliminary version to be quite variable, ranging from seventh grade to

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[153]Herbert A. Smith, "An Analysis of a Typical Instructional Unit in Junior High School Science to Determine the Explicit and Implicit Concept Loading Involved" (Ann Arbor, Michigan: University Microfilms, 1968).

[154]Ibid., p. 6.

[155]Loren Kline, "Eighth-grade Earth Science-Textbook Readability and other Factors Which Could Influence the Success of the Eighth-grade Science Course in Texas Public Schools" (Ann Arbor, Michigan: University Microfilms, 1966).

college, with an average level of eleventh to twelfth grade. He observed that the reading level of the second experimental edition of Investigating the Earth was reduced to a ninth-tenth grade level.

Qutub[156] also reported the 1967 text to have a reading level of 7.5 which indicated the textbook suitable for grades nine or ten. He further stated that the mathematics was not too difficult for grade nine, but recommended cooperation with the mathematics teachers to isolate and teach those mathematical processes necessary for ESCP.

Surveys Related to ESCP. Matthews[157] published the results of a survey in which the question, "At what level should earth science be taught?" was asked. He found that although earth science courses were offered in grades seven through twelve, it was commonly agreed that ninth grade was best. Matthews reported that science educators offered the following reasons for teaching earth science in grade nine:

1. Most of the material presented in the old "general science" course is now being taught in the lower grades. There is a distinct need for a somewhat more advanced science course for the ninth grade student.

2. A provocative, properly presented earth science course can introduce the student to the basic methods of scientific inquiry and investigation.

[156] Musa Y. Qutub, "The Objectives of the Earth Science Curriculum Project; An Evaluation of Their Achievement" (Ann Arbor, Michigan: University Microfilms, 1969).

[157] William H. Matthews III, "Current Status of Earth Science Programs in Secondary Schools," ESCP Newsletter, NL-2 (January, 1964), p. 2.

3. The typical ninth grader has acquired the reading ability necessary to comprehend basic earth science concepts and to master the required vocabulary.

4. Earth science is the ideal medium for illustrating the interdependence of the various basic sciences in the study of the earth and space.

Two student surveys were conducted by the ESCP staff in 1967 and 1968.[158,159] (Appendix B, page 197.)

The data suggested certain agreements as well as disagreements. While students indicated a preference for astronomy in 1967, they changed to a preference for meteorology and geology in 1968. Both groups indicated some desirability for paleontology. The 1967 survey showed a preference for laboratory investigations relating to mapping while the 1968 survey indicated a preference to the "messy" investigations. Students generally requested the same or more laboratory. Generally laboratory reports were considered acceptable, mathematics background was sufficient, and study time was equal to that in other subjects. It was of interest to note that in 1967 the great majority expressed they would recommend this course to a friend. While most students hoped to attend college between thirty-five and fifty percent indicated a preference for a science major.

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[158]"Students Complete ESCP Questionnaires," ESCP Newsletter, NL-13 (February, 1967), pp. 11, 12.

[159]"Students Questionnaire," ESCP Newsletter, NL-17 (October, 1968), p. 3.

A survey of teachers using ESCP was conducted in 1968.[160] Of the 459 returned questionnaires 389 teachers indicated they were using Investigating the Earth as their primary text. Two-thirds of those surveyed showed a master's level of academic achievement. Biology and geology were listed as the disciplines of greatest strength. The average teaching experience was between nine and ten years of which an average of two years had been spent teaching earth science. Forty percent of the teachers indicated average class size to be twenty-five or less. Eighty-two percent of the teachers had class periods between forty-five and fifty-five minutes in length. Three-fourths of all teachers indicated excellent to satisfactory facilities. Over one-third of the teachers were teaching chapters sixteen through eighteen at the time of the April 15th survey. Few had omitted six or more chapters at that time. Seventy-five percent had omitted one or more investigations. Only sixteen percent had rearranged the order of investigations or chapters in any significant way.

Summary of Studies

A search for studies related to ESCP showed that ten research studies and several questionnaires had been produced. The ten research studies and four surveys were reported in this review. Six of the research studies were concerned with

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[160] "Teacher Questionnaire," ESCP Newsletter, NL-17 (October, 1968), p. 6.

student achievement. Five made comparisons between students studying ESCP and students studying some other earth science or earth science-physical science course. Three studies, those by the Psychological Corporation, Shirner's, and Paull, Larson, and Vanden Avond, observed significant achievement difference favoring ESCP students. Two studies, one by Champlin and Hassard and one by Mooney, observed no significant achievement differences between experimental and control groups.

The two studies that compared ESCP directly to traditional earth science courses were The Psychological Corporation Study and the Champlin and Hassard Study. The former reported a cautious difference in favor of the ESCP groups, while the latter reported no significant differences using a smaller sample.

The studies by Schirner and Sargent dealt with teacher variables. Sargent's findings showed a correlation between student achievement and teacher background in professional education courses. Shirner's findings indicated a correlation between teacher's values and verbal behavior, and student achievement. Both studies indicated that the combination of the right curriculum with the appropriate teacher was an important factor in influencing student outcomes.

Paull concluded that ESCP was an effective program for improving scientific understandings and abilities in students. He suggested that teacher academic preparation was important for student outcomes. Mooney found that ESCP could adequately replace a one year course emphasizing earth science and physics.

Two studies examined Unit IV "The Earth and the Universe" from the trial edition. Sonnier determined that college astronomy courses provided adequate background for teachers of ESCP and that the more formal astronomy courses a teacher had in his background, the more independent he became in gaining new astronomy knowledge. Smith concluded that the reading comprehension level and sophistication of information were both too difficult for the Junior high school student.

The studies of Kline and Qutub indicated that the reading level of the 1967 text was satisfactory for ninth or tenth grade students. Matthew reported a survey suggesting ninth grade as the best level for implementing ESCP.

The results of two student surveys were reported. Students responded to questions relating to selection of topics in the textbook which were easiest and more interesting, as well as, those investigations enjoyed most. Other information related to laboratory reports, mathematics in science, study time, report card grades, and "would you recommend this course to a friend?"

The teacher survey revealed a high academic level for ESCP teachers. Other criteria for good teaching such as experience, class size, class time, and facilities seemed very adequate. It was of interest to note that even though many teachers found the text too extensive for total coverage, few omitted chapters, while many omitted investigations, and few attempted to rearrange the course of study.

The Science Processes

It has been estimated that scientific knowledge doubles from the time a child advances from kindergarten to high school.[161] Since this knowledge is accumulating at such a rapid rate it is impossible for any human, including scientists, to keep up-to-date. Certainly it is beyond the scope of the educational enterprise to teach children all there is to know about science.[162]

One strategy that has received increasing emphasis this past decade, is an attempt to equip the child with skills he can use to find solutions to scientific as well as related problems he may encounter in the future.

Science--A Process Approach[163] (SAPA) set as one of its major objectives the goal of equipping each child with competence in the processes of science. These processes provide the child with an ability to define and solve problems. Since the child will be living in a society increasingly

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[161]Paul DeHart Hurd and James Joseph Gallagher, New Directions in Elementary Science Teaching (Belmont, California: Wadsworth Publishing Company, Inc., 1968), p. 2.

[162]James T. Robinson, The Nature of Science and Science Teaching (Belmont, California: Wadsworth Publishing Company, Inc., 1968), pp. 6-9.

[163]Science--A Process Approach: Commentary for Teachers, American Association for the Advancement of Science (New York: Xerox Corp., 1970), p. 11.

influenced by scientific and technological progress, he needs skills necessary to exercise good judgment as an adult in this society.

The Carman School District, Flint, Michigan, adopted Science--A Process Approach as its elementary science curriculum (K-6) beginning fall 1968. SAPA was introduced into kindergarten, one, and two, and plans were made to continue the program by adding a grade each year until all grades were included. Since SAPA had become a part of the Carman District, it was deemed advisable to consider the thirteen processes of Science--A Process Approach as the criteria for judgment of capability in this study.

The Basic Science Processes[164]

1. Observing. Observing, the most basic process of science, uses the five senses to obtain information about objects and events.

2. Using Space/Time Relationships. This process develops skills in the description of spacial relationships and their change with time. Included are studies of shapes, symmetry, motion, and rate of change.

3. Classifying. Classifying is the process used to impose order on collections of objects and events.

Classification systems follow three important principles: They are designed to be useful; they are arbitrary;

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[164] Ibid., pp. 33-125.

and any groups of objects or events can be classified in more than one way.

4. Using Numbers. The inclusion of this process in SAPA is somewhat unique because it is usually included only in a mathematics curriculum. It is included here to help students realize that the ability to use numbers is a basic and fundamental process of science; and to give pupils an opportunity to use numbers in finding answers to scientific questions in real problem situations.

5. Measuring. Closely related to using numbers is the process of measuring. Modern science programs emphasize the use of metric measurement. The student becomes competent in linear, area, volume, weight, mass, and heat measurements.

6. Communicating. Communicating is a process of all human endeavors. In science it may be with oral and written words, diagrams, graphs, maps, mathematical equations, and various kinds of visual demonstrations.

7. Predicting. A prediction is a specific forecast of what future observations will be. Long and continued observation of natural phenomena has led man to conclude that the universe is not capricious. One therefore predicts that the physical relationships inferred will continue to apply in the future.

8. Inferring. "Nothing is more fundamental to clear and logical thought than the ability to distinguish between observation and inference.... An observation is an experience

that is obtained through one of the senses. An inference is an explanation of an observation."[165]

<u>The Integrated Scientific Processes</u>[166]

The basic processes provide a foundation for the integrated processes. Integrated processes involve one or several of the basic processes in their development. It may also be shown that one or more integrated processes unite with the basic processes to develop a more complex integrated process.

1. Controlling Variables. When proceeding with scientific investigation one must intently scrutenize all possible variables. Only when all variables have been identified and carefully controlled can one speak with authority about results. Three kinds of variables are usually identified: constant, manipulative, and responding.

2. Interpreting Data. Interpreting data can be divided into three areas. One part is primarily concerned with data to make inferences, predictions, and hypotheses. Another part deals basically with developing skills in the use of statistical measures of central tendency (mean and medium) and variation (range). The third part develops skills in the use of probability.

3. Formulating Hypotheses. SAPA defines a hypothesis as a generalization that includes all objects or events of the

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[165] <u>Ibid</u>., p. 117.

[166] <u>Ibid</u>., pp. 129-176.

same class. Hypotheses may be formulated on the basis of observation or inference.

4. Defining Operationally. Operational definitions can be considered from the standpoint of use and formulation. Their use is found when testing hypotheses or inferences and their formulation in the construction of them. Physical scientist state operational definitions in the sense of "what you do and what you observe."

5. Experimenting. This final process encompasses all the basic and integrated processes.

Summary

The review of literature was divided into four parts. Part one dealt directly with a review of curriculum development. Subjects treated were the history of curriculum thought and practice, the development of science curricula, a theory of science curriculum development, a history of earth science, and background information to Earth Science Curriculum Project (ESCP).

The review of literature that related to a historical perspective of science education indicated that much of what is considered appropriate and novel today had its roots in earlier times. Three periods of curriculum development were identified in twentieth century literature: subject-centered curriculum, 1890-1930; child-centered curriculum, 1930-1950; and a second subject-centered curriculum, but with emphasis on structure of the discipline, 1950-1970. When tracing the development of science curricula since 1800 a progression of movement such as object teaching, nature study, science as a learned discipline, science for happy living, and science as a structural discipline could be included.

Of particular importance to this study was the recognition of process as an integral part of the science structure. Process, as well as product, the verbalized knowledge aspect of science, gave rise to a perception and understanding called "structure of science." Structure gave rise to selection of a small number of significant conceptual schemes which were then used to give unity to the subject, and from which supporting concepts and processes were hung.

This study focused on a particular innovative science program, the Earth Science Curriculum Project. ESCP had experienced phenomenal growth since its conception in 1962. It presented a multi-discipline approach to study of the earth. It presented a student experience-oriented approach which emphasized inquiry, discovery, and interpretation of student-obtained data.

A discussion of curriculum evaluation formed part two of the study. A review of literature related to ESCP was developed in part three. Studies suggested that ESCP might possibly be a better program for teaching earth science, but teacher and/or student variables were an equally significant factor to be considered.

Part four presented a brief definition of the thirteen processes included in Science--A Process Approach.

CHAPTER III

FEATURES OF THE STUDY

Design of the Study

As stated in Chaper I, the purpose of this study was to develop a set of procedures to serve as a guide for measuring the impact of curriculum implementation, which would be adaptable by most school districts for many school subjects. The writer intends that this guide be sufficiently comprehensive to present an adequate picture of how a new curriculum affected the student body, and yet be simple enough so it could be utilized by a school district whose chief manpower for evaluation was that of teachers and curriculum director.

When planning this study consideration was first given to an approach in which control groups with multiple treatments over several populations would be utilized. Such an evaluation technique assumed that newly implemented curriculum and former curriculum had the same stated goals and therefore identical measures could be administered to the two populations. It further assumed that the population with the higher score could be judged as having the better curriculum. Certainly they might be different. However, it would be extremely hazardous to judge one curriculum better than another from such evidence. Comparison of several of the new programs with traditional curriculum quickly demonstrated this. These innovative programs presented drastically different goals than former curricula. Therefore the concept of better appeared to be inappropriate using these criteria. One rather needed to search the literature for opinions of what experts considered preferred aims of a discipline area. One then needed to choose a program that purported to highlight these preferred goals, and test to see how such a program was actually affecting the student population.

It therefore became the major thrust of this study to attempt such a set of procedures, with the expectation that the guide could be utilized by future curriculum evaluators at the local school district level.

As stated in Chapter I the selection of the student as the unit of analysis reduced the validity of this study since there necessarily was interaction between students within each classroom. Conditions within the Carman School District did not allow individual classrooms to become the unit for analysis. It should also be stated that a major concern in this study was to look at individual differences between students. Using the classroom as the unit of analysis would not have allowed this kind of investigation.

Development of the guide covered three general stages.

1. In order to determine how the curriculum might affect the target population, various areas within the subject

discipline were analyzed as possible regions for evaluation. Selection of interest areas was dependent upon major characteristics of the curriculum program. Once the interest areas were chosen, measures were constructed for administration to the students. Whenever possible, prepared measures which were readily available and commonly known were used.

Carman teachers reported their previous earth science program produced negative attitudes in students. ESCP was proposed as a curriculum that would generate student enthusiasm, raise attitude levels toward the subject, and generally produce a happier, more congenial classroom situation. A test of attitude toward science was chosen to determine whether this hypothesis appeared valid. Various attitude scales were surveyed. A scale developed for measuring attitude toward any subject was used since it appeared sufficiently simple for junior high students and yet demonstrated a high reliability (Chapter III, pages 104 to 106).

The last decade has seen an increasing interest in science as process. The emergence of process as an integral part of science was marked as one of the outstanding developments of this latter half century. In line with this trend, ESCP has also emphasized the processes, as well as the products of scientific endeavor (Chapter II, page 61). It was further noted that Science--A Process Approach had been introduced as the K-6 program within the Carman School District. In view of these observations a measure of student achievement in science process skills was considered vital.

TOSK I and II (Chapter II, page 71) were considered for use as measures for testing achievement in process skills. Neither measure qualified. TOSK I measured general basic factual information in all areas of general science and TOSK II measured understanding of both scientific principals and methods. It was therefore decided to construct a new instrument. This writer therefore chose to adapt from two adult measures and one elementary measure of process that were available (Chapter III, pages 106 to 108).

As stated previously, ESCP listed as part of its overall objectives the development of organized scientific information (Chapter II, pages 61 to 62). Teacher evaluation of Carman students was measured largely on this criterion during the 1970-1971 school year. Objectives as expressed by Carman teachers reflected content as a major concern. It was considered necessary that a measure of content understanding be included in the study.

Four measures of verbalized knowledge were available for use in this part of the study: TOSK I and II, a Comprehensive Final (Chapter III, page 111), and Five Unit Achievement Tests (Chapter III, page 109). As stated before, this writer attempted to use materials readily available and commonly known. TOSK I and II did not fit this description. They also failed to meet those specific requirements needed for a test of understanding of earth science concepts. Since the latter two instruments were included in the teacher guide they received preference. The ESCP Comprehensive Final was specifically designed as a post-test. Its use as a fall pre-test would be suspect. The Five Units Achievement Tests were chosen since it appeared they would serve well as a pool from which questions could be selected for a single achievement instrument. This measure would discriminate well yet could be used as both a pre- and post-test.

It was of interest to this investigator to compare the Carman students' achievement with some standard. A national sample taken in 1964-1965 by the Psychological Corporation (Chapter II, pages 68 to 73) provided such an opportunity. At this time the Comprehensive Final mentioned above was used. Therefore the Comprehensive Final used by this group was administered to the Carman students at the end of the year.

2. The second stage required selection of variables to be built into the test design. Those were selected which showed promise as indicators of strengths and weakness among the student body.

ESCP is an innovative approach to teaching earth science. However the ESCP treatment of subject matter is at a rather sophisticated level of understanding. Individual entering behaviors seemed a possible significant variable. Since the Carman District had no records of achievement, attitude, or I.Q. for their students, it was decided to use grade point average in science from the previous year as a distinguishing variable for this entering behavior.

Another consideration related to sex. The Psychological Testing Corporation study suggested higher performance for boys than for girls (Chapter II, page). Carman teachers regarded sex as a possible significant variable within their student population. It was therefore decided that sex differences should be considered.

Studies by Paull, Shirner, and Sargent (Chapter II, pages 76 to 79) suggested the teacher variable as important. Teaching style, experience, and academic background were listed as possible factors. It was therefore of interest to determine if evidence could be obtained to indicate teacher differences as factors affecting student change in the Carman School District.

3. The last stage was designed to interpret test results in a diagnostic manner. A list of kinds of information that might be useful to help diagnose the results was developed. Various survey instruments were constructed to gather the required information.

Since the teacher variable might be affected by such factors as teaching approach, experience, and academic background, instruments were designed to gather probable significant data. This investigator was limited to the amount of time he could spend in direct classroom observation. Therefore, instruments were designed to help interpret daily classroom routine. Since processes are an important part of an inquiry-orientated science program evidence was gathered to assess exposure to these processes. Other relevant information was solicited through the use of end-of-year questionnaires.

Some General Components Affecting the Carman School District

The Carman School District, Flint, Michigan was a middle classed, principally blue collared, white community lying within the boundaries of the Flint School District. Major industries within the area generally related to automobile production.

During the previous school year the junior high population had been housed in three widely separated buildings. A major millage proposal was defeated by the constituents of the District five weeks prior to opening of classes in 1970. This reduction of funds forced the District to close its junior high school buildings and move into the two senior high schools. The two high schools will be coded Y and Z during the remainder of this report. These were put on half day schedules with grades ten through twelve meeting in the morning and grades seven through nine meeting during the afternoon.

An additional problem faced the District when budget requirements forced the release of almost one hundred teachers, kindergarten through grade twelve. Determination for dismissal was based upon teacher seniority, resulting in some teachers being asked to instruct in disciplines for which they were not effectively trained.

Population. The eighth grade students of the Carman School District, 1970-1971, who participated in the Earth

Science Curriculum Project (ESCP) program, formed the population for this study. The group consisted of a total of 634 students in 23 classes under the direction of seven teachers. The sub-population from which samples for analysis were chosen consisted of 194 students under the direction of five teachers. Eighty-four students were selected for analysis on three measures across time, and 179 students participated in an analysis on a single post-measure. A further discussion of these samples is found on pages 112 to 114 and page 116.

Selection of Textbooks. The Earth Science Curriculum Project (ESCP) was developed by the American Geological Institute to facilitate learning of earth science at the junior high level. Project materials included a teaching package consisting of manipulative apparatus, visual aids, and various models. These materials were integrated with the textbook, *Investigating the Earth*,[1] to form a teaching unit in which laboratory investigations were related to textual presentation.

Each earth science teacher at schools Y and Z had sufficient copies of *Investigating the Earth* for classroom use only. Two Carman teachers also had sufficient copies of *Modern Earth Science*[2] for classroom use. While these two

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[1] *Investigating the Earth*, *op*. *cit*.

[2] William L. Ramsey and Raymond A. Burckley, *Modern Earth Science* (New York: Holt, Rinehart, and Winston, Inc., 1965).

series could be considered basic texts, it should be understood that students used them as classroom references to supplement lecture and demonstrations, and to aid investigations.

Selection of Classes. Eight persons taught earth science in two buildings. Five teachers were chosen to participate in the study. Three of the five had participated in an earth science summer workshop at Michigan State University during the summer of 1970 and had prior experience teaching earth science. One of these three had piloted ESCP during the previous year. Two of the five did not participate in the workshop. One had prior experience and was doing graduate work in earth science. This teacher, and the teacher who had piloted the program, elected to use Modern Earth Science as the major student reference and Investigating the Earth as supplemental. Laboratory experiences were generally chosen from Investigating the Earth to enable the students to use the classroom ESCP kits.

The fifth teacher had no previous experience with earth science, but was selected because she had taught biology the two previous years and held a master's degree. Three teachers were omitted from the study, one because he was a music instructor transferred to earth science, another because it was originally planned that he would assist on a part-time basis, and the eighth since he preferred not to teach using ESCP.

From the remaining twenty ESCP classes seven were chosen to participate in the study. One class was selected from each of the teachers using Modern Earth Science and the remaining five classes from Investigating the Earth. Four classes were selected from Y and three from Z. This decision was based upon a consideration of distribution of students between the two buildings, academic background of teachers, teaching experience, number of classes taught and basic textbook used.

Distribution of these seven classes was arbitrary within the limits stated above. No attempt was made to select classes based upon student ability or teacher performance. A schedule that encompassed the total school day was used as the criterion. Table 3.1 shows the distribution of the 194 students in the seven classes included in the sample.

The Gates MacGinitie Reading Tests and the Otis Quick-Scoring Mental Ability Tests were administered to all classes in the sample during February, 1971 to assess student levels in reading and I.Q. Student responses indicated a mean vocabulary reading level of 8.0 and a mean comprehension reading level of 7.5. The mean I.Q. for the group was 105.

Description of Classrooms. Classrooms A and B were portable "trailer-house" units placed within close proximity to the main building. These small teaching units provided no sink or water supply and had no tables for group work or laboratory investigations. An office desk near the front of the room served as the teacher desk. Chalkboard space was minimal.

TABLE 3.1

DISTRIBUTION OF CLASSES USED IN ESCP EVALUATION
CARMAN SCHOOL DISTRICT, FLINT, MICHIGAN,
1970-1971

	High School Y			High School Z	
	Room				
	A	B	C	D	C
First Hour	A M* 23#				
Second Hour		B M 23			
Third Hour			C_1 I** 25	D_1 1 29	
Home Room					
Fourth Hour			C_2 I 32		E 1 34
Fifth Hour				D_2 1 28	

Note: Capital letters A through E indicate teacher and classrooms
C_1, C_2 same teacher
D_1, D_2 same teacher
*M indicates <u>Modern Earth Science</u>
**1 indicates <u>Investigating the Earth</u>
#numeral indicates student enrollment
Average class time--42 minutes
Average class size--27.7

Classroom C was a seventy-five student, theater type, lecture hall. Laboratory sessions for this classroom were held in a well-equipped high school chemistry laboratory across the hallway.

The fourth classroom, D, housed eight work tables with chairs. A teaching laboratory table with sink was located at the front of the room and a preparatory alcove lay adjacent to it. The fifth classroom, E, was similar to D, but had no teaching laboratory table.

Each classroom was provided with its own set of ESCP kit materials and texts. Each room was to have had texts for reference, although these proved to be inadequate.

Experimental and Descriptive Phases of Study

This investigation involved two distinct phases. Part one of the experimental phase required administration of pre- and post-tests to determine student change following treatment. Variables related to student scholastic ability in science, student's sex, and teacher-classroom differences were considered on three measures over time. Part two of the experimental phase used a single instrument during the last week of school.

The second phase employed the use of questionnaires and teacher-logs. This descriptive phase attempted to survey text content covered, teacher reactions, analysis of science process skills, teacher background, and student reactions.

Experimental Phase--Discussion of Instruments. Late in August 1970, the investigator met with administrative personnel to discuss the implementation of evaluation techniques for eighth-grade ESCP students. A subsequent meeting which included ESCP teaching personnel suggested a tentative calendar for testing. The following measures were administered as pre- and post-test during the research:

1. Attitude Toward Science,
2. Process Measure for Junior High School Students, and
3. ESCP Achievement Test.

Attitude Toward Science. To ascertain student attitude toward science the writer adapted a generalized master scale developed by Silance and Remmers.[3] This scale was designed to measure attitude toward any school subject (Appendix C, page 200). It was based on the premise that valid measurement, on a single scale, could be made of attitudes toward any large class of objects.

The scale values made use of the Thurstone[4] equal-appearing-intervals whereby an eleven point scale extended from complete agreement to complete disagreement.[5] However,

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[3]H. H. Remmers and N. L. Gage, Education Measurement and Evaluation (New York: Harper and Brothers, 1954), p. 437.

[4]Louis L. Thurstone and Ernest J. Chave, The Measurement of Attitudes (Chicago: University of Chicago Press, 1929), p. 96.

[5]Marvin E. Shaw and Jach M. Wright, Scales for Measurement of Attitudes (New York: McGraw-Hill Book Company, 1967), p. 293.

the scale differed from that of Thurstone's in that a random order of statements was not used. Instead, the statements appeared in a descending arrangement from highly favorable to highly unfavorable.

Two equivalent scale forms were produced. Each form was available as a forty-five or seventeen item scale. The investigator chose to use one form of forty-five items for both the pre- and post-tests since Shaw[6] considered these forms more reliable than the shorter forms. It was not considered beneficial to use equivalent forms since the time span between pre- and post-tests was over seven months long, and students did not see the results of either measure.

Reliabilities for the scale were reported for the following courses: biology, .81 (N-260); chemistry, .71 (N-771); English, .68 (N-705); mathematics, .74 (N-579).[7] Bolton (1938)[8] validated this scale using criterion groups measured for interest and values. Strunk (1957)[9] advanced some evidence of concurrent validity when he obtained a correlation of .39 between this scale and scores of 130 subjects on a graphic rating scale of expression of interest in a psychology course.

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[6] Ibid., p. 294.

[7] Ibid., p. 294.

[8] E. B. Bolton, "The Measurement of Attitudes Toward Mathematics," Psychological Monograms, L (1938), pp. 155-182.

[9] O. Strunk, Jr., "Attitude Toward Psychology as a Factor in the Judgment of Readability of a Psychology Textbook," Proc., W. Va. Academy of Science, XXIX (1957-1958), pp. 175-179.

The name of the attitude object, in this case science, was placed at the top of the scale. Adaptation was limited to changing certain words or phrases to be more suitable for junior high students.

The student responded by placing a check mark (✓) next to each statement with which he agreed, a cross (x) next to each with which he disagreed, and question mark (?) by each for which he was uncertain. Scoring was accomplished by determining the median of the scale values endorsed by the respondent.

The Process Measure for Junior High School Students. This measure (Appendix D, page 206) was adapted by the investigator using portions of "Science Process Test for Elementary Teachers,"[10] "Science Process Measure for Teachers," Forms A and B,[11] "Individual Competency Measures,"[12] and questions developed by the writer.

Ten questions were adapted from the "Science Process Test for Elementary Teachers." This unpublished test was a forty item multiple choice test designed to measure process skills such as those emphasized in Science--A Process Approach.

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[10]Evan A. Sweetzer, "Science Process Test for Elementary Teachers" (3rd Edition) mimeographed (East Lansing, Michigan: Science-Mathematics Teaching Center, Michigan State University, 1968).

[11]Science Process Measure for Teachers, Forms A and B (Washington, D.C.: American Association for the Advancement of Science, 1967).

[12]Unpublished tests developed by Darrel W. Fyffe and Richard Robison (East Lansing, Michigan: Michigan State University, 1970).

Sweetzer reported an item analysis for two groups of experienced teachers.[13] The Kuder Richardson reliability coefficient for the first group of forty-nine was 0.65. The reliability for the second group of one hundred thirteen was 0.76.

"Science Process Measure for Teachers" was an instrument designed to evaluate teachers who participated in <u>Science--A Process Approach</u> workshops. It attempted to measure teacher's ability to understand the eight basic processes defined in the program.[14] This instrument differed from the usual evaluation since it required the respondent to actually work through examples of processes rather than simply indicate a correct response to a multiple choice. It was therefore assumed such a measure would display a truer dimension of the teacher's understanding of the processes. A major portion of the investigator's instrument was adapted from these tests.

The "Science Process Measure for Elementary School Children" was developed by two doctoral students as an attempt to create multiple choice test questions for the integrated

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[13]Steven M. Barnes, "The Reactions of Selected Elementary Teachers to the Training for and Implementation of Science Curriculum Improvement Study in Selected Schools in Michigan" (unpublished Ph.D. dissertation, College of Education, Michigan State University, 1969), p. 56.

[14]A detailed description of the thirteen processes is found in Chapter II, pages 86 to 90.

science processes as defined by Science--A Process Approach.[15] These questions were administered to elementary children from the greater Lansing, Michigan, area, and analyzed for difficulty and discrimination. This information was used by the writer when selecting questions for the Carman students.

The writer's process measure, a partial compilation of parts of the above mentioned tests, attempted to solicit the strongest aspects from each of them. It was decided to construct and administer a single form of the measure because of the time lapse between tests. A reliability coefficient of .87 and .78 was established for the pre- and post-tests respectively using the following formula:

$$r = \frac{MS_R - MS_{RC}}{MS_R}$$

r = reliability coefficient

MS_R = mean square subjects

MS_{RC} = mean square interaction between subjects and test items.[16]

Content validity was established as satisfactory by presenting measure to Dr. Clarence Nelson, Director of Evaluation Services, Michigan State University, for examination.

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[15]Based on information obtained from Dr. Glen Berkheimer, Michigan State University, East Lansing, Michigan, in an interview October, 1971.

[16]C. J. Hoyt, "Test Reliability Estimated by Analysis of Variance," Psychometrika, VII (1941), pp. 153-160, as found in William A. Mehrens and Robert L. Ebel, Principles of Educational and Psychological Measurement (Chicago: Rand McNally and Company, 1967), p. 111.

ESCP Achievement Test. A seventy question, multiple choice, ESCP Achievement test (Appendix E, page 229) was developed by the investigator from the five "Unit Achievement Tests" located in the ESCP Teacher's Guide.[17] These measures were developed for use at the end of each teaching unit of Investigating the Earth by the Psychological Testing Corporation, New Jersey. Each measure consisted of between forty-seven and seventy-one multiple choice questions. To help interpret the students answers, each item included a response analysis, showing a "p" value indicating difficulty and an "r" value indicating discrimination. In this paper item difficulty was stated in percent of respondents indicating correct answers.

The authors of Investigating the Earth, Teacher's Guide suggested that as a "general rule of thumb" items discriminating at a level of .30 or lower should usually be replaced. Therefore any items with a discrimination level of .30 or less were eliminated from the tests. The five unit tests were originally designed to be administered immediately following teaching of a unit. Carman District students were tested in fall and spring. The fall pre-test was given before treatment and the spring post-test after a completed year of treatment. This meant that in the pre-test all questions related to material studied months before. Concern for item difficulty

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[17] Teacher's Guide, op. cit., pp. 345-381.

therefore became important. If items were too difficult validity would be affected. It was therefore deemed advisable that no item be chosen with a difficulty level less than .50. All questions with a difficulty level of less than .50 were eliminated.

After a careful analysis of the text, Investigating the Earth, and the remaining items in the five unit tests, a selection was made of questions to be included in the ESCP Achievement Test. Items were chosen so each section of the student text received equal representation. Within each section items of least difficulty received preference for selection. Care was taken that no question paralleled other items in content measured. When this did occur the next least difficult question was chosen. One item needed to be selected with a difficulty level of less than .50 because enough satisfactory questions were not included. Two items were eliminated even though the "p" value was highest because in the opinion of this investigator they were too ambiguous.

One might well question the advisability of using the least difficult items since they may tend to ask for information of a lower level of understanding. The author weighed this point of view and concluded that difficulty was of a more immediate concern because difficult questions would probably be nothing more than multiple "guess" questions and therefore reduce any discrimination between students.

Table 3.2 shows a partial appraisal of the ESCP Achievement Test following administration of both the pre- and post-test to 84 students.

TABLE 3.2

APPRAISAL OF ESCP ACHIEVEMENT TEST

	Pre	Post
Kuder Richardson Reliability No. 20	.7806	.8671
Standard error of measurement	3.8406	3.8343
Mean item difficulty	61	57
Mean item discrimination	28	37

ESCP Comprehensive Final. This measure was developed by the Psychological Testing Corporation as the final examination for ESCP (Appendix F, page 242). It was similar to the ESCP Achievement Test described above, for it attempted to sample student understandings over the entire year. The measure was used as written by the Psychological Testing Corporation. It was chosen as part of the evaluation because data of student results was available for comparison from a national sample taken in 1964-1965 (Chapter II, page 73). It was administered by this investigator to the seven sample Carman classes during the final week of the school year, 1970-1971. Table 3.3 shows a partial analysis of the final after administration to 179 students.

TABLE 3.3

PARTIAL ANALYSIS OF ESCP COMPREHENSIVE FINAL, CARMAN, 1971

Kuder Richardson Reliability No. 20	.6181
Standard error of measurement	3.1514
Mean item difficulty	69
Mean item discrimination	24

Experimental Phase--Design of Study. The first three tests were administered during consecutive weeks in October, 1970 and May 1971. This writer supervised the administration of the tests to assure uniform measuring for all classes whenever possible. After administration of the pre- and post-tests a count was made of students who had responded to all six testing situations. Each classroom was considered individually. The students in each classroom were divided into two groups based upon the previous year's science grade as follows: high GPA--A, B, students; low GPA--C or lower students. These two groups were then further reclassified by dividing each into subgroups based upon sex. Four groups, as shown in Table 3.4, were identified for each classroom (high - male, high female, low male, low female).

It was observed from Table 3.4 that the largest "N" available for these subclasses was three. Students from subclasses numbering greater than three were chosen using a table of

TABLE 3.4

DISTRIBUTION OF CARMAN STUDENTS WHO RESPONDED TO ALL SIX TESTING SITUATIONS SHOWING GRADE POINT AVERAGE AND SEX AS DETERMINED BY SEVENTH YEAR SCIENCE GRADE

Classroom	High GPA	Male	Female	Low GPA	Male	Female
A	8	5	3	6	3	3
B	9	3	6	6	3	3
C_1	7	3	4	8	4	4
C_2	11	8	3	15	11	4
D_1	10	6	4	11	5	6
D_2	10	4	6	11	3	8
E	10	4	6	13	8	5

random numbers. Thus each subclass had three respondents and each classroom twelve respondents producing a sample of eighty-four students for analysis. Table 3.5 shows the design for analysis of hypotheses one through five.

The second question identified in Chapter I of this study was to measure success of ESCP in the Carman School District through use of three measures showing (1) attitude toward science, (2) attainment of science process skills, and (3) increased knowledge of science content. One general hypothesis was proposed for this part of the study.

1. There will be no differences between composite pre- and post-test scores for the three instruments

TABLE 3.5

MATRIX SHOWING DESIGN FOR HYPOTHESIS ONE THROUGH FIVE

Classroom	Grade point average from seventh-grade science	Sex	Student	Attitude		Process		Achievement	
				Pre	Post	Pre	Post	Pre	Post
A	High	Male	R_1 R_2 R_3						
		Female	R_4 R_5 R_6						
	Low	Male	⋮						
		Female	R_{10} R_{11} R_{12}						
⋮	⋮	⋮	⋮						
E									

measuring student attitude toward science, student understanding of science process skills, and student achievement of science knowledge.

Questions had been raised regarding relative difficulty of ESCP at grade eight level. Faculty and administration showed concern whether all eighth-grade students had sufficient entering behaviors to show significant gains when using ESCP. A third and fourth question identified in Chapter I attempted to measure grade point average in science from the previous year and sex as effective predictors of change. Hypothesis two and three spoke to this purpose.

2. There will be no differences between composite pre- and post-test scores for the three instruments measuring student attitude toward science, student understanding of science process skills, and student achievement of science knowledge as determined by grade point average in science from the previous year.
3. There will be no differences between composite pre- and post-test scores for the three instruments as determined by sex.

Two classrooms used Modern Earth Science as the basic reference. Teachers varied greatly as to experience and academic preparation. Classroom enrollment and facilities differed considerably. A fifth question considered performance between classrooms. The following hypothesis addressed itself to this concern.

4. There will be no differences between composite pre- and post-test scores for these three measures as determined by classroom.

A fifth hypothesis was tested to determine any interactions between variables stated in hypotheses two, three, and four.

5. There will be no interactions between grade point average, sex, and classrooms as indicated by the three measures.

The sixth question attempted to compare the Carman School District ESCP students with a national sample taken in 1964-1965. All students from the seven sample classes were to participate in this part of the study. Hypothesis six addressed itself to this purpose.

6. There will be no differences between the Carman School District eighth-grade ESCP students and eighth-graders from a national norm as determined by the Comprehensive Final during the 1964-1965 ESCP trial period.

Experimental Phase--Analysis of Data. To analyze data collected during the experimental phase, the writer selected two statistical treatments. These treatments clarified some aspects of the study and tested the hypotheses stated previously in this chapter. Hypotheses were rejected when the value of an F-test exceeded the .05 confidence level.

A multivariate analysis of different scores (MANODS) was used to determine whether any significant changes occurred across attitude toward science, science process skills, and science knowledge when taken together. The purpose of this test was to reveal if significant changes had occurred during the ESCP program. Since course objectives related to these three aspects of student behavior, significant gains in all three might suggest a successful program. In addition, univariate analysis of each of the measures could suggest aspects of strengths and weaknesses. A basic limitation to the validity of this analysis was an assumption that the test-retest reliability for each instrument was equal to one. To the degree that this assumption was met the analysis was valid. This analysis was best suited for interpretation of hypothesis one as stated on page 113 of this chapter.

A multivariate analysis of covariance (MANCOVA) was selected for use in analyzing the data relevant to testing hypotheses two, three, four, and five as stated on pages 115 through 116. The above limitations stated for MANODS were not applicable to MANCOVA. It statistically controlled for initial differences on pre-test scores between groups on the three measures. Thus, the adjusted scores employed in the analysis reflected only differences in the final group means not accountable to differences in the initial group means. MANCOVA not only provided information required in testing for significant differences between groups subjected to the same treatments, but whether there were significant differences between group interactions as well.

The purpose of this test, then, was to reveal if factors such as grade point average from the previous year's science class and/or sex would successfully predict differences among students across the three measures, attitude, process, and knowledge, as well as, determine if differences existed between classrooms.

Scores related to hypothesis six were analyzed by comparing the Carman School District student mean with the national sample mean from 1964-1965.

Descriptive Phase--Discussion of Instruments. One technique frequently employed for gathering vital descriptive information about curricula was the use of surveys and questionnaires. Five instruments were designed by the investigator for this purpose: Teacher-log, Science Process Rating Scale, Teacher Questionnaire, Academic Background, and Student Questionnaire.

Teacher-log. To better ascertain the objectives and content of ESCP at Carman School District, the faculty was asked to supply information to daily questionnaires regarding material covered during three separate four-week intervals. In November, 1970, a memo was sent to all ESCP faculty informing them of this obligation (Appendix G, page 252).

The one page daily log (Appendix G, page 254) was designed to measure exposure to textbook content and laboratory skills, and evaluate student attitude. To facilitate identification of the laboratory skills definitions of the thirteen science processes as proposed in Science--A Process Approach (Appendix G, page 255) were included with each set of log sheets. Three recording periods were suggested:

November 16, 1970 through December 11, 1970
January 11, 1971 through February 5, 1971, and
March 1, 1971 through March 26, 1971.

During each of these four week periods respondents were asked to record a brief daily summary of the following:

1. general objective(s) for the day,
2. pages referred to in the text,
3. type of teaching approach(es) used,
4. time afforded the teaching approach(es),
5. (if a laboratory exercise) a rating of "exposure" to any of the thirteen science process skills applicable for the day,
6. a statement of results, and
7. a rating of students' attitude toward science for that class period.

Science process rating scale. A second questionnaire (Appendix H, page 259) was aimed exclusively at the thirteen processes as defined by Science--A Process Approach. Teachers were asked to determine "amount of exposure" on each of the processes over the total school year. Exposure was defined as a composite of time and emphasis given to each process during the laboratory experiences. Teachers were instructed to rate each process using a scale of one through three;

one indicating low exposure, two--average exposure, and three--high exposure. Teachers were further instructed to weigh each process in such a manner that a rating of two be forced as average. Thus the total of all ratings equaled twenty-six.

This scale, together with ratings included in the laboratory reports of the "Teacher Log," suggested the degree to which ESCP investigations provided opportunity for students to work with the thirteen processes as described by Science--A Process Approach.

Teacher questionnaire. A report summarizing the first year's implementation was submitted by the ESCP faculty in May, 1971 (Appendix I, page 261). Teachers were asked to comment on questions related to textbook, laboratory, schedule, students, difficulty, content covered, teacher time, facilities, and present observations, that could lead to course improvement. Thus, the questionnaire offered an opportunity to evaluate progress and submit criticisms and suggestions.

Academic background. Teachers submitted a summary listing of academic emphasis and teaching experience (Appendix J, page 268).

Student questionnaire. A questionnaire attempting to survey student reaction to certain aspects of ESCP was submitted as part of the spring testing sequence (Appendix K, page 270). Areas investigated included textbook difficulty, value of laboratory experiences, student likes and dislikes, as well as, suggestions for improvement. Students were asked to compare last years science with ESCP as to difficulty, enjoyment, report card grade, and decide if they would recommend ESCP to a friend.

Descriptive Phase--Analysis of Data. During the summer of 1971 all descriptive measures were tabulated. Summaries of teacher-logs were prepared. Teacher and student reactions were compared. When considered applicable, percent ratings were determined to assist evaluation.

Summary

This investigation involved an experimental and a descriptive phase. Part one of the experimental phase required administration of three sets of pre- and post-tests in the areas of student attitude toward science, achievement of science process skills, and understanding of science knowledge. Variables related to previous scholastic ability as measured by report card grades in seventh year science, sex, and teacher-classroom differences were considered.

Hypothesis one as stated in Chapter III was tested through a multivariate analysis of different scores. Hypotheses two through five as stated in Chapter III utilized a multivariate analysis of covariance.

Hypotheses were rejected when the value of an F-test exceeded the .05 confidence level.

Part two of this first phase compared the Carman School District students with a national sample on an end-of-year comprehension final. Hypothesis six as stated in this chapter related to this comparison.

The descriptive phase employed the use of five survey instruments. A teacher log presented a daily report of materials covered, approaches used, and attitudes observed. Teachers rated each of thirteen science process skills with regard to classroom emphasis. An end-of-year questionnaire to teachers and students attempted to solicit constructive criticism of the program. Teachers submitted a summary of their academic background and teaching experiences.

CHAPTER IV

ANALYSIS OF DATA AND RESULTS

The purpose of this chapter is to present the results obtained from the instruments used to collect student data as described in the experimental and descriptive phases of Chapter III, as well as, an analysis of the six hypotheses. Discussion of the three pre- and post-tests, Attitude Toward Science, Science Process Skills, Earth Science Curriculum Project (ESCP) Achievement Test, and ESCP Comprehensive Final are presented first. Presented next is the feedback information from the five survey instruments, Teacher Logs, Teacher Questionnaire, Evaluation of Science Process Skills, Teacher Background, and Student Questionnaire.

Experimental Phase--Analysis and Results of Data

The first hypothesis referred to overall changes as measured by student attitude toward science, aptitude in science process skills, and understanding of science content.

Ho_1: There will be no differences between composite pre- and post-test scores for the three measures Attitude Toward Science, Science Process Skills, and ESCP Achievement Test.

The results of the multivariate analysis of difference scores on these data produced an F ratio of 32.1520 with a probability of less than .0001. As stated in Chapter III all hypotheses were rejected when the value of an F-test exceeded the .05 confidence level. Therefore the null hypothesis was rejected (see Table 4.1, page 125).

Post hoc analysis suggested three univariate tests.

Ho_{11}: There will be no change in attitude toward science as measured by the pre- and post-test scores.

Ho_{12}: There will be no change in ability to perform science process skills as measured by the pre- and post-test scores.

Ho_{13}: There will be no change in achievement of science content as measured by the pre- and post-test scores.

Examination of Table 4.1 shows a probability of .0118 for hypothesis Ho_{11}, 0.0001 for Ho_{12}, and 0.0001 for Ho_{13}. Thus all hypotheses were rejected. A further analysis of test scores (Table 4.2) shows an overall negative change for attitude and an overall positive change for process and achievement.

Hypotheses two, three, four, and five were analyzed using a Multivariate Analysis of Covariance (MANCOVA).

By way of introduction to MANCOVA the most traditional statistics were included in Tables 4.2 through 4.5. Table 4.2, page 126, gave the means and standard deviation for tests two through five employed in the study. Table 4.3, page 126, provided an intercorrelation matrix of these same tests. Table 4.4, page 127, showed the least square estimates adjusted for covariates--effect times variables.

TABLE 4.1

SUMMARY OF MULTIVARIATE ANALYSIS OF DIFFERENT SCORES WHEN CONSIDERING PRE- AND POST-TEST SCORES FOR STUDENTS ON THE MEASURES: ATTITUDE TOWARD SCIENCE, SCIENCE PROCESS SKILLS, AND ESCP ACHIEVEMENT AS RELATED TO OVERALL CHANGE

	Mean Square Between	Mean Square Within	F Test	Probability
Multivariate Test	Degrees of Freedom--for hypothesis, 3; for error, 54			
All Measures			32.1520	0.0001*
Univariate Tests	Degrees of Freedom--for hypotheses, 1; for error, 56			
Attitude Toward Science	1683.0476	248.2024	6.7809	0.0118**
Science Process Skills	4983.4405	67.8214	73.4788	0.0001*
ESCP Achievement	861.4405	30.8095	27.9602	0.0001*

* Significant at the 0.0001 level of probability
** Significant at the 0.05 level of probability

TABLE 4.2

MEANS AND STANDARD DEVIATIONS FOR MULTIVARIATE ANALYSIS OF COVARIANCE

	Attitude		Process		Achievement	
	Pre	Post	Pre	Post	Pre	Post
Means	73.190	68.714	28.298	36.000	27.119	30.322
S.D.	16.911	20.216	9.572	9.249	6.010	7.066

TABLE 4.3

INTERCORRELATION MATRIX FOR MULTIVARIATE ANALYSIS OF COVARIANCE

	Attitude		Process		Achievement	
	Pre	Post	Pre	Post	Pre	Post
Pre Att	1.000					
Pst Att	0.653	1.000				
Pre Pro	0.121	0.289	1.000			
Pst Pro	0.115	0.307	0.618	1.000		
Pre Ach	0.088	0.203	0.494	0.607	1.000	
Pst Ach	0.153	0.260	0.376	0.560	0.650	1.000

TABLE 4.4

LEAST SQUARE ESTIMATES ADJUSTED FOR COVARIATES--
EFFECT TIMES VARIABLES

Variable Tested		Post* Attitude	Post* Process	Post* Achievement
GPA#	$M_{high} - M_{low}$##	-8.098171	-0.786591	3.953555
Sex	$M_{male} - M_{female}$	-4.698271	-0.436245	0.300773
Class				
A	$M_{c_1} - M_{c_7}$###	-2.167714	-0.386254	-3.025261
B	$M_{c_2} - M_{c_7}$	-7.193531	-1.299864	-6.147973
C_1	$M_{c_3} - M_{c_7}$	5.821509	-3.615002	-4.824734
C_2	$M_{c_4} - M_{c_7}$	1.806661	1.507906	-9.581579
D_1	$M_{c_5} - M_{c_7}$	-3.472009	0.381967	-2.159742
E	$M_{c_6} - M_{c_7}$	-8.368285	2.149103	-5.238041
D_2	M_{c_7}	0.000000	0.000000	0.000000

*All variables adjusted for covariates.
#GPA = Grade point average in science from the previous year.
##M = Mean score for group.
###c_1 through c_7 refer to classrooms A through E respectively.

Table 4.5, page 129, shows the standard errors of adjusted estimates--effects times variables.

When analyzing with MANCOVA, the first step was to determine if the covariates were in anyway related to dependent variables (pre-test related to post-test). This test was performed by a Chi Square for test of hypothesis of no association between dependent and independent variables (covariates). It was found that the relation was indeed significant at the 0.0001 of probability. The significant relationship between covariates and individual dependent measures indicated multiple correlation coefficients as shown in Table 4.6.

The regression equations that yielded the multiple correlation coefficients were located in Table 4.7, page 130. Given these regression equations the adjusted scores employed in MANCOVA took the form of the equations in Table 4.8, page 131.

Ho_2: There will be no differences between composite scores of the three measures, Attitude Toward Science, Science Process Skills, and ESCP Achievement, as determined by grade point average in science from the previous year.

Analysis of the tests (Table 4.9, page 132) showed an F-ratio of 3.8540 and a probability of 0.0145; therefore the null hypothesis was rejected.

Post hoc analysis suggested three univariate hypothesis.

Ho_{21}: There will be no change between pre- and post-test scores for attitude toward science as determined by student grade point average in science from the previous year.

TABLE 4.5

STANDARD ERRORS OF ADJUSTED ESTIMATES--
EFFECTS TIMES VARIABLES

Variable Tested	Post Attitude	Post Process	Post Achievement
GPA# $M_{high} - M_{low}$##	4.26213	1.89524	1.54311
Sex $M_{male} - M_{female}$	3.50176	1.55713	1.26782
Class			
A $M_{c_1} - M_{c_7}$###	6.32293	2.81167	2.28923
B $M_{c_2} - M_{c_7}$	6.63714	2.95134	2.40299
C_1 $M_{c_3} - M_{c_7}$	6.23805	2.77387	2.25850
C_2 $M_{c_4} - M_{c_7}$	6.52394	2.90100	2.36200
D_1 $M_{c_5} - M_{c_7}$	6.24380	2.77643	2.26058
E $M_{c_6} - M_{c_7}$	7.37232	3.27825	2.66916
D_2 M_{c_7}	0.00000	0.00000	0.00000

#GPA = Grade point average in science from the previous year.
##M = Mean score for group.
###c_1 through c_7 refer to classrooms A through E respectively.

TABLE 4.6

STATISTICS FOR MULTIPLE CORRELATION COEFFICIENTS

Variable	Multiple Correlation Coefficient
Post Attitude	0.6882
Post Process	0.7090
Post Achievement	0.6597

TABLE 4.7

EQUATION FOR REGRESSION COEFFICIENTS--INDEPENDENT TIMES DEPENDENT VARIABLES

	Post-test	Pre-test				
		Attitude		Process		Achievement
General Formula	$\hat{Y} - \bar{Y}$	$B_{1.1}(X - \bar{X})$		$B_{1.2}(X - \bar{X})$	+	$B_{1.3}(X - \bar{X})$
Attitude	$\hat{Y}$ - 45.001 =	.748(X-73.190)	+	.391(X-28.298)	+	.191(X-27.119)
Process	$\hat{Y}$ - 45.001 =	.016(X-73.190)	+	.403(X-28.298)	+	.613(X-27.119)
Achievement	$\hat{Y}$ - 45.001 =	.138(X-73.190)	+	.047(X-28.298)	+	.719(X-27.119)

$\hat{Y}$ indicates estimated score for individual on post test.

$\bar{Y}$ indicates mean score over all post-tests.

B indicates regression coefficient.

X indicates individual score on pre-test.

$\bar{X}$ indicates mean score on pre-test.

TABLE 4.8

REGRESSION EQUATIONS FOR ADJUSTED SCORES

	Post-test		Pre-test	
		Attitude	Process	Achievement
General Formula	$Y' = Y_{ij}$	$- B_{1.1}(X_{1j}-\bar{X}_{1}.)$	$- B_{1.2}(X_{2j}-\bar{X}_{2}.)$	$- B_{1.3}(X_{3j}-\bar{X}_{3}.)$
Attitude	$Y' = Y1j$	$- .748(X_{1j}-73.190)$	$- .391(X_{2j}-28.298)$	$- .191(X_{3j}-27.119)$
Process	$Y' = Y_{2j}$	$- .016(X_{1j}-73.190)$	$- .403(X_{2j}-28.290)$	$- .613(X_{3j}-27.119)$
Achievement	$Y' = Y_{3j}$	$- .138(X_{1j}-73.190)$	$- .047(X_{2j}-28.290)$	$- .719(X_{3j}-27.119)$

Y' = indicates individually adjusted scores on post-test.

$\bar{X}$ = mean score on pre-tests.

B = regression coefficient.

Y_{ij} indicates individual scores on post-test.

X_{ij} indicates individual scores on pre-test, where i - 1,3 (indicating test number); j - 1,84 (the individual's number).

TABLE 4.9

SUMMARY OF MULTIVARIATE ANALYSIS OF COVARIANCE WHEN CONSIDERING PRE- AND POST-TEST SCORES FOR STUDENTS ON THE MEASURES: ATTITUDE TOWARD SCIENCE, SCIENCE PROCESS SKILLS, AND ESCP ACHIEVEMENT AS RELATED TO GRADE POINT AVERAGE IN SCIENCE FROM THE PREVIOUS YEAR

	Mean Square Between	Mean Square Within	F Test	Probability
Multivariate Test	Degrees of Freedom - for hypothesis, 3; for error, 51			
All Measures			3.8540	0.0145*
Univariate Tests	Degrees of Freedom - for hypothesis, 1; for error, 53			
Attitude Toward Science	820.6322	227.3152	3.6101	0.0629
Science Process Skills	7.7422	44.9473	0.1722	0.6798
ESCP Achievement	195.5916	29.7968	6.5642	0.0133*

*Significant at the 0.05 level of probability.

Ho_{22}: There will be no change between pre- and post-test scores for science process skills as determined by student grade point average in science from the previous year.

Ho_{23}: There will be no change between pre- and post-test scores for achievement in science understandings as determined by student grade point average in science from the previous year.

Examination of Table 4.9 shows a probability of 0.0629 for hypothesis Ho_{21}, 0.6798 for Ho_{22}, and 0.0133 for Ho_{23}. Thus the data failed to reject Ho_{21}, and Ho_{22}, but did reject Ho_{23}.

Ho_3: There will be no differences between composite scores on the three measures, Attitude Toward Science, Science Process Skills, and ESCP Achievement Test as determined by sex.

Analysis of this hypothesis showed an F-ratio of 0.6321 and a probability of 0.5977 and therefore failed to reject at the required level of probability.

Ho_4: There will be no differences on composite scores of the three measures, Attitude Toward Science, Science Process Skills, and ESCP Achievement Test when comparing classes.

Analysis of this data (Table 4.10, page 134) shows an F-ratio of 1.9510 and a probability of .0162; therefore, hypothesis four was rejected.

Post hoc consideration of the data suggested three univariate hypotheses.

Ho_{41}: There will be no differences between classrooms when considering the measure Attitude Toward Science.

Ho_{42}: There will be no differences between classrooms when considering the measure Science Process Skills.

TABLE 4.10

SUMMARY OF MULTIVARIATE ANALYSIS OF COVARIANCE WHEN CONSIDERING PRE- AND POST-TEST SCORES FOR STUDENTS ON MEASURES: ATTITUDE TOWARD SCIENCE, SCIENCE PROCESS SKILLS, AND ESCP ACHIEVEMENT AS RELATED TO CLASSES

	Mean Square Between	Mean Square Within	F Test	Probability
Multivariate Test	Degrees of Freedom--for hypothesis, 18; for error, 144.7351			
All Measures			1.9510	0.0162#
Univariate Tests	Degrees of Freedom--for hypotheses, 6; for error, 53			
Attitude Toward Science	315.6017	227.3152	1.3884	0.2365
Science Process Skills	38.2358	44.9473	0.8507	0.5370
ESCP Achievement	98.5218	29.7968	3.3065	0.0078##

#Significant at the 0.05 level of probability.

##Significant at the 0.01 level of probability.

Ho_{43}: There will be no differences between classrooms when considering the measure ESCP Achievement.

Examination of Table 4.10 shows a probability of 0.2365 for Ho_{41}, 0.5370 for Ho_{42}, and 0.0078 for Ho_{43}. Thus the data failed to reject Ho_{41} and Ho_{42} but did reject Ho_{43}. It was interesting to note that hypotheses referring to attitude and processes were the ones not rejected, while the hypothesis referring to achievement was again rejected.

Tables 4.4 and 4.5 show the least square estimates adjusted for covariates and the standard errors of adjusted estimates. Of particular interest were readings related to achievement between classrooms. Analysis of this data show an ordering of scores for classrooms from high to low for ESCP achievement as follows: D_2, D_1, A, C_1, E, B, and C_2

Ho_5: There will be no interactions between grade point average, sex, and classrooms as demonstrated by the three measures.

An analysis of this hypothesis shows F-ratios and probability factors as indicated in Table 4.11.

In each case the data failed to reject at the required 0.05 level of probability.

It was considered of interest to compare the Carman School District students with scores from a national sample taken in 1964-1965 as reported in Chapter II, pages 68 through 72. Hypothesis six spoke to this concern.

Ho_6: There will be no differences between Carman School District eighth-grade ESCP students and eighth graders from a national norm as determined by the Comprehensive Final during the 1964-1965 ESCP trial period.

Data relevant to this hypothesis is stated in Table 4.12.

TABLE 4.11

F-RATIO AND PROBABILITY FOR INTERACTION HYPOTHESIS

Interaction	F-ratio	Probability
Sex and GPA	1.3023	0.2838
Sex and Classes	1.6168	0.0913
GPA and Classes	1.6679	0.0516
Sex, Classes and GPA	1.5150	0.0940

TABLE 4.12

COMPARISON OF 1970-1971 CARMAN SCHOOL DISTRICT ESCP STUDENTS MEAN AND STANDARD DEVIATION WITH THE 1964-1965 NATIONAL ESCP EIGHTH-GRADE STUDENT SAMPLE AS DETERMINED BY THE COMPREHENSIVE FINAL

Group	Standard Deviation	Mean	Number of Respondents
Carman	5.10	15.69	179
National Sample	8.19	27.11	1410

Observation of the data shows the national sample to have attained a mean of 11.42 points higher than the Carman School District students. A statistical analysis of this difference was performed using a Z-test for the difference between the means of samples. The results indicated a Z score of 2.50, indicating a significant difference at the 0.05 level. Thus hypothesis six was rejected.

Report of Descriptive Information

All ESCP faculty members at the Carman School District were invited to participate in the 1970-1971 surveys. Table 4.13 indicated responses to the instruments by the teachers and/or their students.

TABLE 4.13

RESPONSES TO SURVEY INSTRUMENTS BY CARMAN SCHOOL DISTRICT ESCP TEACHERS AND/OR THEIR STUDENTS DURING 1970-1971

Teacher	Teacher Log	End of Year Teacher Evaluation of ESCP	End of Year Rating of Science Processes	Teaching Back-ground	Student Evalua-tion of ESCP
A	X	X	X	X	X
B#		X	X	X	X
C	X	X	X	X	X
D	X	X	X	X	X
E	X	X	X	X	X
F*	X	X	X	X	
G*		X	X		

X Indicates response.
Teacher B did not submit a Teacher Log.
* Students from Teachers F and G did not participate in the pre- and post-test student evaluation.

<u>Teacher Logs</u>. Logs were submitted by four of the five teachers in the ESCP student sample. One ESCP teacher not included in this sample also submitted logs. A listing of teachers, dates covered, and number of four-week logs submitted is shown in Table 4.14.

TABLE 4.14

LISTING OF ESCP TEACHERS SUBMITTING LOGS

Teacher	Number of Logs Submitted	Dates Covered
A*	2	Nov. 16, 1970-Dec. 15, 1970
		Jan. 12, 1971-Feb. 11, 1971
C	3	Jan. 18, 1971-Feb. 12, 1971
		Feb. 15, 1971-Mar. 12, 1971
		Mar. 15, 1971-Apr. 19, 1971
D	3	Nov. 11, 1970-Dec. 11, 1970
		Jan. 11, 1971-Feb. 5, 1971
		Mar. 1, 1971-Mar. 26, 1971
E	3	Nov. 16, 1970-Dec. 14, 1970
		Jan. 11, 1971-Feb. 8, 1971
		Feb. 22, 1971-Mar. 19, 1971
F	2	Jan. 4, 1971-Jan. 29, 1971
		Mar. 3, 1971-Apr. 6, 1971

*Class A used <u>Modern Earth Science</u> as the basic text.

Five, forty-two minute class periods were allowed per week for earth science. Classes were reported as laboratory sessions, or regular class sessions including lecture, demonstration, discussion, film presentation, and study time.

The authors of ESCP encouraged ample time for laboratory investigations. At least two and as many as four laboratory sessions per week were recommended.[1] Sixty-six investigations were included in the text. The authors expected a normal laboratory investigation to occupy forty-five minutes. Carman School District teachers frequently reported two laboratory sessions necessary for a single exercise. Champlin and Hassard,[2] reporting on the experimental implementation of ESCP in 1965-1966, stated that approximately seventy-five percent of class time was spent in laboratory situation. Table 4.15 shows a tabulation of the percent of class time used for laboratory investigations and film presentations during the logging periods in Carman ESCP classrooms.

Each day the log requested information regarding student attitude toward science. Responses were indicated by checking one of five attitudes: very enthusiastic, moderately enthusiastic, average enthusiasm and interest, moderately uninterested, and very uninterested. A breakdown of student attitudes during the logging periods was tabulated by this researcher using a scale of one through five, where five indicated very enthusiastic and one indicated very uninterested. Classroom averages are presented in Table 4.16.

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[1] Investigating the Earth, Teacher's Guide, op. cit., p. 11.

[2] Champlin and Hassard, op. cit., p. 5.

TABLE 4.15

PERCENT OF TOTAL CLASS TIME USED FOR LABORATORY INVESTIGATIONS AND FILM PRESENTATIONS DURING THE 1970-1971 LOGGING PERIODS AT CARMAN

Teacher	Log 1	Log 2	Log 3	Average for Logs
A	47.3 (52.6)*	31.5		39.0 (44.7)
C	26.3 (36.8)	42.1 (57.8)	23.8 (42.8)	30.5 (45.7)
D	29.4 (47.0)	26.3	38.8 (61.1)	31.4 (44.4)
E	29.4	10.0	16.6	18.1
F		45.0	40.0	42.5

*Parentheses denote percentages for laboratory and film presentations taken together.

TABLE 4.16

STUDENT ATTITUDE TOWARD SCIENCE DURING THE 1970-1971 LOGGING PERIODS

Teacher	Log 1	Log 2	Log 3	Average Attitude
A	3.4	2.9		3.2
C	3.8	4.3	3.6	3.9
D	3.3	3.6	3.4	3.5
E	2.6	2.5	2.4	2.5
F		4.0	4.3	4.1

Average attitude for classes A, C, D, E--3.3
Average attitude for classes A, C, D, E, F--3.4
Scale ratings: 5--high to 1--low.

It would appear that most teachers tended to rate their students attitudes slightly above average. Tables 4.15 and 4.16 were compared. When the thirteen individual logging periods were rank ordered using the Spearman Rank-order Correlation Coefficient a correlation of 0.51 was established.[3] A correlation of 0.60 was determined between average laboratory time and average class attitude using the same correlation coefficient.

Three teachers used films to supplement their presentations, Teacher "C" presented over one film per week during the logging periods. Reported attitudes during these sessions were generally higher than other regular class sessions.

It was hypothesized that student attitudes toward science would improve with exposure to ESCP. Table 4.16 was again examined for trends in student attitudes during individual logging periods. Evidence of a definite trend did not appear from this data. While two classrooms suggested minor improvement, three suggested some decline in attitude.

Student attitudes were then separately tabulated for laboratory sessions and regular class sessions. A report of this data is found in Table 4.17.

Observation of Table 4.17 revealed a consistently higher attitude for laboratory sessions than for regular classroom sessions.

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[3]N. M. Downie and N. W. Heath, Basic Statistical Methods (3rd Edition, New York: Harper and Row, 1970), p. 122.

TABLE 4.17

COMPARISON OF AVERAGE STUDENT ATTITUDE BETWEEN LABORATORY INVESTIGATIONS AND OTHER CLASSROOM ROUTINES, USING INFORMATION FROM LOGS

Teacher	Laboratory Investigations	Other Classroom Routines
A	3.9	2.7
C	4.5	3.6
D	4.4	3.1
E	2.7	2.4
F	4.5	3.8

Scale rating: 5--high to 1--low.

One of the stated purposes of this study was to measure student aptitude of science process skills. An attempt was made to rate the degree to which students were exposed to learning activities for each of the thirteen processes while participating in laboratory investigations. Teachers rated each of the processes on "exposure" to learning the skill as part of their log reports. A scale of one through three was employed where one indicated low exposure; two, average exposure; and three, high exposure. Table 4.18 showed a tabulation of ratings for each classroom when summed across all laboratory sessions.

<u>End of Year Evaluation of Process Skills Taught with ESCP</u>. Near the end of the school term teachers were again

TABLE 4.18

RATING OF "EXPOSURE" TO EACH OF THE THIRTEEN PROCESSES BY CLASSROOM WHEN SUMMED ACROSS ALL LABORATORY SESSIONS USING TEACHER LOGS

Process	A	C	D	E	F	Average Rating by Teachers A,C,D,E	Average Rating by Teachers A,C,D,E,F (All Logs)
Observation	35#	46	51	20	26	38.0	35.6
Classification	12	14	23	0	13	12.3	12.4
Time/Space Relationships	9	14	26	3	15	13.0	13.4
Using Numbers	7	23	19	15	11	16.0	15.0
Communicating	18	21	24	15	0	19.5	15.6
Measuring	21	45	27	15	23	27.0	26.2
Inferring	16	35	38	9	18	24.0	23.2
Predicting	0	37	24	5	5	16.5	14.2
Formulating Hypotheses	6	29	33	0	2	17.0	14.0
Making Operational Definitions	0	38	25	5	2	17.0	14.0
Controlling Variables	8	36	28	13	2	21.3	17.4
Interpreting Data	20	38	36	9	7	25.8	22.0
Experimenting	6	35	21	2	7	16.0	14.2

#Total of the individual ratings for the specified process as listed in each laboratory log report when summed across the total number of laboratory sessions taught by that teacher.

asked to rate each of the thirteen processes on student "exposure" to learning the processes; this time as a summary of the total school year. It was of interest to this investigator to determine if such data could be gathered at the end of the school year rather than request teachers to submit such information on a day-to-day basis. Teachers were informed that a total rating value of 26 had to materialize over the thirteen processes. This focused an average point value of two for "exposure" on the thirteen processes. Table 4.19 shows the tabulation of ratings when summed across teachers.

When the two columns listed in Table 4.19 were arranged in order of rank a coefficient of 0.89 was determined again using the Spearman Rank order correlation coefficient.[4] The Spearman correlation coefficients between ratings listed in the teacher logs (Table 4.18) and those in the end-of-year report (Table 4.19) were also established. When considering only those teachers who both submitted logs and also participated in the pre- and post-test student evaluation (Teachers A, C, D, and E), a correlation of 0.62 was reported. It would appear that these two methods of gathering similar data on processes, the log, and year end ratings, had something in common.

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[4]Downie and Heath, loc. cit.

TABLE 4.19

END OF YEAR SUMMARY OF SCIENCE PROCESS RATINGS FOR THE 1970-1971 SCHOOL YEAR WHEN SUMMED ACROSS TEACHERS

Process	Sum of Ratings--Teachers A,C,D,E	Sum of Ratings--Teachers A,B,C,D,E,F,G (All Teachers)
Observation	11	20
Classification	7	14
Time/Space Relationships	6	10
Using Numbers	9	15
Communicating	11	16
Measuring	8	15
Inferring	8	14
Predicting	8	14
Formulating Hypotheses	6	11
Making Operational Definitions	6	11
Controlling Variables	6	9
Interpreting Data	10	17
Experimenting	8	16

Data under the heading, Average Rating--Teachers A, C, D, E, F from Table 4.18 and under the heading Sum of Ratings--Teachers A, B, C, D, E, F, G from Table 4.19 were compared. The Teacher-log (Table 4.18) reported the following processes as receiving average or stronger emphasis:

Observing	Interpreting Data	Using Numbers
Measuring	Controlling Variables	Predicting
Inferring	Communicating	Experimenting

Data from the end-of-year evaluation of process skills taught with ESCP (Table 4.19) listed the following processes as receiving average or stronger emphasis:

Observing	Experimenting	Inferring
Interpreting Data	Using Numbers	Predicting
Communicating	Measuring	Classifying

Comparison of these two lists suggested the following processes as receiving greatest emphasis during the school year:

Observing	Inferring	Experimenting
Measuring	Communicating	Predicting
Interpreting Data	Using Numbers	

The authors of ESCP listed as behavioral themes, unifying threads such as experimentation, intuition, with observation as the base, comprehension of scale, and prediction (Chapter II, page 61).

When the finalized list of process receiving the greatest emphasis was matched with the list of behavioral themes the following picture emerged:

Behavioral Themes	Processes Receiving Greatest Emphasis	
Science as inquiry:		
Experimentation	Experimenting	Interpreting Data
Intuition	Inferring	
Observation as base	Observing	Communicating
Comprehension of scale	Measuring	
	Using Numbers	
Prediction	Predicting	

It would appear that "exposure" to the processes did correlate quite well with the behavioral themes as expressed by the authors of ESCP.

End of Year Evaluation of ESCP, 1970-1971, by the Carman Teachers

The end of year evaluation was submitted to all ESCP teachers. Replies to the thirty-two question instrument were tabulated and analyzed by this investigator.

Using a five point scale ranging from "very easy" to "much too difficult," all teachers considered the reading level of their texts as difficult. There were no differences for either textbook.

When teachers, using the same scale, were asked to rate the concepts presented in the course, those using Modern Earth Science considered concept presentation satisfactory while four of the five employing Investigating the Earth considered concept presentation as difficult.

Reports of class time used for laboratory varied from 20 to 60 percent with an average of 39 percent. These observations were considerably higher than reports of 18 to 43 percent with an average of 32.3 percent established during the logging periods. It would appear that teachers tended to over-subscribe when questioned at the end of the year.

A comparison of laboratory time between the first two and last two months of school showed a slight decline from 46 to 41 percent. Similar comparisons from the logs showed a decline from 33.1 to 29.5 percent. Only one teacher reported any overall increase in laboratory time on either the log or year-end report.

Five teachers felt that in future years more time should be alloted to investigations. Inadequate facilities and teacher inexperience with an activity orientated program were listed as reasons for limited laboratory time.

When students were rated on a five point scale for overall attitude toward science, scores varied from moderately enthusiastic to somewhat uninterested with most ratings as average enthusiasm and interest. When comparing beginning and end of year attitudes, four teachers felt that an improvement had taken place while two reported a decline in enthusiasm. Two of those reporting improvement did not have students in the ESCP evaluation classes.

Those teachers having students in the seven sample classrooms were asked to compare their "experimental" classes with other classes taught when considering attitude, achievement in process skills, and achievement of science knowledge. Since only minor differences were noted it was assumed these classes to be fairly representative of the total population.

The half-day schedule hindered instruction for some teachers and was a help to others. Overall it seemed to make little difference to the program. There was some mention of weariness during the latter part of the day and also some indication that the schedule reduced student progress in late afternoon.

Agreement could not be established about whether girls or boys enjoyed more success with ESCP.

Three of the seven teachers felt that ESCP could be taught more successfully at ninth or other grade level. Text difficulty and use of ESCP as a replacement for ninth-grade general science were listed as reasons for change. Those disagreeing felt the ESCP was a good preparation for high school and some activities were too "childish" for ninth-graders.

Six teachers felt that the basic ESCP program should be kept next year. However, textbooks and facilities were still a concern. There seemed to be a general agreement that teachers should be allowed time at the beginning of the school term to set objectives and plan a sequence of content and investigations to be treated during the year.

Amount of textbook content covered varied greatly from room to room. As much as 75% and as little as 33% of the text material was taught. While no pattern could be definitely reported, most teachers tended to follow the sequence of the book. However, single exceptions included skipping one or two chapters to greatly "skipping over large sections of the text." Most classes had little or no exposure to Unit IV, "Earth's Environment in Space," and several had piecemeal coverage of Unit III, "Earth's Biography."

Laboratory activities generally followed those in the text. Students exposed to Modern Earth Science tended to have more teacher-prepared laboratory investigations. Several teachers reported additional activities related to space travel, ecology, rocks and fossils, field trips, and extensive use of films.

One teacher reported serious student apathy to such a degree that the last two months were spent with individualized student study groups. Ten study units were selected from the latter chapters of the text. Students chose those they wished to study. They were allowed to work in groups. This cooperative effort improved interest in science for most students.

Teachers were asked to suggest a topic of study they felt could have been eliminated. They were also asked to select topics which they and/or the students enjoyed most and which they and/or the students enjoyed least. Topics listed as enjoyed most by the teacher were usually reported as enjoyed most by the students. No relationships of interest were found when considering a topic to be omitted and topic enjoyed least by the students. Perhaps pleasant things are more easily remembered than unpleasant. One teacher commented that there was a direct relationship between preparation and enjoyment by students.

Most teachers felt they had sufficient materials, but insufficient textbooks and laboratory materials remained a problem with one or two. Several comments related to the poor construction of certain ESCP kit materials. Teachers generally felt adequate preparation time was provided.

Teachers and Classrooms. Table 4.20 listed the academic and teaching background of six ESCP teachers. The seventh member had taught music education previous to his encounter with earth science.

Table 4.21 shows a comparison of teachers and classes at Carman with teachers and classes included in the 1964-1965 ESCP trial evaluation period.[5] National trial period teachers generally had more teaching experience than Carman

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[5] "Characteristics of ESCP Teachers and Schools," ESCP Newsletter, NL-8 (July, 1965), p. 8.

TABLE 4.20

BIOGRAPHY OF CARMAN SCHOOL DISTRICT ESCP TEACHER'S ACADEMIC AND TEACHING EXPERIENCE, 1970-1971

Teacher	Semester Hours: Bio Sci Un	Bio Sci Gr	Phy Sci Un	Phy Sci Gr	Ear Sci Un	Ear Sci Gr	Under-graduate major	Master's Degree	MSU Summer Wksp 1970	Teach Exp	Teach Exp in Science	Teach Exp in Ear Sci
A	8	2	40			24	Chemistry		Yes	5	5	4
B	34	26	29		17	6	General Science Conservation	Biology		3	3	3
C	37			7	4		Biology	Guidance and Counseling	Yes	4	4	4
D	12	2	24	4		18	General Science	Science	Yes	11	11	8
E			4				Social Studies	Audio Visual Education		6	2	1
F#			22	10		3	Chemistry Geography Social Studies	Geography	Yes	18	18	1

#Not included in sample classrooms.

TABLE 4.21

COMPARISON OF TEACHERS AND CLASSES FOR 1970-1971 CARMAN SCHOOL DISTRICT ESCP STUDENT EVALUATION SAMPLE AND 1964-1965 ESCP TRIAL EVALUATION SAMPLE

	Carman Sample				Trial Sample			
	High	Mean	Low		High	Mean	Low	
Total Teaching Experience	18	4.8	2		34	8	0	
Earth Science Teaching Experience	8	4.0	1		12	2	0	
Total Science Credits (semester hours)	112	62.0	16		103	33	6	
Credits Earned in Earth Science (semester hours)	24	13.8	0		94	24	3	
Highest Degree Earned	M.A.	B.A.	None		M.A.	B.A.	None	
	4	1	0		42	39	1	
A--Unlimited; B--Satisfactory; C--Minimal; D--Unsatisfactory								
Laboratory Facilities	A	B	C	D	A	B	C	D
	2	2	0	3	12	42	22	6
Average Class Size	High	Mean	Low		High	Mean	Low	
	34	27.7	23		39	30	10	

School District teachers, however, the Carman faculty had more experience in earth science. Inversely, the Carman faculty had more total science credits while the trial teachers had more earth science credits. Five of the six Carman teachers held master's degrees while fifty-one percent of trial teachers held the advanced degree. It should be noted that no Carman teachers held a master's degree in earth science and three of the degrees were in non-science areas.

Four of the seven Carman classes met in rooms with facilities rated satisfactory or better. Three of the rooms were quite unsatisfactory since no laboratory tables with sinks were available and two rooms had nothing more than desks for use with investigations. Two-thirds of the trial classrooms were rated as satisfactory or better with only about eight percent of the rooms considered unsatisfactory. Average classroom sizes slightly favored the Carman School District.

Student Evaluation of ESCP. Students from the ESCP sample classes were asked to respond to a questionnaire in an attempt to learn something of their opinions regarding the course. Responses to the questionnaire were reported in Appendix L, page 272.

Even though teachers considered the text as difficult over half of the students did not feel it was too hard. While 70% of the teachers considered concept presentation as difficult 67% of the students did not feel ideas taught in class were too hard. Teachers and students generally agreed that more time should be spent with laboratory investigations.

Over half of the students felt laboratory periods were more worthwhile than other class sessions.

Fifty percent of the students felt eighth-grade science was harder than seventh-grade science, while 43 percent said they enjoyed ESCP more than seventh-grade. Report card grades were similar for the two years.

Of particular interest were responses to the question, "Would you recommend ESCP to a friend?" It was surprising to this investigator that only 22 percent stated, "No," when evidence from attitude measures used with the sample student groups indicated a declining enthusiasm.

When students were asked what they liked best about science, 75% of the replies related to student activity-orientated experiences. Over half responded directly to more laboratory sessions.

Those experiences least enjoyed by students had a direct bearing on traditional classroom teaching techniques. Almost 75% of the students indicated studying from textbooks and the tests that followed as least enjoyable.

Most students felt that ESCP could be improved if more emphasis was placed on activity-orientated classes and less on textbook teaching. About 48 percent of the students spoke for activities and films, and about 30 percent against textbook teaching when asked how science could be improved.

<u>Summary</u>

The purpose of this chapter was to present results obtained from instruments used to collect student data as described in Chapter III, as well as, an analysis of six hypotheses. Research was conducted as part of an experimental and descriptive inquiry.

Five hypotheses were tested on a matrix in which interest areas related to student attitude toward science, aptitude of science process skills, and understanding of science knowledge were crossed with student's sex, grade point average in science from the previous year, and classroom. A sixth hypothesis compared student content understanding with a national norm established in 1964-1965.

Descriptive information was reported and analyzed from five survey instruments: Teacher Logs, Teacher Questionnaire, Evaluation of Science Process Skills, Teacher Background, and a Student Questionnaire.

CHAPTER V

SUMMARY AND CONCLUSIONS

This chapter presented a brief review of the study, including its purpose, design, hypotheses tested, and information gathered from survey instruments. The conclusions contained in this chapter were based upon data presented in Chapter IV.

Discussion of this study as a guide for curriculum evaluation, concerns for future evaluations, and personal impressions are also included. Recommendations to the Carman School District and problems for further investigation conclude the chapter.

Review of Investigation

The purpose of this study was to develop a set of procedures that could guide a local school district as it attempted to assess the impact of new curricular programs. In particular this study attempted to evaluate the Earth Science Curriculum Program (ESCP) during its first year of implementation with eighth grade students in the Carman School District, Flint, Michigan.

In order to investigate this program the writer conducted a two part study at Flint, Michigan. The first part consisted of two phases. Phase one of the experimental study required administration of pre- and post-tests to determine student change following treatment. Variables relating to student scholastic ability as determined by grade point average in science from the previous year (GPA), sex, and teacher-classroom differences were considered. Phase two of the experimental study used a single instrument during the last week of school.

The second part employed the use of questionnaires and teacher-logs. This descriptive investigation attempted to survey text content covered, teaching methods, teacher reactions, analysis of science process skills, teacher background, and student reactions.

Experimental Investigation. Beginning in August, 1970, this writer met with administrative and teaching personnel of the Carman School District to plan the evaluation. Five ESCP teachers and seven ESCP classes were chosen to form the sample for this study. The following three measures were prepared for administration as pre- and post-tests with the sample classes:

1. Attitude Toward Science
2. Science Process Measure for Junior High School Students, and
3. ESCP Achievement Test.

The Attitude Toward Science measure was designed to ascertain any change in student attitude toward science after experiencing one year of ESCP. The Process Measure attempted to demonstrate change in student ability to use the thirteen science process skills as defined by Science--A Process Approach[1] (SAPA) (Chapter II, pages 86 to 90). The ESCP Achievement Test, a listing of test items selected from the five "Unit Achievement Tests" located in the ESCP Teacher's Guide,[2] attempted to measure changes in student understanding of science knowledge.

Tests were administered during consecutive weeks in October, 1970, and May, 1971. A total of eighty-four students was chosen as the sample for analysis. Students in each class were divided into two groups based upon the previous year's science grade as follows: high--A, B students; low--C or lower students. These two groups were further divided into subgroups based upon sex. Thus for each class four subgroups were identified as high-male, high-female, low-male, low-female. A matrix showing the design for part one of the experimental phase is located in Table 3.5, page 114.

Five hypotheses were designed for phase one of the ESCP evaluation at Carman. All hypotheses were rejected when the value of an F-test exceeded the .05 confidence level. The first hypothesis referred to overall change as measured by student attitude toward science, aptitude in science process skills, and understanding of science content.

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[1]Science--A Process Approach, loc. cit.

[2]ESCP Teacher's Guide, loc. cit.

> Ho_1: There will be no differences between composite pre- and post-test scores for the three measures Attitude Toward Science, Science Process Skills, and ESCP achievement.

The hypothesis was rejected. Further analysis showed significant change on all measures, with a negative change for attitudes, and a positive change for process skills and achievement of science knowledge.

Hypothesis two, three, four, and five related to the variables GPA, sex, and teacher-classroom differences.

> Ho_2: There will be no differences on the composite scores for the three instruments measuring attitude, process skills, and achievement of science knowledge as determined by grade point average in science from the previous year (GPA).

Hypothesis two was rejected. Further analysis showed support for a hypothesis of no change in attitude or in process skills as determined by GPA, but did reject a null hypothesis for change in achievement of science knowledge as determined by GPA.

> Ho_3: There will be no differences between composite scores on the three measures attitude, process skills, and achievement of science knowledge as determined by sex.

The hypothesis was not rejected.

> Ho_4: There will be no differences on composite scores of the three measures attitude, process skills, and achievement when comparing classes.

Hypothesis four was rejected. Further analysis showed support for a hypothesis of no change in attitude and process skills as determined by classes, but did reject a null hypothesis for change in achievement of science knowledge as determined by classes.

> Ho_5: There will be no interaction between GPA, sex, and classes as demonstrated by the three measures.

The hypothesis was not rejected.

Phase two of the experimental study required the administration of an ESCP Comprehensive Final to all students in the seven classes during the last week of school. These results were compared with those from a sample of eighth-grade students taken during the national trial period, 1964-1965. Hypothesis six related to this aspect of the study.

> Ho_6: There will be no differences between Carman eighth-graders from a national norm as determined by the Comprehensive Final administered during the 1964-1965 ESCP trial period.

Hypothesis six was rejected. Carman students scored lower than the national norm.

Experimental Investigation--Conclusions. In view of the testing of the hypotheses held for this part of the study, the following conclusions were drawn:

1. There were significant changes during the 1970-1971 ESCP school year that related to earth science. Students generally held less positive attitudes toward science near the end of the school year than were held at the beginning of the school year. In spite of this attitude students showed improvement in both achievement in science process skills and achievement of science knowledge.

2. Students with a higher grade point average in science during the previous school year did significantly better in achievement of science knowledge than those with a lower GPA.

No differences could be ascertained for attitudes or achievement in process skills when considering GPA.

3. There were no significant differences observable in any of the three areas, attitude toward science, achievement in science process skills, and achievement of science knowledge as determined by sex. This conclusion was also supported by teacher observation.

4. Classes, classroom, and teacher were important when determining success in earth science as measured by achievement in science knowledge. A rank ordering of the seven classes showed that D_2, D_1, and A comprised those listed in the upper one-half.

5. Combinations of the three variables GPA, sex, and classes showed no interactions affecting the outcome of the test results.

6. Carman students showed a significantly lower knowledge level of ESCP understandings than did the national sample from 1964-1965. Interpretation of these conclusions is limited by conditions as stated in Chapter I, page 20, and 21.

Descriptive Investigation. Five instruments were designed by this investigator for gathering descriptive information.

Teacher-log. The teacher-log was prepared for teachers as a daily review of material covered, approaches used, and attitudes observed. Each teacher was asked to prepare three daily logs for periods of four weeks each.

End-of-year science process rating scale. Teachers rated the thirteen science processes as defined by SAPA on "exposure" to the students. Exposure was described as a combination of time and emphasis to a particular process.

End-of-year teacher questionnaire. Teachers completed a detailed questionnaire which offered an opportunity to evaluate progress and offer criticisms and suggestions.

Academic background. Teachers submitted a summary listing of academic emphasis and teaching experiences.

Student questionnaire. A questionnaire attempting to survey students reaction to certain aspects of ESCP was submitted as part of the spring testing sequence.

Descriptive Investigation--Conclusions. Laboratory time. Five, forty-two minute class periods were allowed per week for earth science. The authors of ESCP suggested that at least fifty percent of this time be devoted to laboratory oriented experiences. Reports from the teacher logs and the end-of-year teacher evaluations indicated from between 32 to 39% of class time was used for laboratory investigations. Laboratory time declined slightly as the year progressed. However, teachers felt more time should be allotted to investigations in future years.

Attitude toward science. Student attitudes were generally classified as average for enthusiasm and interest. No definite evidence could be obtained from teachers to indicate an overall deterioration of attitudes even though the pre- and post-attitude measure demonstrated significant negative changes.

Only 22% of the students stated, "No" to the question, "Would you recommend ESCP to a friend?" It may indicate that attitudes for science were still favorable despite the apparent decline.

Of special significance was the observation that consistently higher attitudes were associated with laboratory investigations and consistently lower attitudes were associated with other classroom routines such as lecture, demonstrations, reading, and testing. Teachers who interspersed lectures with audio-visual materials also experienced stronger positive attitudes toward science. It would appear that while there was a strong positive attitude toward science demonstrated when students participated in laboratory or audio-visual experiences, this advantage did not show strong transfer to other kinds of classroom experiences. Student enthusiasm seemed to vacilate according to the kind of learning experience offered.

Students reported that studying from textbooks and the tests that followed were the least enjoyable class experiences. There appeared to be a strong relationship between textbook with traditional teaching, and dislike for science. Most students felt that ESCP could be improved if more emphasis was placed on student activity-orientated class sessions and less on textbook teaching. Activities other than those related to usual textbook materials were considered more enjoyable and more worth while. Teachers would do well to weigh the value of student enthusiasm and interest as it related to desired learnings.

Student "exposure" to science process skills. The thirteen processes as defined by SAPA were used to measure student achievement of science process skills. It was of interest to determine how well classroom "exposure" to these processes correlated with behavioral themes as expressed by ESCP. A summary comparison of the processes receiving average or stronger emphasis in the Carman ESCP classes with the ESCP behavioral themes as discussed in Chapter II, page 61, suggested that they did correlate quite well.

Text and grade level. Two texts were used with ESCP at Carman. No class completed all of the material presented in either text. Content covered varied from as much as 3/4 to as little as 1/3. Teachers regarded the reading level of both texts as difficult, but students generally expressed that it was not too hard. The text, Modern Earth Science, was thought to present concepts in a more easily understood manner than Investigating the Earth, the text designed for ESCP. The judgment of the Carman faculty and students partially supported findings from Kline and Qutub (Chapter II, page 80) when they reported the text, Investigating the Earth, suitable for ninth or tenth grade level.

Three of the seven teachers felt ESCP could be taught more effectively at ninth grade level. This point of view was supported in Matthew's national survey which stated that teachers commonly agreed ninth grade was best for earth science (Chapter II, page 81).

Teacher and classrooms. Teachers and students generally felt no great loss to student learning as a result of being forced to use the senior high school on a half day afternoon schedule. A comparison between ESCP teachers and classes at Carman and those included in the 1964-1965 trial evaluation period favored trial teachers in the area of earned credits in earth science. Trial classrooms were also favored over Carman classrooms when considering laboratory facilities.

As noted previously in Chapter V, there was a difference in achievement of science knowledge attributable to classes. An analysis of the data on Table 4.4, page 127 showed classes D_2, D_1, and A as comprising the upper 50 percentile of reported scores. Classroom D was rated as a room with satisfactory facilities and classroom A as unsatisfactory. Teacher D reported 18 academic hours in earth science and 8 years experience teaching earth science. Teacher A reported 24 hours in earth science and four years experience teaching earth science. Since teacher A had piloted ESCP the previous year, he was the only member of the faculty with ESCP teaching experience. In addition, both individuals attended the 1970 summer earth science workshop held at Michigan State University for Carman School District teachers. From this data it appeared that teacher experience and training did become important factors for predicting student success toward achievement of earth science knowledge.

Discussion of the Carman Study as a Guide for Curriculum Evaluation

The Earth Science Curriculum Project at Carman School District presented a satisfactory setting in which to develop and test a guide for curriculum evaluation. The situation was such that it was impossible to design a control group within the study, and only one treatment was available for measurement. Use of control groups and multiple treatments within small populations is frequently either undesirable or impossible. Avoiding the presence of confounding variables in a small school population is extremely difficult and their presence initiates serious problems which often render data useless since there appears to be no way in which to interpret the results.

It therefore became apparent to this investigator that an approach to curriculum evaluation would need to be developed which would not require the use of either control groups or multiple treatments across several groups. Local school districts would desire such a simplified evaluation if it could identify curriculum problems, highlight strengths, and suggest reasons why these variations existed.

The Carman School District evaluation utilized students, faculty, administrative personnel, and curriculum specialists. Aspects of the study included experimental and descriptive analyses. The guide did not utilize a control group or employ several treatments, but rather considered three variables and three measurements across one treatment.

The three measurements reflected those educational goals considered most relevant. Science had often been associated with poor student attitudes. Students generally depicted science as too hard and uninteresting. It had been frequently stated that attitudes would improve when the new curricular science materials came into common use. Since ESCP was a new curricular program it was supposed that student attitudes would improve after treatment. Therefore a measure of attitude was deemed important.

The last decade had seen an increasing interest in science as process. Modern programs at all levels had emphasized the importance of the processes to scientific literacy and understanding. The emergence of science as process was marked as one of the outstanding developments of this latter half century. It was therefore considered vital that a measure of achievement in process skills be included.

The products of the scientific endeavor had long been accepted as vital knowledge. A total evaluation of ESCP at Carman School District without a measure of product would have been incomplete. Therefore such a measure was included.

Thus the curriculum was examined to determine which of its aspects appeared most useful for analysis. Instruments were then designed to evaluate those aspects of student behavior deemed most important to the subject area. Variables were selected which showed promise in assisting the evaluator to determine particular strengths or weaknesses within the population.

In order to develop a more complete picture of the curriculum to be assessed descriptive instruments were designed. These instruments allowed for subjective expression by student and faculty and were constructed to help investigate reasons for any changes as indicated by the pre- and post-tests.

Teacher logs presented an opportunity to gather day-to-day information without the necessity of frequent and persistent classroom visits by the investigator. They provided a feeling for the kind of atmosphere characteristic of each classroom.

Academic information from teachers provided an immediate assessment of strengths within the discipline. Teacher and student questionnaires offered data particular to the subject area being assessed and reactions of those most closely associated with the area.

Administration of pre- and post-tests appeared to be an effective means for gathering significant data on student behavior. The careful selection and development of these measurement criteria served to show general areas of strength and weakness. The choice of appropriate variables proved to be of vital importance when identifying specific problems, as well as pointing out areas of strength. When such strong points had been identified, the survey instruments frequently suggested reasons for the strength. When areas of weakness were identified the survey instruments frequently suggested recommendations for remedial measures.

Thus an evaluation guide was developed in which several measurements were used over a single treatment within one population. Pre- and post-tests identified broad areas of interest. Carefully selected variables further differentiated within each area. Finally survey instruments determined reasons for changes and suggested future action.

A Set of Procedures to Guide Future Evaluations

The interested faculty should collectively determine the following:

a. Identify areas that best manifest outstanding characteristics and highlight the program as unique from that formerly used.

b. Identify characteristics that promise to be most useful for differentiating between students.

c. Identify kinds of information to be gathered through survey instruments, with priority given those that promise to help the evaluator decide why certain differences existed and how improvements could be enacted.

Plan for Action. In order to facilitate planning for a curriculum evaluation as described in this study, the following outline is suggested.

1. Identify the discipline to be evaluated. The discipline would normally be considered a discrete subject area such as science, mathematics, social studies, or reading. However, it may be that interdisciplinary studies such as earth science; or an elementary mathematics-science, social studies-science combination may be of concern. Such combinations are acceptable if areas of interest as described below can be identified as common to the multi-discipline.

2. Select areas of interest which best demonstrate outstanding characteristics of the curricular program. One should consider differences between the new program and that previously used. One should also consider special emphases as stated by the authors of the new program. Since the major purpose of the evaluation is to assess the new program during its implementation, seeking strengths and weaknesses as related to local school district needs, these interest areas should reflect the goals of the program as seen by the local school district.

Areas of interest might include the following: intellectual skills, structure of the subject area, problem solving, verbalized knowledge, comprehension, work meaning, creativity, motor skills, and attitude toward the subject, appreciation as related to certain aspects within the subject, or concepts such as open-mindedness and curiosity.

3. Choose variables which appear to show promise as identifiers of specific problems and strengths within the

areas of interest. Such variables might relate to student or teacher-classroom differences. It is necessary to list possible variables and predict how their use might show differentiation among the student body. Consideration should be given to the following list: Entering behaviors as identified by grade point average, or I.Q., achievement, and aptitude tests; socio-economic factors, race, and programs used at previous grade levels; also academic background and experience of teachers, as well as differences as related to classroom equipment and organization.

4. Develop a testing program design representative of the above conditions, The matrix design of the testing program must consider all significant independent and dependent variables and be constructed to allow for analytical interpretation of results. Assistance from a research consultant may be required.

5. Prepare or select measures to be used in each of the areas of interest. It is recommended that machine scored test be used when possible to reduce the work load for the evaluator. It would be advisable that when measures are selected to test the various curricular areas, priority be given those measures that can be adaptable as part of the regular course evaluation. Students should realize that they will be individually evaluated on the basis of their responses to these measures (exceptions would be attitude measures as used in this study). This should encourage students to do

their best and therefore present a more accurate picture of change (see problems for further investigation, page 180).

6. List the kinds of information that might be helpful to diagnostically interpret results of the testing program. The purpose of the experimental phase of evaluation as referred to under points two through five was to identify specific areas of strength and weakness as related to implementation within the particular school setting. The purpose of the descriptive phase as referred to under points six and seven is to dignostically determine why such strengths and weaknesses exist. Therefore it is necessary to anticipate possible differences which might become manifest as a result of the testing program, and compile a list of kinds of information which could suggest reasons why these differences exist. The list should attempt to include all possible reasons for outcomes from the pre- and post-tests.

7. Develop the various kinds of survey instruments necessary for gathering information under point six. The instruments will tend to be subjective in nature. Possible considerations include: teacher logs, classroom observations, end-of-year summaries, ratings of classrooms, equipment, textbooks, and teachers.

8. Administer the test and survey instruments according to an agreed calendar. Timing of the testing program must be studied. Pre- and post-tests should be administered as part of a predetermined sequence. Students who are unable to submit to the tests on the specified day should be given

opportunity to "make up" the test to reduce sample attrition.

October is satisfactory for the pre-tests, but the middle or late May could prove to be late for the post-tests since many school closing activities may cause scheduling conflicts. However, if test measures can be chosen which are adaptable as part of the regular course evaluation the problem of post-test timing will be greatly reduced.

9. Record and analyze results from the tests. University testing services may be of help at this point.

10. Tabulate and analyze results from the survey instruments.

11. Interpret results from the tests with the aid of the survey instruments. Strengths and weaknesses are to be identified and diagnostically interpreted. A prognostic analysis should then follow. One needs to determine action which will serve to re-enforce those aspects of the program that proved adequate and suggest remedial change to correct those areas which showed weakness. The evaluator will probably find it necessary to consult research specialists to assist with this aspect of the evaluation, as well as with points four and nine. Most state universities provide such research counseling services.

12. Present recommendations for change. If the evaluation research was internally directed by faculty, the report should be presented first to the faculty and second to administration and board. Evaluation initiated by the administration should be reported back to the administration, then to

the faculty, and finally to the board. An externally directed study would be reported first to parties external to the local school district and then to administration, faculty, and board.

Personal Impressions

While developing this evaluation guide certain impressions were received which this writer considered important to any school system anticipating adoption and implementation of a new curriculum program. As this writer worked with the schools it became evident that teachers generally had difficulty identifying and adapting to the radically different teaching philosophy espoused in the curriculum program. Teachers who had been out in the field for several years frequently found the approach quite foreign.

The teacher, for example, taught the textbook, using lecture and demonstration as the prime vehicle for dispensing information. Thus what should have been student investigation often became teacher demonstration. What little laboratory experiences were offered usually served to verify previously identified understandings and could be termed "cookbook" exercises. The concept of using laboratory investigations as a way of discovering new information seemed a remote idea. Observations such as these suggested that when experienced teachers were confronted with an innovative education program they attempted to force the new materials to fit their previous concepts of how best to teach. Lack of good intentions was not necessarily the problem. A teacher did not instruct as the curriculum program intended simply because he did not know how to do it. To be told how was not sufficient. Transmitting ideas which were assimilated at nothing more than the verbal level was seldom useful.

The new programs promoted a distinctly different approach to teaching which was far removed from the traditional. Students were to be encouraged to work as closely with the real world as possible. The approach required a different classroom atmosphere than usually envisioned by the public. The classroom was to become a beehive of purposeful endeavor in which children worked directly with physical objects. The environment encouraged students to "try things out." They were directed to handle, manipulate, and do. They were to ask questions and propose solutions. They were to experiment to test hypotheses, and accept or reject them; not because of text or teacher, but on the basis of their own observations.

Therefore the teacher's role was to be changed; it was enlarged. His major concern was not to lecture, assign readings and questions, or evaluate recall. While he might still be a "teller" he also became a listener, guide, counselor, and organizer. He helped the student observe, ask questions, design experiments, and interpret results. Now the child's activity became the center of interest. The teacher was placed in the position of a supporting role; supporting to the student.

Teachers who had been used to operating as a central classroom figure and dispenser of knowledge often had difficulty adjusting to this new role. If left to chance the teacher's perception of his job remained much the same even though new materials were brought in and placed about the room. Lecture and demonstration still dominated. Students were still the passive recipients of teacher dispensations, recording information to be digested and regurgitated at the proper time. The major thrust of these programs, understanding through inquiry, was never recognized by the teacher and therefore never implemented.

It had been fairly well established that the new curricular programs were improvements over older materials. Yet so often they failed to produce the expected results because the teaching philosophy built into the program had not been accepted or understood by the classroom teacher. It therefore became very obvious to this writer that the most important concern relating to adoption of new curricular programs was that of teacher orientation and training. This meant that one or two days of introductory workshop would not be sufficient. Ample time had to be allowed so teachers could work their way into the materials, just as their students would be expected to do. Their workshop classroom had to become a beehive of purposeful endeavor, where teachers "tried things out for themselves." They needed to handle, manipulate, and do. They needed to ask questions and propose solutions. They needed to experiment and test their hypotheses, and learn to accept or reject them, not because of book or instructor, but on the basis of their own observations. Only after such preparation, one in which the teacher began to learn by doing, would he feel confident to allow students to do the same.

Recommendations to the Carman School District

In view of the findings reported in Chapter IV the following recommendations are presented.

1. Grade placement for ESCP should be reconsidered. Since the vertical science curricular arrangement has not been finalized for junior and senior high students in the Carman School District, the possibility of shifting ESCP to grade nine should be studied.

2. In the event that ESCP remains at the eighth grade level, it is recommended that consideration be given to revising the two track program (Appendix M, page 277) so that Intermediate Science Curriculum Study (ISCS II and III) become the suggested path for the second track. It is further recommended that students who rate in the lower "grade point average in science from the previous year" be encouraged to follow the ISCS track.

3. In the event that either earth science is judged best at the eighth grade level or is changed to a different level opportunity for an inservice workshop should be provided in which earth science teachers can prescribe priorities, define objectives, establish methods, and select materials for the

year. Such a workshop would allow the faculty to plan a sequence of content and investigations to be treated.

4. Shirner[1] and Sargent's[2] studies strongly suggest that the combination of the right curriculum with the appropriate teacher is an important factor in influencing student outcome. Observation of the teachers by this writer suggest vast differences with regard to personality and method of teaching. Carman School District teachers chose to accept a dramatically different kind of earth science program without regard to individual teaching mannerisms. It is the opinion of this investigator that some teachers found difficulty identifying with the new approach. Therefore it is recommended that with future introduction of any new curricular program provisions be made for necessary inservice training to adequately acquaint teachers with the goals, methods, and materials of the program. An educational program, no matter how well prepared, can be only partially effective if teachers are not trained to use it as designed or are incapable of adapting the particular teaching style required.

5. It is also recommended, that if after becoming adequately acquainted with a particular educational package,

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[1]Shirner, "A Comparison of Student Outcomes in Various Earth Science Courses Taught by Seventeen Iowa Teachers," _loc_. _cit_.

[2]Sargent, "A Study to Determine Certain Characteristics of Earth Science Curriculum Project Teachers and Students in Permissive and Authoritarian Classrooms which Lead to Greater Academic Achievement in these Students," _loc_. _cit_.

a teacher feels unable to adapt the materials to his personal teaching style and cannot effectively adapt his style to the materials, that the teacher be allowed to select other materials to help him with course instruction.

6. It is recommended that ESCP be taught in such a way that student investigations have highest priority.

7. It is also recommended that at least 60% of class time be devoted to laboratory investigations and audio-visual presentations.

8. It is recommended that the teachers and administrators be made aware of the need to improve student attitudes toward science. In support of this recognition every effort should be made to develop more student orientated classroom activities. Attitudes seem to be improved when students become involved, while at the same time attitudes seem to be less enthusiastic when the textbook and the teacher dominate the learning experience.

Problems for Further Investigation

The data gathered in this study and observation of students and teachers over the evaluation period suggested areas for further investigation.

One of the problems associated with gathering of data within a typical classroom situation is reliability of test results. One is never quite certain how well student behavior is reflected by test scores. This is particularly true when the pre-test is given in the fall while students appear fresh and energetic and the post-test is given in the spring when students have become more apathetic. Most schools still use grades as a major motivating force for academic achievement. It is in such schools where this question of test score reliability becomes a major concern. Does the student's score reflect his ability when the student apparently has nothing to gain or lose after filling out a test? It is recommended that investigations be conducted to establish more acceptable techniques for improving reliability of research studies when operating in public school settings.

No instruments specifically designed for use with junior high students were found for determination of attitudes or achievement in process skills at the time of this study. Therefore the investigator adapted from measures not necessarily suited to the particular needs of the study. Considerable research is needed for development of tests specifically written for school children at all grade levels.

Variables for analysis within the model were quite limited since the test school district had no previous testing program in the areas of aptitude, intelligence, or achievement. Additional study is needed to determine effects when other variables such as I.Q., achievement, race, socio-economic factors, and previous elementary science programs are considered for inclusion in the research matrix. In this way evidence can be gathered to further test the overall hypothesis of this study.

While there seemed to be a positive correlation between information gathered on time devoted to laboratory sessions, student attitudes toward science, and "exposure to process skills" when considering teacher logs and teacher end-of-year reports, it appeared that the gathering of such data using end-of-year reports was prone to considerable subjective judgment. Yet it can be argued that utilization of end-of-year reports would simplify data gathering for both teacher and evaluator. Therefore more research is recommended to develop reliable end-of-year data gathering procedures useful for diagnostic, evaluative, and prognostic interpretation of the school program.

Teacher differences present a major concern when planning curriculum evaluation at the local level. Many questions of both a pragmatic and philosophical nature warrant consideration. Teachers' generally are not enthusiastic when evaluation of curriculum suggest judgment of their ability as instructors. Yet differences between classrooms are appropriate and useful variables.

Will teachers initiate evaluations when there is a possibility that results will be interpreted in relationship to their abilities as educators? Can and should curriculum evaluation be interpreted as teacher accountability?

How can administrators deal with curriculum evaluation without appearing to threaten faculty positions?

How does an investigator design a curriculum evaluation that looks at all important aspects of the program without infringing upon faculty rights? These and other questions related to teacher accountability require considerable future study.

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APPENDICES

APPENDIX A

INVESTIGATING THE EARTH
OUTLINE OF CONTENTS

OUTLINE OF CONTENTS--INVESTIGATING THE EARTH

UNIT I--THE DYNAMIC EARTH

Chapter I <u>The Changing Earth</u>
Evidence of Change
Prediction and Patterns of Change
Earth Changes and Man

Chapter 2 <u>Earth Materials</u>
From Planet to Atom
Atoms and Molecules in Earth Materials
Abundance of the Elements

Chapter 3 <u>Earth Measurement</u>
Determining the Shape of the Earth
Measuring the Earth

Chapter 4 <u>Earth Motions</u>
The Many Motions of the Earth
Effects of Earth Motion

Chapter 5 <u>Fields and Forces</u>
Fields, Motions, and Forces
The Gravitational Field of the Earth
The Magnetic Field of the Earth

Chapter 6 <u>Energy Flow</u>
Energy and Change
The Earth's Source of Energy

UNIT II--EARTH CYCLES

Chapter 7 <u>Energy and Air Motions</u>
Solar Radiation and the Earth
The Atmosphere in Motion

Chapter 8 <u>Water in the Air</u>
The Water Cycle
Clouds and Rain
Masses, Fronts, and Cyclones

Chapter 9 <u>Waters of the Land</u>
Moisture Income and Storage
Moisture Outgo
The Local Water Budget

Chapter 20 Development of a Continent
Early History of North America
Later History of North America
The Great Ice Age

Chapter 21 Evolution of Landscapes
Processes that Shape the Land
Landscape in Perspective

UNIT IV--EARTH'S ENVIRONMENT IN SPACE

Chapter 22 The Moon: A Natural Satellite
Lunar Landscapes
The Moon as a Satellite
Lunar Research

Chapter 23 The Solar System
Motions of the Planets
The Sun's Family
Origin of the Solar System

Chapter 24 Stars as Other Suns
Measuring the Amount of Radiation
Measuring the Direction of Radiation
Measuring the Quality of Radiation

Chapter 25 Stellar Evolution and Galaxies
Steller Evolution
We Live in a Galaxy
Our Galaxy Among Its Neighbors

Chapter 26 The Universe and Its Origin
General Picture of the Universe
Relativity
Origins

APPENDIX B

RESULTS OF TWO STUDENT SURVEYS CONDUCTED BY THE ESCP NATIONAL STAFF FOR THE YEARS 1967 AND 1968

SUMMARY OF RESULTS OF TWO STUDENT SURVEYS CONDUCTED BY THE ESCP NATIONAL STAFF FOR THE YEAR 1967-1968

1967 Survey	1968 Survey
435 responses sex and ability evenly divided	228 responses sex: boys--115, girls--113 ability: high--77 average--85 low--66

Easiest chapter to read and understand

Chapter I- The Changing Earth
followed by:
Chap. 12--The Land Wears Away
Chap. 4--Earth Motions
Chap. 6--Energy Flow
Chap. 9--Waters of the Land

Most interesting chapter

1967 Survey	1968 Survey
Earth's Environment in Space followed by: Record of Life	Chap. 8--Water in the Air followed by: Chap. 12--The Land Wears Away Chap. 13--Sediments in the Sea Chap. 14--Mountains from the Sea Chap. 19--Life--Present and Past

Investigations enjoyed most

1967 Survey	1968 Survey
Those related to mapping and The Footprint Puzzle	9-3: Movement of Water in Earth 10-6: Investigating Current 5-1: Temperature Fields 13-4: Inv. Density Currents 12-6: Inv. Factors of Stream Erosion 12-7: Inv. Stream Action 6-2: Inv. Flow and Change in Energy

Number of days per week of laboratory preferred

1967 Survey		1968 Survey	
2-3 days	80%	2-3 days	37%
less time	8%	4 days	14%
		5 days	6%
		0 days	1%

Writing up laboratory reports was not too difficult		
	80%	84%
Mathematics background was sufficient		
	60%	84%
Did not need more study time than for other subjects		
	75%	26%
Homework was beneficial to understanding		
	25%	82%
Grades were the same as in other courses		
		58%
	high ability:	higher grade--35% lower grade-- 5%
	average ability:	higher grade--25% lower grade-- 14%
	low ability:	higher grade--11% lower grade-- 36%
Would you recommend this course to a friend		
	80%	
Plan to attend college		
	80%	87%
Plan to major in science		
	50%	35%

APPENDIX C

ATTITUDE TOWARD SCIENCE

ATTITUDE TOWARD SCIENCE

Please indicate your feelings toward each of the statements in this booklet. It will help us to improve the science program in your school. There are no right or wrong answers to the items. Our interest is in your opinion only.

Follow the directions on the first page of the booklet. A separate response sheet is provided. Simply place a check mark (✓) after each number corresponding to the sentences with which you agree; a cross (X) after each number corresponding to statements with which you disagree; or a question mark (?) after numbers corresponding to statements with which you are undecided.

Your responses to items in the booklet will in NO way affect your grade in any course you are taking--so BE HONEST.

Note: Please place your name on the response sheet.
Thank you for helping us.

ATTITUDE MEASURE SHOWING SCALE VALUES

ATTITUDE TOWARD SCIENCE

Please read each of the following statements carefully. Put a check mark (✓) if you agree with the statement. Put a cross (X) if you disagree with the statement If you simply cannot decide about a statement, you may place a question mark (?) beside it.

(Scale values)		
10.3	1.	No matter what happens, science always comes first.
10.2	2.	I would rather study science than eat.
9.8	3.	I love to study science.
9.7	4.	Science is of great value.
9.6	5.	Science has a very great attraction for me.
9.4	6.	I really enjoy science.
9.2	7.	Science is profitable to everybody who takes it.
9.1	8.	Science develops good reasoning ability.
9.0	9.	Science is very practical.
8.9	10.	Any student who takes science is bound to be helped.
8.8	11.	Science teaches me to be accurate.
8.7	12.	Science is useful in all aspects of life.
8.5	13.	Science is a good subject.
8.4	14.	All of our great men studied science.
8.3	15.	Science is important in people's lives.
8.1	16.	All lessons and all methods used in science are clear and definite.
7.9	17.	Science is O.K.
7.7	18.	I am willing to spend my time studying science.
7.6	19.	Science is not receiving enough attention in public schools.
7.3	20.	Science saves time.

continued

(Scale values)		
6.8	21.	Science is not a bore.
6.5	22.	Science is a good pastime.
6.1	23.	I don't believe science will do anybody any harm.
5.8	24.	I am careless in my attitude toward science, but I would not like to see this attitude become general.
5.5	25.	I haven't any definite like or dislike for science.
4.7	26.	Science will benefit only the brighter students.
3.6	27.	My parents never had science; so I see no merit in it.
3.5	28.	I could do very well without science.
3.4	29.	Average students never take science in senior high school; so it should be removed from schools.
3.3	30.	The minds of students are not kept active in science.
3.1	31.	I am not interested in science.
2.9	32.	Science does not teach you to think.
2.8	33.	Science is very dry.
2.6	34.	Science reminds me of the saying, "A lot of fuss about nothing."
2.5	35.	I have no desire for science.
2.4	36.	I have seen no value in science.
2.2	37.	I would not advise any one to take science.
2.1	38.	Science is based on "foggy" ideas.
1.6	39.	Science is a waste of time.
1.5	40.	It is a punishment for anybody to take science.
1.3	41.	Science is disliked by all students.

continued

(Scale
values)

1.0 42. I look forward to science with horror.

0.8 43. I detest science.

0.7 44. Science is the most undesirable subject taught.

0.6 45. I hate science.

NAME________________________________

RESPONSE SHEET FOR

ATTITUDE TOWARD SCIENCE

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______
10. ______
11. ______
12. ______
13. ______
14. ______
15. ______
16. ______
17. ______
18. ______
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28. ______
29. ______
30. ______
31. ______
32. ______
33. ______
34. ______
35. ______
36. ______
37. ______
38. ______
39. ______
40. ______
41. ______
42. ______
43. ______
44. ______
45. ______

APPENDIX D

SCIENCE PROCESS MEASURE FOR JUNIOR HIGH SCHOOL STUDENTS

SCIENCE PROCESS MEASURE

for

Junior High School Students

Please complete each of the problems to the best of your ability. Answer those questions you find easier first; then return to the harder problems

Do NOT write on these question pages

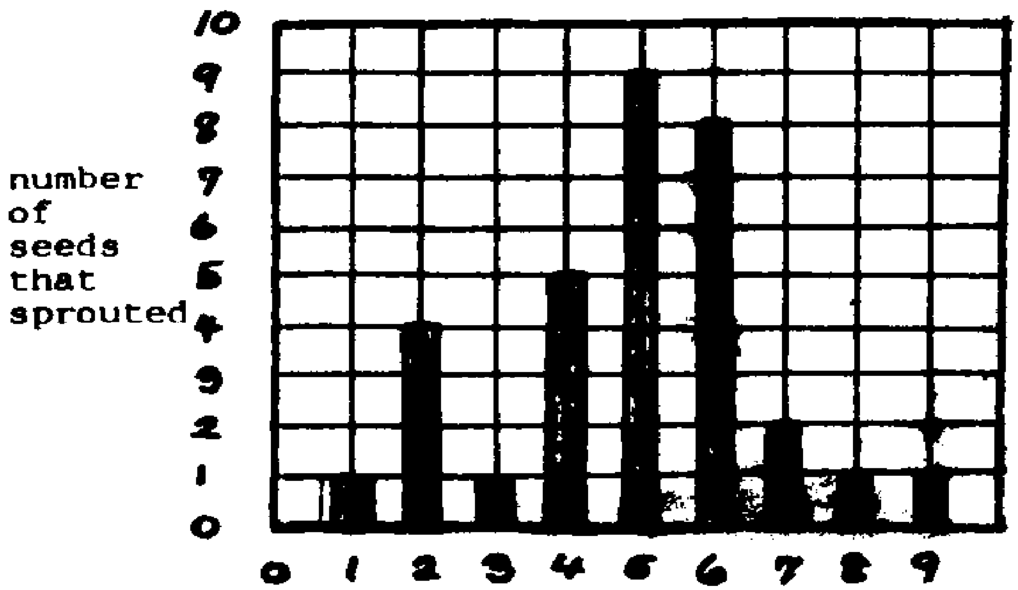
Place your name and all answers on the response sheets provided.

A supply bag has been provided. It contains a ruler and two sets of objects. You will need these supplies for questions 5, 6, 7, 8, 12, 13, 14.

Thank you for doing your best

SCIENCE PROCESS MEASURE

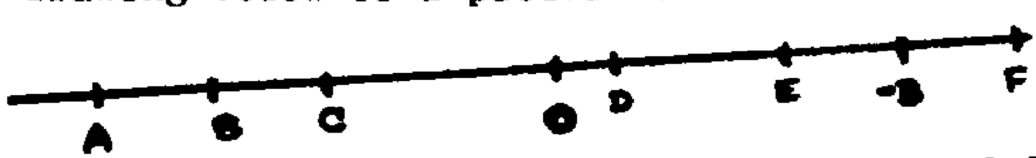
The eighth science class planted a mixture of several different kinds of seeds. The graph pictured below shows the number of seeds that sprouted over a period of nine days.



1. On the response sheet indicate the number of the day or days on which <u>more</u> seeds sprouted than on the <u>second</u> day.

2. On the response sheet indicate the number of the day or days on which <u>fewer</u> seeds sprouted than on the <u>fourth</u> day.

The drawing below is a picture of a number line.



3. On the response sheet indicate the position of 3.

4. On the response sheet indicate the position of ⁻2.

5. Remove the contents from the container marked (X). You will find this container in the supply bag. Empty the contents and examine them carefully. We will choose the <u>raisin</u> for this problem. On the response sheet write words that name observable properties of this raisin.

   Your description should be complete enough so some other person, who does not know which object we have picked, can select the raisin as the object described by you.

   When you are finished, replace the objects to the supply bag.

6. Remove the contents from the container marked (Z). Also remove the ruler. Empty the contents and examine them carefully. This time we will select the Wrigley's gum. On the response sheet describe this object as completely as you can. Be sure to use your ruler and the <u>metric</u> system for measurement.

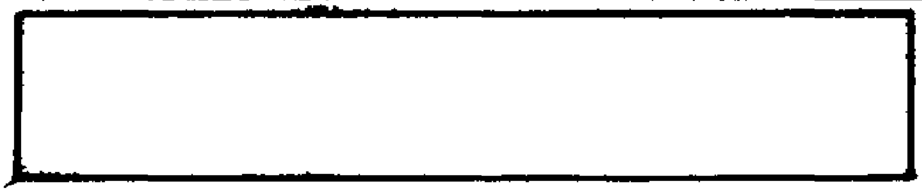
   When you are finished, replace the objects to the supply bag.

Here is a table of data collected during an experiment to see how long it took a white rat to travel a maze during a six day trial period.

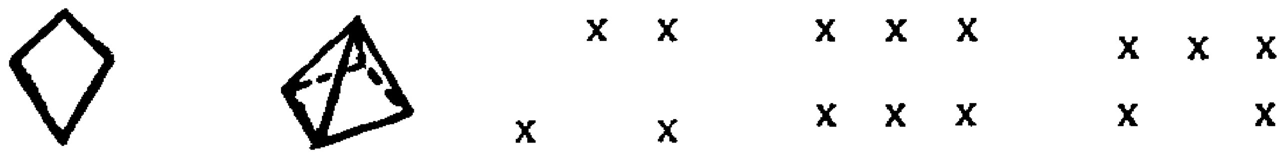
DAY	TIME TO TRAVEL MAZE seconds
MON	120
TUES	90
WED	60
THURS	40
FRI	30
SAT	25

7. Construct a bar graph on your response sheet which illustrates these data. Be sure to label the axes. (that is, be sure to write what each part of your graph is describing).

8. Remove the ruler from your supply bag. On your response sheet indicate the length of this rectangle. Write your answer to the nearest <u>millimeter</u>.



9. On your response sheet list <u>all</u> patterns which are symmetrical. (that is, can be divided into equal parts).

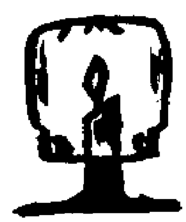


(1) (2) (3) (4) (5)

10. A text book states that the distance from planet (X) to its nearest moon is 6.61×10^{5} kilometers. On your response sheet indicate which of the following numerals represents 6.61×10^{5} .

(1) .0061
(2) 6.610
(3) 66,100
(4) 661,000
(5) none of these

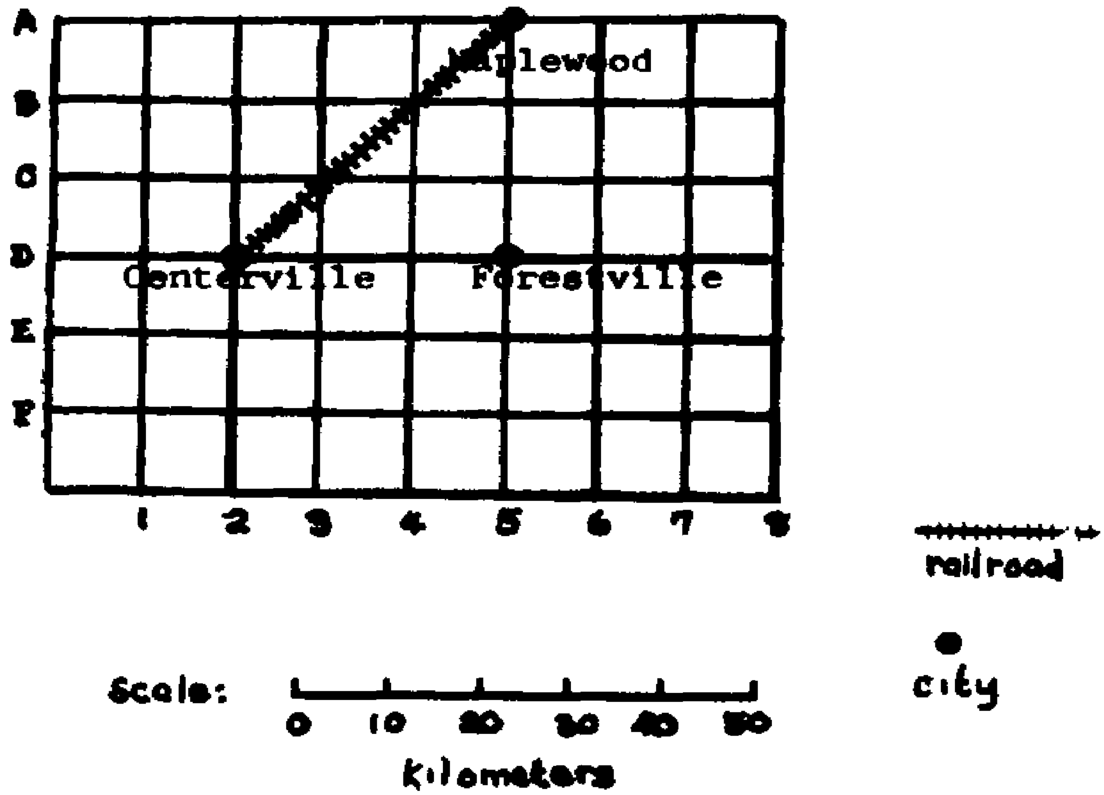
11. A candle goes out when a quart jar is placed over it. See drawing below.



On your response sheet indicate which of the following we can conclude from this information.

(1) oxygen is required for burning
(2) the air was all used up
(3) the candle no longer has enough of something to continue burning
(4) candles burn oxygen
(5) both (1) and (4)

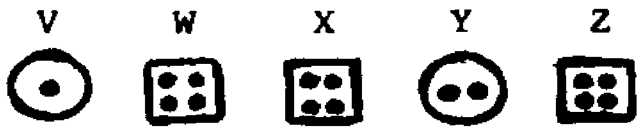
You will need the map pictured below and your ruler for the next three questions. Remember to write all answers on the response sheet.



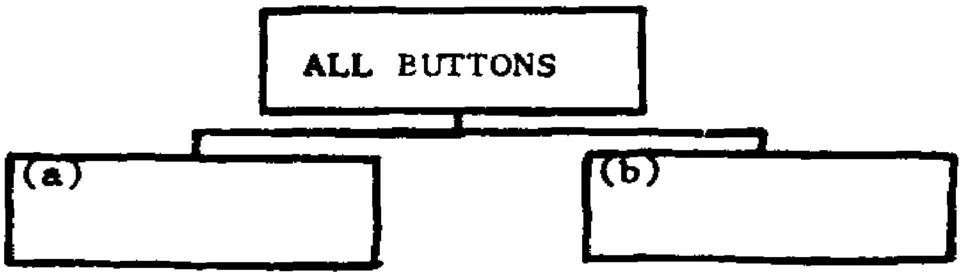
12. On this map, 1 cm represents how many kilometers?

13. Locate Centerville using the coordinates A,B,C, ... and 1,2,3, ...

14. A farmer lives 10 km from Forestville and at the intersection of a numeral and a letter. If that is all the information we have, what possible locations could his farm have? Mark these locations with x's on the map on the response sheet. Be sure to mark <u>all</u> correct responses.



15. The drawing shows five buttons. You are to divide these buttons into two groups. See the boxes pictured below.



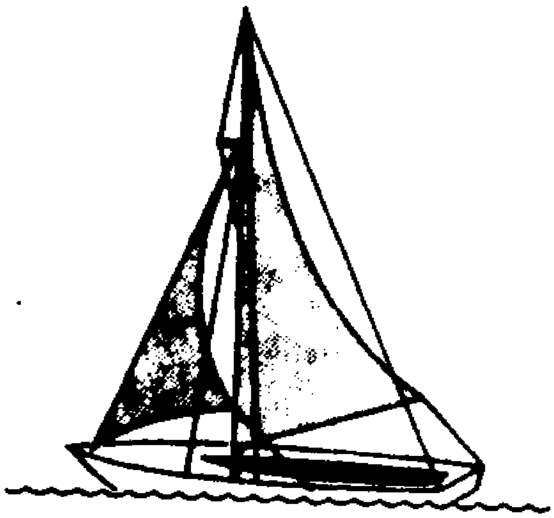
If buttons V and Y are placed into box (b), which buttons should be placed into box (a)? Choose your answer from the list below and write it on the response sheet.

(1) W
(2) W, X
(3) W,X,Z
(4) all of the buttons should be placed into box (b)
(5) there will be one button left over

---

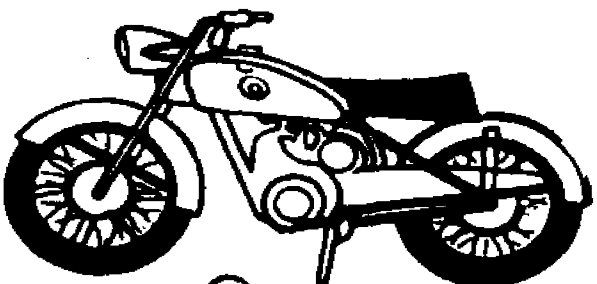
16. On the next page are drawings of eight means of transportation. Examine them carefully. Name three characteristic differences of these vehicles that you might use to classify them into groups. An example of such a characteristic could be: land travel vs. water travel.

On your response sheet list three more characteristics.

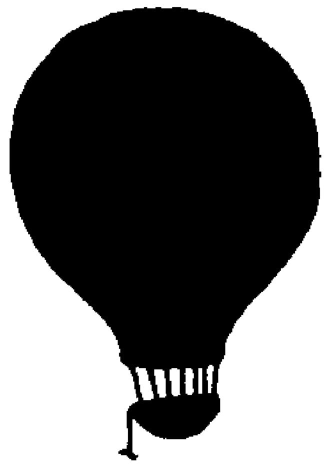


(A)

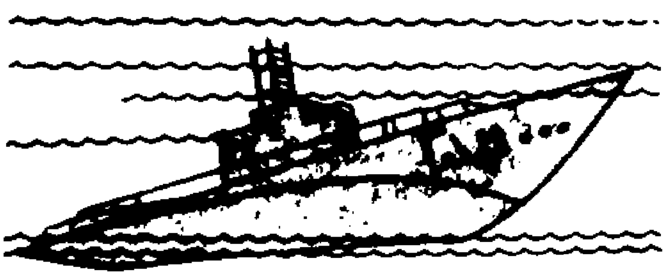
(B)



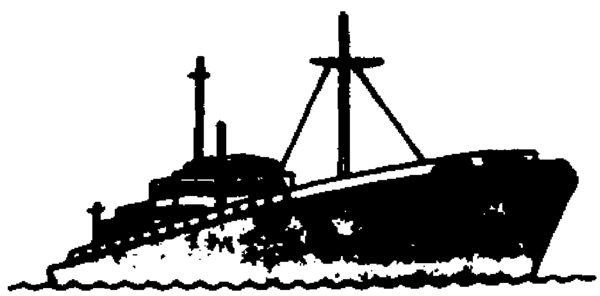
(C)



(D)

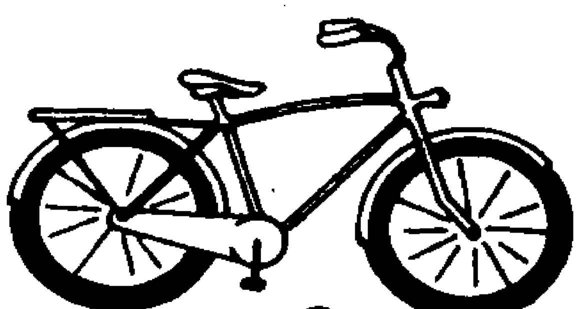


(E)



(F)

(G)



(H)

17. A diagram for a two-stage classification plan is drawn on the response sheet. Fill in the blanks so you can divide the vehicles from problem 16 in two groups at the stage one level.

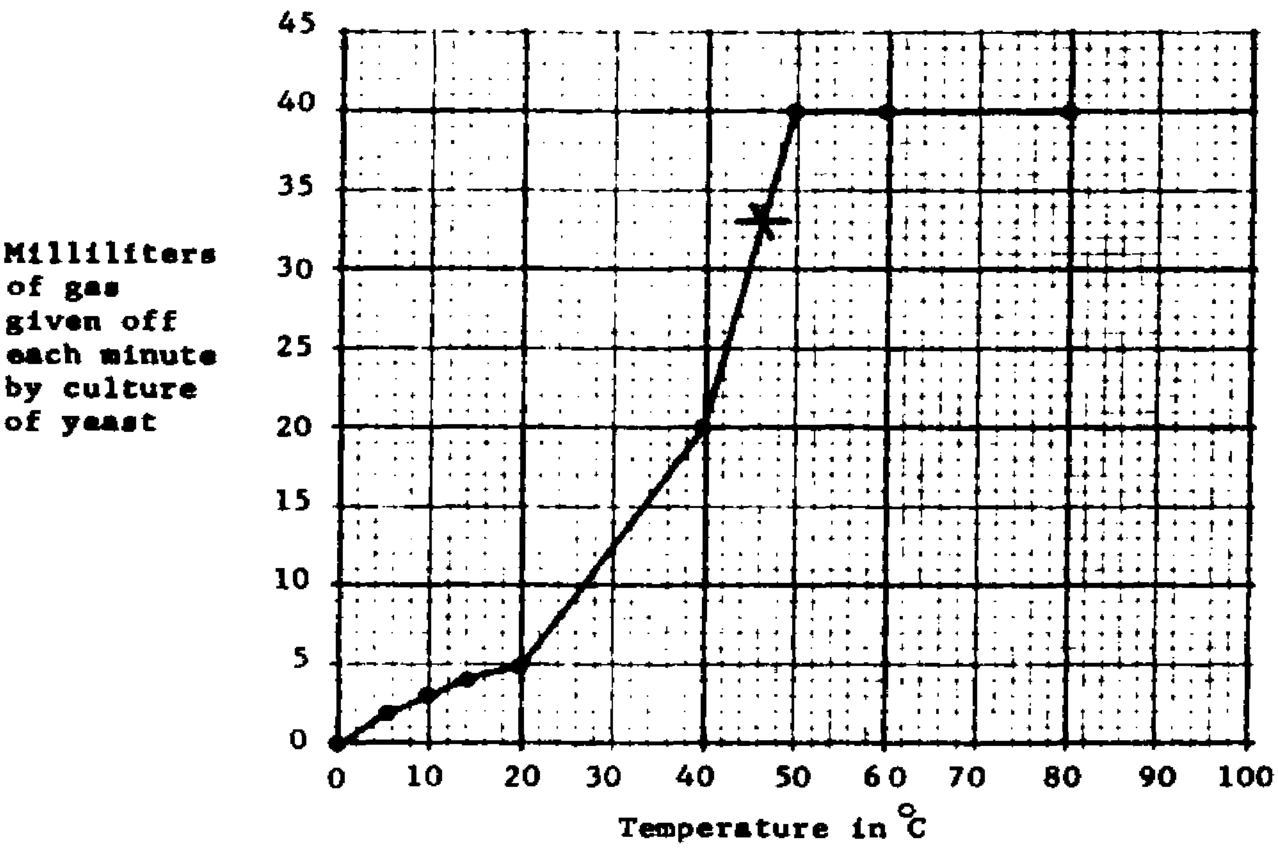
Complete the diagram by classifying the objects again at the stage two level.

Write the names of your characteristics on the lines provided (they may or may not be the same characteristics used in problem 16).

Write the correct capital letters on the lines provided.

Problem 18 refers to the graph pictured below.

Volume of Gas Given Off Each Minute by a Yeast Culture Grown at Different Temperatures



18. On your response sheet indicate the number of milliliters of gas you predict would be given off each minute if the culture of yeast were grown at 46° C.

Definition: An <u>inference</u> is something you think is true because of what you observe.
Example: Observation - you look out the window and see leaves on a tree moving.
Inference - there is a wind today.

19. Look at the picture of the tree. Which of the following statements are observations and which are inferences, if any? Encircle your answer on the response sheet.

(a) The tree in the picture has no leaves on it.

(b) The drawing shows the tree during the fall of the year.

(c) The tree is intended to look as if it were not alive.

(d) The tree in the picture is not symmetrical.

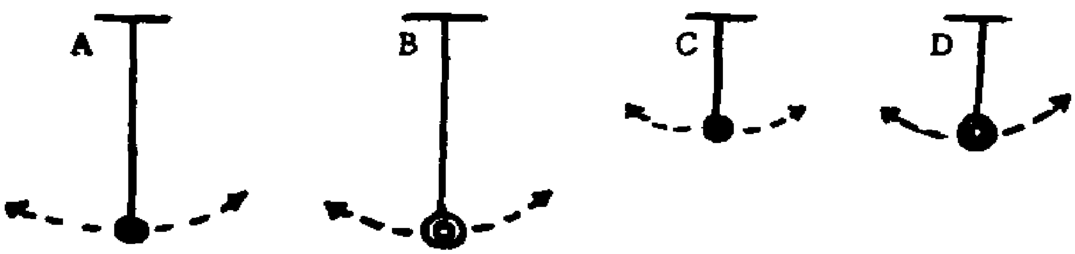
A kickball is 0.5 meter around (circumference). From the pitcher's mound to homeplate is ten meters. When a student rolls the ball on the ground, it takes two seconds for the ball to roll from the pitcher's mound to homeplate.

20. What is the average speed of the ball in units of distance per unit of time?

21. What is the average speed of the ball in number of revolutions per unit of time?

Definition: A <u>variable</u> is a condition that changes.

22. The eighth grade science class was investigating the problem of swinging pendulums. Four pendulums are pictured below. Pendulum (A) and (C) each have a five gram washer tied to a string. Pendulums (B) and (D) have ten gram washers tied to strings. Pendulum (A) was tested and it was found to swing back and forth twenty-five times in thirty seconds. When pendulum (C) was tested there were forty swings in thirty seconds.



What is the <u>variable</u> between (A) and (C) that is being tested? On your response sheet indicate the answer from the list below.

(1) weight of washers
(2) length of strings
(3) both weight and length
(4) the difference in number of swings
(5) the amount of time

Items 23 - 26 are concerned with the following chemical test on powders: Place answers on response sheet.

LIQUID	POWDER		
	baking soda	unknown	corn starch
vinegar	bubbled	bubbled	no reaction
unknown	bubbled	bubbled turned purple	turned purple
iodine solution	no reaction	turned purple	turned purple

23. What happened when the iodine solution was mixed with starch?

    (1) it bubbled
    (2) it turned purple
    (3) it bubbled and turned purple
    (4) it showed no reaction
    (5) none of the above

24. From the results indicated on the chart, one can conclude that:

    (1) baking soda and the unknown are the same substance
    (2) the unknown contains some baking soda
    (3) baking soda contains some of the unknown substance
    (4) the unknown contains no baking soda
    (5) the unknown contains no corn starch

25. One can conclude from these chemical test that:

    (1) the unknown liquid contains no vinegar
    (2) the unknown liquid contains no iodine
    (3) vinegar and the unknown are the same liquid
    (4) the iodine solution and the unknown are the same liquid
    (5) the unknown liquid contains some vinegar and some iodine

26. In this investigation which of the following could be considered the <u>variable</u>?

    (1) baking soda
    (2) all three of the liquids
    (3) the unknown powder and corn starch
    (4) the unknown powder and the unknown liquid
    (5) none of these

Definition: An <u>operational definition</u> explains what something is by telling what it does.

27. The best <u>operational definition</u> for the area of this paper is:

(1) how many one-inch blocks will fill it
(2) how large itis
(3) how many one-inch squares will cover its surface
(4) both (1) and (2)
(5) both (1) and (3)

28. Mr. Henry's class was studying science when the word <u>porosity</u> appeared. Mr. Henry prepared two demonstrations to help the students understand the word. The demonstrations were as follows:

A. Took a quart jar filled with marbles and poured one cup of sand over the marbles to allow the sand to sift downward.

B. Took a quart jar filled with sand and added one pint of water. The water filtered downward into the sand.

Probably the best <u>operational definition</u> of the word <u>porosity</u> would be:

(1) the amount of solid you add to a loosely packed solid without changing the volume
(2) the amount of liquid or solid that can occupy the spaces between liquid or solid particles without changeing the volume
(3) the amount of liquid that can be added to a solid without changing the volume
(4) the amount of liquid or solid that can be added to a loosely packed solid without changing the volume

29. An <u>experiment</u> usually involves the following process skill or skills:

(1) observing
(2) controlling variables
(3) making operational definitions
(4) none of the above
(5) involves (1), (2), and (3)

Items 30 and 31 are concerned with an experiment on behavior in mealworms. (a mealworm is the larva of a beetle) In this investigation a Q-tip was used. (a Q-tip is a small stick with a bit of cotton firmly attached to the end)

In the experiment a Q-tip saturated with water was thrust near a mealworm. The mealworm backed up.

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

    (1) mealworms are sensitive to water
    (2) mealworms can see objects moving toward them
    (3) mealworms are sensitive (or will react) to a Q-tip saturated with water
    (4) mealworms fear moving objects
    (5) none of the above hypotheses are correct

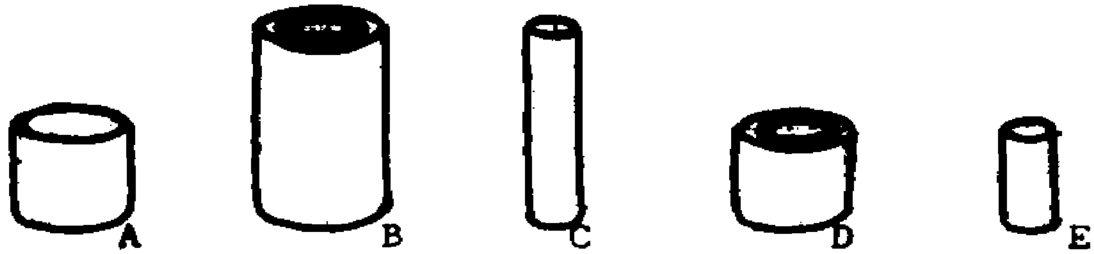
31. There is most justification for saying that:

    (1) mealworms always respond to water
    (2) the mealworm could see an object moving toward it
    (3) the mealworm responded to moist approaching cotton
    (4) mealworms do not like to be disturbed
    (5) mealworms will respond to anything new brought into their environment

---

32. For which of the following situations would you be most justified to set up an experiment?

    (1) determine the number of students wearing glasses in the classroom
    (2) determine the number of flashlight bulbs one flashlight battery can light
    (3) identify the observable properties of a Monarch butterfly
    (4) when given a handful of small rocks, you are asked to arrange the rocks into three separate groups
    (5) determining which of six shapes are symmetrical



33. The above drawing shows five copper rods. You will notice that the rods differ in length, diameter, and whether they are hollow (rods B & D), or solid (rods A, C, E).

    Suppose you roll these rods down an inclined plane (a slanted surface). You are testing to determine if there is any difference in the amount of time it takes for a solid and a hollow rod to reach the bottom of the inclined plane.

    Which two rods would you use in your experiment?

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

34. Jean watches a bull fight and states that bulls charge red objects. To test that idea she should use a bull and:

    (1) red objects and objects of other colors placed about the ring, but no matador.
    (2) a matador standing and holding various colored objects for a short time
    (3) a moving matador waving a cape that is red on one side and green on the other
    (4) a moving matador waving several capes of many different colors for a short time each.

35. A girl removed a lid from a jar by prying with the blade of a table knife. From that operation you might say a knife is a

    (1) sterling silver object with one sharp edge and a decorated handle
    (2) stainless steel object about eight inches long with a thin blade
    (3) metal object that can be used as a lever to open jars
    (4) form of an inclined plane that reduces the force needed to cut

RESPONSE SHEET FOR

SCIENCE PROCESS MEASURE

for

Junior High School Students

Write your name

HERE________________________

All answers are to be written on these pages

RESPONSE SHEET FOR SCIENCE PROCESS MEASURE

1. ____________________________________

2. ____________________________________

3. ____________________________________

4. ____________________________________

5. ____________________________________

____

____

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____

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6. ____________________________________

____

____

____

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____

7.

8. ______________________________

9. ______________________________

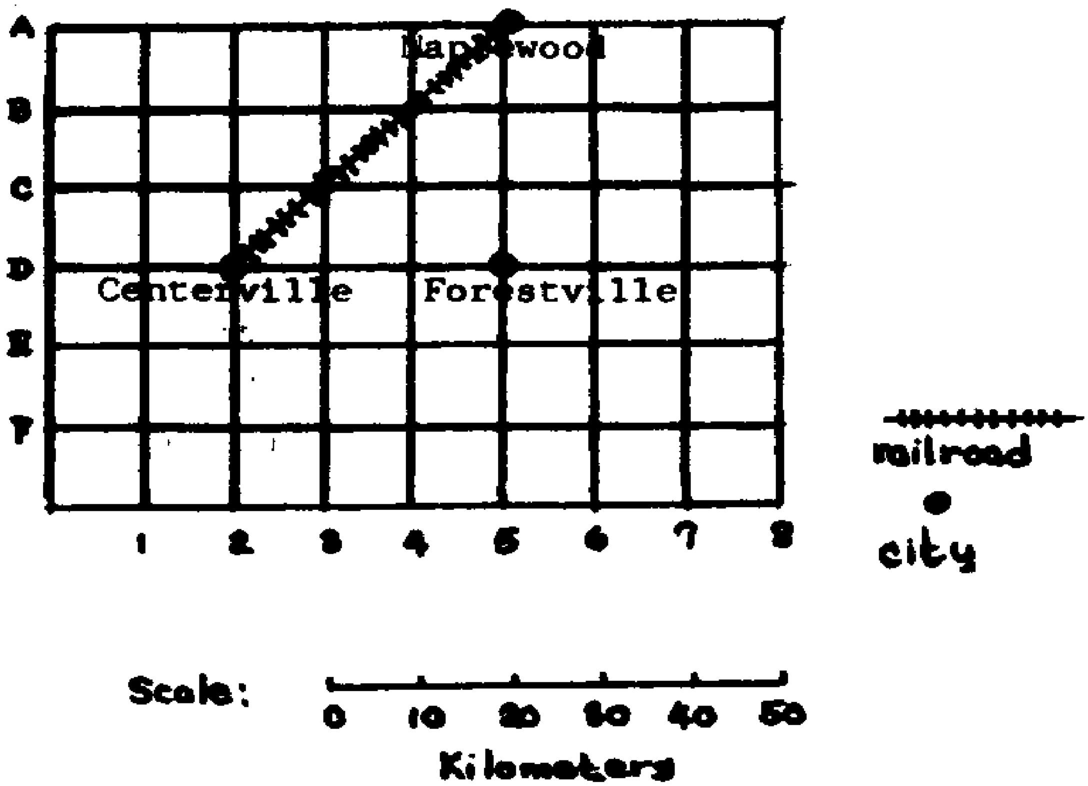
10. ______________________________

11. ______________________________

12. ______________________________

13. ______________________________

14. Write the x's on the map



15. ______________________________

16. ______________________________

____

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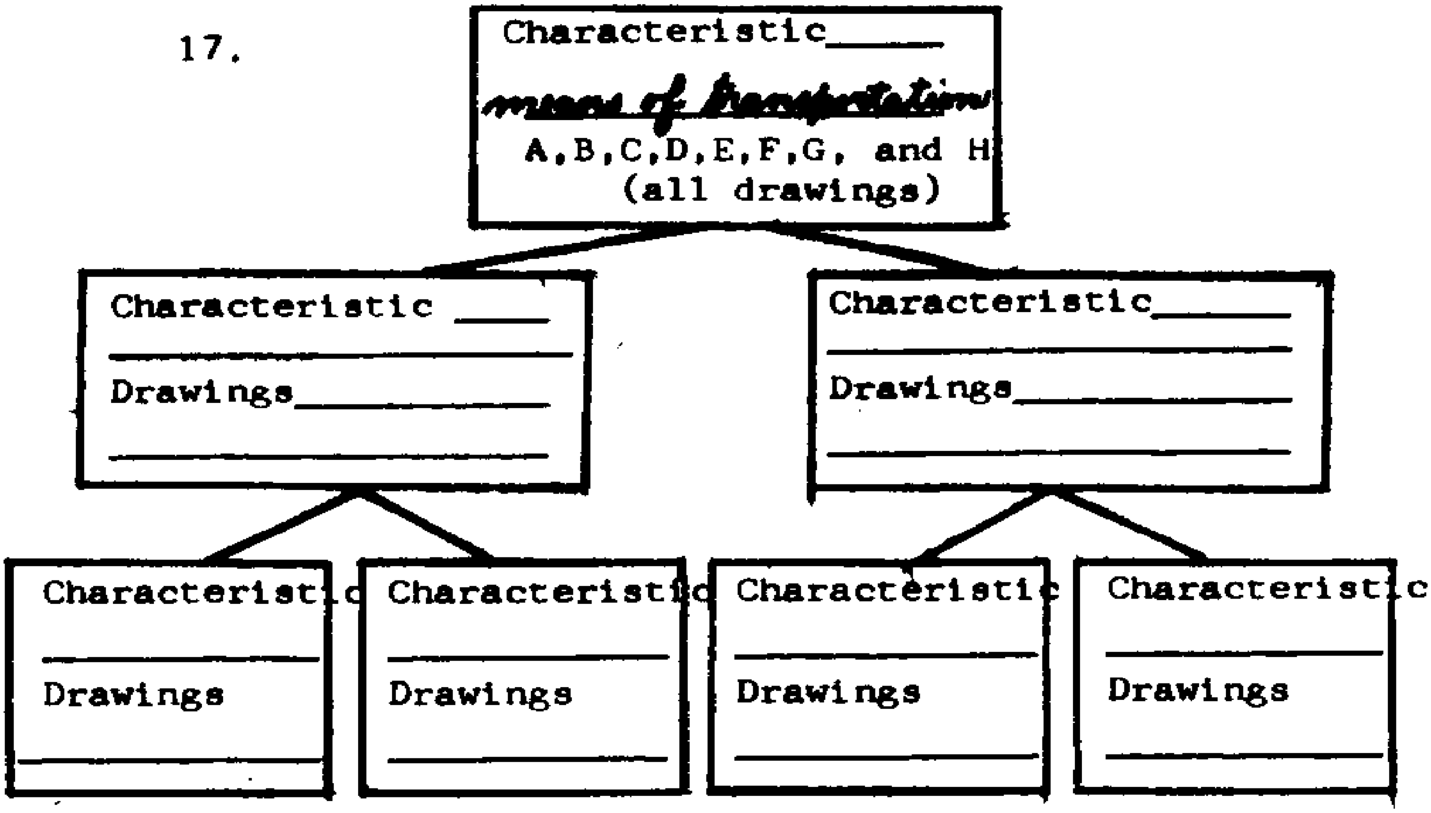
17.



18. ______________________ milliliters per minute

19. Circle the correct answer

(a) observation inference neither

(b) observation inference neither

(c) observation inference neither

(d) observation inference neither

20. ______________________

21. ______________________

22. ______________________

23. ____________________

24. ____________________

25. ____________________

26. ____________________

27. ____________________

28. ____________________

29. ____________________

30. ____________________

31. ____________________

32. ____________________

33. ____________________

34. ____________________

35. ____________________

WEIGHTING OF RESPONSES TO SCIENCE PROCESS MEASURE FOR JUNIOR HIGH SCHOOL STUDENTS

Process Measured	Problem Number in Test	Score Points Allowed	Acceptable Responses
Observation	5	4	one point each correct observation up to four correct observations
	6	2	one point each correct observation up to two correct observations, measurement responses not included
Space/Time Relationships	9	4	one point for each symmetry identified (1,2,4,5)
	20	1	5 M/sec
	21	1	10 rev/sec or 20 rev/2 sec
Classification	15	2	response (3)
	16	1	must list correctly two properties
	17	3	1 point first stage 1 point each part of second stage
Using Numbers	3	2	identify letter B
	4	2	identify letter E
	10	2	response (4)
Communication	1	1	all responses correctly identified (4,5,6)
	2	1	all responses correctly identified (1,2,3,7,8,9)
	7	4	1 point horizontal axis identified 1 point vertical axis identified 1 point graph accurately drawn 1 point drew bar graph
Prediction	12	1	response (10)
	13	1	response D-2
	14	2	1 point for each set of two responses correctly identified (D4, C5, D6, E5)
	18	2	response 33, 32 or 34 one point

continued

Inference	11	2	response (3)
	19	4	1 point for each correct response, a. observation b. inference c. inference d. observation.
Measurement	6	4	2 point accurate response for length 1 point approximate response 2 point accurate response for width 1 point approximate response
	8	2	2 points accurate response 9.8 cm 1 point approximate response
Formulating Hypotheses	30	2	response (3)
	31	2	3
	34	2	1
Defining Operationally	27	2	3
	28	2	4
	35	2	3
Controlling Variables	22	2	2
	26	2	2
	33	2	3
Interpreting Data	23	2	2
	24	2	2
	25	2	5
Experimenting	29	3	5
	32	3	2

APPENDIX E

ESCP ACHIEVEMENT TEST

ESCP ACHIEVEMENT TEST

Please answer each of the following questions to the best of your ability.

Do NOT write one these question pages.

Directions for using the Michigan State University answer sheet:

Write your name on the line following "YOUR NAME."

When your teacher tells you to begin, open the booklet and start the test.

All responses are to be indicated on the Michigan State University answer sheet.

This is how you will indicate your answer - Read the question and select the correct answer. Now choose one of the boxes on the answer sheet following the number of your problem. Box 1 = a, box 2 = b, box 3 = c , box 4 = d. You will never use box 5.

Choose the box that corresponds to your answer and shade it in.

Continue with the next problem.

Thank you for doing your best

ESCP ACHIEVEMENT TEST

1. What is the immediate cause of the wind?
   a. Coriolis effect
   b. pressure differences
   c. humidity differences
   d. rotation of the earth

2. 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

3. The entrance of water into the soil is called
   a. porosity
   b. capillarity
   c. infiltration
   d. permeability

4. Which of the following major physical features has the LEAST influence on climates of North America?
   a. the Gulf of Mexico
   b. the western mountain ranges
   c. the Mississippi River system
   d. the three main air-mass streams

5. 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

6. The moon has little or no atmosphere because
   a. plants never existed on the moon
   b. its gravitational field is too weak to hold an atmosphere
   c. the gravity field of the earth attracted the gases from the moon
   d. high temperatures from solar radiation caused the gases to escape

7. At a given instant, about what percentage of the earth is illuminated by the sun?
   a. 23
   b. 50
   c. 67
   d. 100

8. A location on a large continent has much colder winters and warmer summers than ocean locations at the same latitude partly because
   a. the subtropical high keeps the air dry
   b. the air masses do not originate over the oceans
   c. warm ocean currents keep ocean locations warm
   d. the transparency and circulation of water make it slow to heat and cool

9. The order of scale within the universe is best represented in which of the following?
   a. earth, sun, solar system, stars, galaxies
   b. sun, galaxies, earth, stars, solar system
   c. sun, earth,solar system, galaxies, stars
   d. galaxies, sun, earth, solar system, stars

10. Temperatures generally decrease toward the poles because
   a. air movement is generally toward the equator
   b. cold polar air masses prevent surface heating of the land
   c. cold surfaces do not absorb solar energy as readily as warm
   d. less solar energy per unit area falls on the earth's surface toward the poles

11. There is a greater concentration of water vapor in the atmosphere in the summer than in the winter because in summer there is
   a. greater air density
   b. more frequent thunderstorms
   c. stronger flow of air from the ocean
   d. higher rate of evapotranspiration

12. When air is cooled to a temperature at which it can hold no more moisture, it is said to be at the
   a. dew point
   b. evaporation level
   c. freezing temperature
   d. adiabatic temperature

13. The texture of an igneous rock gives information regarding the
   a. rate at which the rock cooled
   b. chemical composition of the rock
   c. origin of material from which the rock formed
   d. number of times the rock has been through the rock cycle

14. How do effects of physical weathering differ most fundamentally from those of chemical weathering?
    a. chemical weathering changes the composition of particles whereas physical weathering does not
    b. chemical weathering changes the size of particles whereas physical weathering does not
    c. physical weathering changes the composition of particles whereas chemical weathering does not
    d. physical weathering changes the size of particles whereas chemical weathering does not

15. The displacement of the spectral lines of a galaxy toward the long wave length (red end) indicates that the galaxy is
    a. exploding
    b. contracting
    c. approaching the earth
    d. moving away from the earth

16. Which of the following statements BEST describes landscape evolution?
    a. it occurs during Ice Ages only
    b. it occurs only on young landscapes
    c. it occurs whenever climate changes or crustal movements occur
    d. it is constantly occurring in response to natural processes

17. How does the astronomer study the gas between the stars?
    a. by observing supernovas
    b. by observing nuclear fusion in the gaseous cloud
    c. by collecting samples with interstellar space probes
    d. by examining the spectrum of radiation from distant stars which pass through the gas

18. 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

19. Which of the following is the best evidence of crustal movement?
    a. a lava flow
    b. a buried soil profile
    c. tilted sedimentary rocks
    d. sediments below sea level

20. The fossil record shows changes from primitive to more advanced forms of life and thus provides support for the theory of
    a. evolution
    b. relativity
    c. superposition
    d. uniformitarianism

21. A rock with a high percentage of open spaces has high
    a. porosity
    b. base flow
    c. capillarity
    d. permeability

22. Although quartz is made up of SiO_4 tetrahedrons, its chemical formula, SiO_2, can be explained by
    a. impurities in the mineral
    b. the sharing of oxygen atoms
    c. excess oxygen in the tetrahedrons
    d. different charges on the silicon atom

23. 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
    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

24. 3×10^3 equals
    a. 30
    b. 300
    c. 3000
    d. 30,000

25. Which of the following field quantities requires a direction as a part of its complete description?
    a. force
    b. density
    c. temperature
    d. air pressure

26. How does the rate at which heat is absorbed and radiated on black surfaces compare to the rate on light surfaces?
    a. it is faster
    b. it is slower
    c. it is the same
    d. it is either slower or faster depending upon the temperature

27. Geologic time is divided into "chapters" on the basis of
    a. erosional surfaces
    b. the fossil record
    c. the amount of rock deformation
    d. the thickness of sedimentary beds

28. The light year is a unit of
    a. time
    b. velocity
    c. distance
    d. acceleration

29. Runoff and erosion would probably be greatest on a land area that is
    a. sloping and contour plowed
    b. sloping and barren of vegetation
    c. gently sloping and covered with grass
    d. flat-lying and lightly covered with vegetation

30. There is evidence that Mars has drastic daily changes in temperature. Such changes can best be explained by
    a. a thin atmosphere
    b. its distance from the sun
    c. fluctuations in solar radiation
    d. reflection of heat by the atmosphere

31. What characteristic of metamorphic rock 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

32. What element is most common in the earth's crust?
    a. oxygen
    b. silicon
    c. hydrogen
    d. aluminum

33. 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

34. What happens to most of the water which falls as rain?
    a. it recharges the soil-moister deficit
    b. it becomes runoff and moves to the oceans
    c. it is stored in the soil as capillary water
    d. it is returned to the atmosphere through evapotranspiration

35. What is needed to determine the moon's distance from earth by the surveyor's method?
    a. the displacement of lunar specral lines on a spectrograph
    b. two points on earth of unknown distance and two sides of the triangle
    c. a sight on the moon to measure its angular diameter from one place on earth
    d. a base line of known distance between two observers on earth and two angles of the triangle

36. 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

37. About what percent of the earth's surface area is covered by ocean?
    a. 20
    b. 40
    c. 70
    d. 90

38. An echo sounder may be used to determine the
    a. depth of the mantle
    b. areas of crustal activity
    c. topography of the ocean floor
    d. density of water at the lower regions of the ocean

39. If the lowest temperature reading at a station on a given day was 5°C and the highest reading in the afternoon was 15°C, the daily mean temperature would be
    a. 3°C
    b. 5°C
    c. 10°C
    d. 20°C

40. 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

41. In a model of the earth with a diameter of 20 cm, about how far would man's deepest penetration of the crust extend?
    a. 0.025 cm
    b. 2.5 cm
    c. 7.6 cm
    d. 15cm

42. Which of the following supports the hypothesis that the earth's outer core is fluid?
    a. it transmits radio waves
    b. it does not transmit shear waves
    c. it is the source of volcanic materials
    d. it transmits shear waves faster than compressional waves

43. What causes a compass needle to point north?
    a. gravity
    b. magnetism
    c. electricity
    d. nuclear energy

44. Which of the following can form in the shortest length of time?
    a. a volcano
    b. a coral reef
    c. a soil profile
    d. a mountain range

45. A humid climate is one in which
    a. precipitation exceeds potential evapotranspiration
    b. more than 5 cm of precipitation falls during the driest months
    c. more than 10 cm of precipitation falls during the driest month
    d. more than 50 cm of precipitation falls in an average year

46. A star with a great mass tends to have a short life because it
    a. becomes a supernova
    b. consumes its fuel rapidly
    c. has a core of heavy elements
    d. collapses to form a white dwarf

47. The half-life of C^{14} is 5,700 years. What proportion of the original C^{14} would be left after 11,400 years?
    a. $\frac{1}{4}$
    b. $\frac{1}{2}$
    c. 3/4
    d. 7/8

48. Given only the distance of a planet from the sun, which of the following can be computed?
    a. its mass
    b. its orbital period
    c. its surface gravity
    d. its period of rotation

49. The fact that a degree of latitude is longer at the poles than at the equator proves that
    a. latitude lines are parallel
    b. meridians are not parallel
    c. the earth is not a perfect sphere
    d. the north star is not directly over the north pole

50. Why is the surface of the land irregular despite active gradation since the beginning of the earth?
    a. gradation is slow and inefficient
    b. parts of the crust have been uplifted
    c. gradation does not reduce elevation differences
    d. the deposition of sediment re-elevates the continents

51. What is the relationship between molecular motion and temperature?
    a. the faster molecules move, the higher the temperature
    b. the slower molecules move, the higher the temperature
    c. high temperatures result when molecules move in one direction
    d. high temperatures result when molecules move in opposing directions

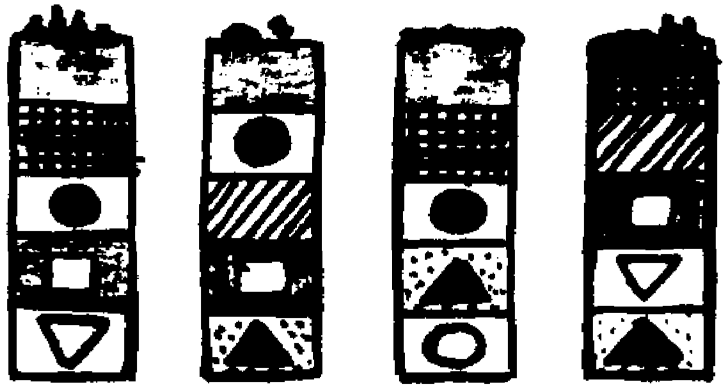
52. Of what importance to the hydrologic cycle are the tiny particles of dust found everywhere in the atmosphere?
    a. they aid in the processes of condensation and precipitation
    b. they increase the amount of evaporation that takes place
    c. they increase the amount of water the atmosphere can hold
    d. they are the source of most of the dissolved salt in the sea

53. Which was a mountain range folded towards the end of the Paleozoic?
    a. the Sierra Nevada
    b. the Rocky mountains
    c. the Appalachians mountains
    d. the Canadian Shield

54. One particularly important indicator of ancient climates is the
    a. radioactivity of the deposits
    b. thickness of sedimentary layers
    c. folding of sedimantary layers
    d. type and distribution of fossils

55. What is the Milky Way?
   a. a cloud of hot gas surrounding the earth
   b. a cluster of stars that is one of many in our galaxy
   c. an immense rotating system of many billion stars
   d. a cloud of hot interstellar gas that is the birth-place of new stars

56. Warm air tends to rise through cooler air because
   a. it weighs less
   b. it is less dense
   c. heat transfer decreases
   d. a convection cell is set up



57. What is the youngest rock shown?
   a. 
   b. 
   c. 
   d. 

58. Which of the following sequences correctly represents the rock units from oldest to youngest?
   a. 
   b. 
   c. 
   d. 

59. If the altitude of Polaris is 47 degrees, what is the observer's latitude?
   a. 0 degrees
   b. 25 degrees N
   c. 43 degrees N
   d. 47 degrees N

60. Which of the following is an example of one-way change?
    a. the hydrologic cycle
    b. the history of a piece of rock
    c. the evolution of animal life
    d. the movement of water by the atmosphere

61. If the distance between crests of incoming waves is 200 m and the time between each passing crest is 20 seconds, how fast are these waves traveling?

$$\text{wave velocity} = \frac{\text{wave length}}{\text{period}}$$

    a. 0.1 m/sec
    b. 5 m/sec
    c. 10 m/sec
    d. 4,000 m/sec

62. 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

63. The density of an object of a given volume is determined by its
    a. size
    b. mass
    c. shape
    d. weight

64. What is the ultimate source of energy for the biologic realm?
    a. plants
    b. the sun
    c. the soil
    d. photosynthesis

65. Which of the following mineral characteristics is NOT determined by the way the atoms are arranged?
    a. shape
    b. color
    c. hardness
    d. the way it breaks

66. What is the cause of the earth's seasons?
    a. its elliptical orbit and varying speed of revolution
    b. its greater distance from the sun during winter than summer
    c. inclination of its axis of rotation to the plane of its orbit
    d. variation in the amount of energy given off by the sun

67. For rocks containing fossils, which of the following would probably be the oldest?
    a. birds
    b. trilobites
    c. horse teeth
    d. dinosaur bones

68. If astronomers on earth note that a certain distant galaxy is apparently receding from the Milky Way galaxy, what conclusion may be drawn?
    a. only our galaxy is moving
    b. only the distant galaxy is moving
    c. both galaxies are moving
    d. either or both galaxies may be moving

69. A swimmer or a ship will float higher in seawater than in fresh water because the
    a. density of seawater is greater
    b. density of seawater is usually less
    c. amount of hydrogen in seawater is greater
    d. thermocline is nearer the surface in seawater

70. If the solar system formed from the hydrogen-filled clouds of cosmic dust, what conclusion would be most logical concerning other planetary systems?
    a. they would be very rare
    b. they would all be about the same age
    c. they would all be about the same size
    d. they would be common throughout the universe

APPENDIX F

ESCP COMPREHENSIVE FINAL TEST

ESCP COMPREHENSIVE FINAL TEST

1. Temperatures generally decrease toward the poles becaues
   1. cold polar air masses prevent surface heating.
   2. the earth's axis is not perpendicular to its orbital plane.
   3. cold surfaces do not absorb solar energy as readily as warm surfaces.
   4. less solar energy per unit area falls on the surface toward the poles.

2. What factor determines the potential evapotranspiration of any area?
   1. Soil porosity
   2. Annual precipitation
   3. Availability of water
   4. Availability of energy

3. In the "concentric-shell" model of the earth, what happens to the shell density from the earth's core outward?
   1. It increases
   2. It decreases
   3. It remains the same
   4. It decreases to a point and then increases

4. The conclusion that large areas of the present continents have been covered by the sea during long periods of geologic time is best supported by evidence found in
   1. the fossil record.
   2. radioactive dating.
   3. study of coastline features.
   4. relative uplift of modern coastal areas.

5. The rate of flow of water through a rock is determined by the
   1. types of minerals which make up the rock.
   2. total amount of space between mineral grains.
   3. number of connected pore spaces and their size.
   4. position of the rock with respect to the water table.

6. The major way through which moisture is returned to the ocean is by means of
   1. ground water.
   2. gravity water.
   3. surface runoff.
   4. continental air masses.

7. Which of the following interfaces would be easiest to identify?
   1. Galaxies-intergalactic space
   2. Atmosphere-interplanetary space
   3. Atmosphere-hydrosphere at 0° C
   4. Atmosphere-hydrosphere at 100° C

8. What is the single most important factor controlling the life history of a star?
   1. Mass
   2. Size
   3. Density
   4. Temperature

9. Landscape evolution is best described as occurring
   1. only on young landscapes.
   2. only during periods of maximum rainfall.
   3. only when climate changes or crustal movements occur.
   4. constantly in response to natural agents and processes.

10. The fundamental difference between the continental and oceanic crusts is in
    1. elevation.
    2. structure.
    3. thickness.
    4. composition.

11. The best evidence that not all of the solar radiation reaching the earth is lost by reradiation may be found in
    1. fossils.
    2. volcanoes.
    3. coal deposits.
    4. ocean currents.

12. The presence of wave-cut terraces 30m above present sea level would most likely indicate that
    1. the land mass has risen.
    2. tides were higher in the past.
    3. storm waves were higher in the past.
    4. either land or sea level has undergone change.

13. What fundamental assumption is made by geologists when they interpret the geologic record found in the rocks?
    1. The temperature of the earth was much higher when the earth was first formed
    2. The composition of the atmosphere and oceans has not changed significantly with time
    3. Chemical and physical processes took place during geologic history that do not take place today
    4. Features found in rocks were produced by the same processes which are producing those features today

14. How does the amount of water that escapes from the soil through vegetation compare with the amount carried away by rivers in the United States?
    1. The amount in each case is about the same
    2. The amount carried by rivers is at least 100 times greater
    3. The amount that escapes through vegetation is greater
    4. The amount that escapes through vegetation is insignificant

15. Which earth process would be increased if there were a slight increase in solar energy received by the earth?
    1. Erosion
    2. Infiltration
    3. Evapotranspiration
    4. Mountain building

16. If the solar system were reduced to the size of a pinhead, how big would our galaxy be on the same scale?
    1. About the size of a golfball
    2. About the size of an automobile
    3. About 30m across
    4. About 320km across

17. A mass of fragmented rock will weather faster than a solid mass of the same weight and chemical composition because
    1. surface area is increased.
    2. the volume of the material is increased.
    3. molecular structure is altered by crushing.
    4. the inner structure of the material is exposed.

18. Which of the following conclusions in earth science is based on limited data with heavy dependence on assumptions and inference?
    1. The density of the earth is 5.5 gm/cm^3
    2. The half life of U^{238} is 4.51×10^9 years
    3. The solar system is about 5×10^9 years old
    4. The earth is tilted 23 1/2 degrees to the ecliptic plane

19. Which of the following best summarizes the reasons why the ancients did not arrive at the correct nature of the solar system?
    1. Newton's laws were not known and good telescopes were not available
    2. Kepler's laws were not known and ancient mathematics was inadequate
    3. They viewed the system from within and the earth seemed to be at rest
    4. The sun was not known to be a star and the spectroscope was not available.

20. Which of the following does NOT support the statement that the seasons are due to ellipticity of the earth's orbit?
    1. The sun's energy output remains essentially constant
    2. The sun's rays are essentially parallel when they reach the earth
    3. The earth's axis of rotation is perpendicular to its orbital plane
    4. Summer in the Northern Hemisphere occurs at the same time as winter in the Southern Hemisphere

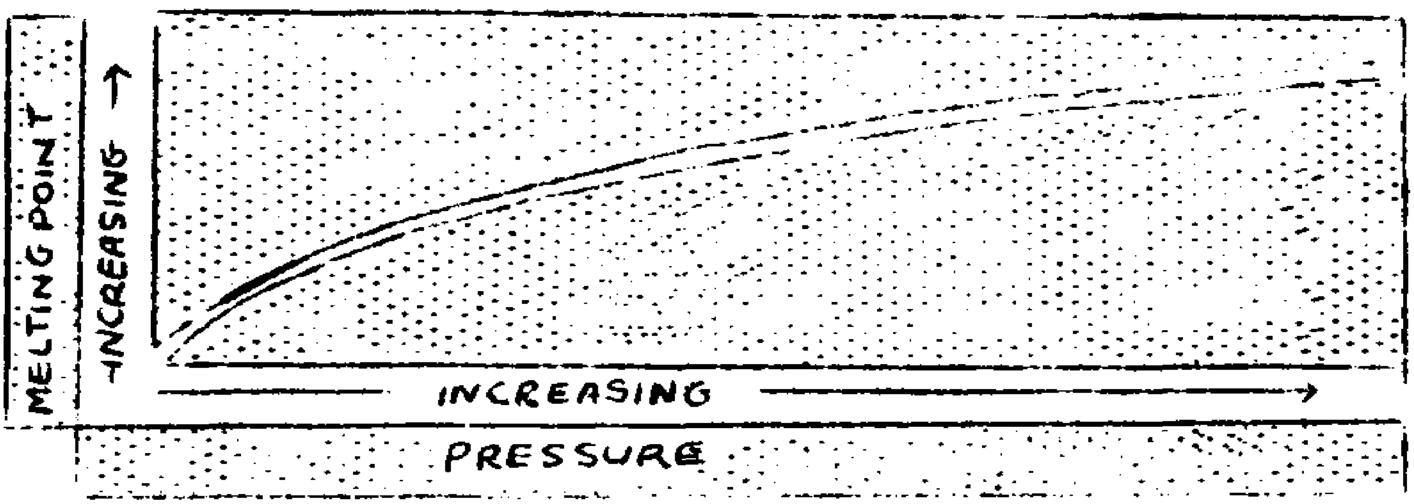
21. Which of the following is the best statement of uniformitarianism (simplicity)?
    1. The fundamental laws of nature do not change with time
    2. The earth and all its features are undergoing constant change
    3. Although earth processes produce change, their intensity is constant
    4. The surface of the earth is gradually being reduced to a level plain

22. What two factors control the magnitude of a star?
    1. Size and color
    2. Luminosity and distance
    3. Age and location in the galaxy
    4. Apparent brightness and distance

23. If the earth's mass remained the same but its diameter were reduced to one-half of its present size, what would be the effect on the earth's atmosphere?
    1. It would expand and escape into space
    2. It would contain more oxygen and less nitrogen
    3. It would decrease in density and in water vapor content
    4. It would increase in density and decrease in volume

Question 24 is based on the following information and graph.

The melting point of a substance at various pressures was determined and plotted on a graph as shown.



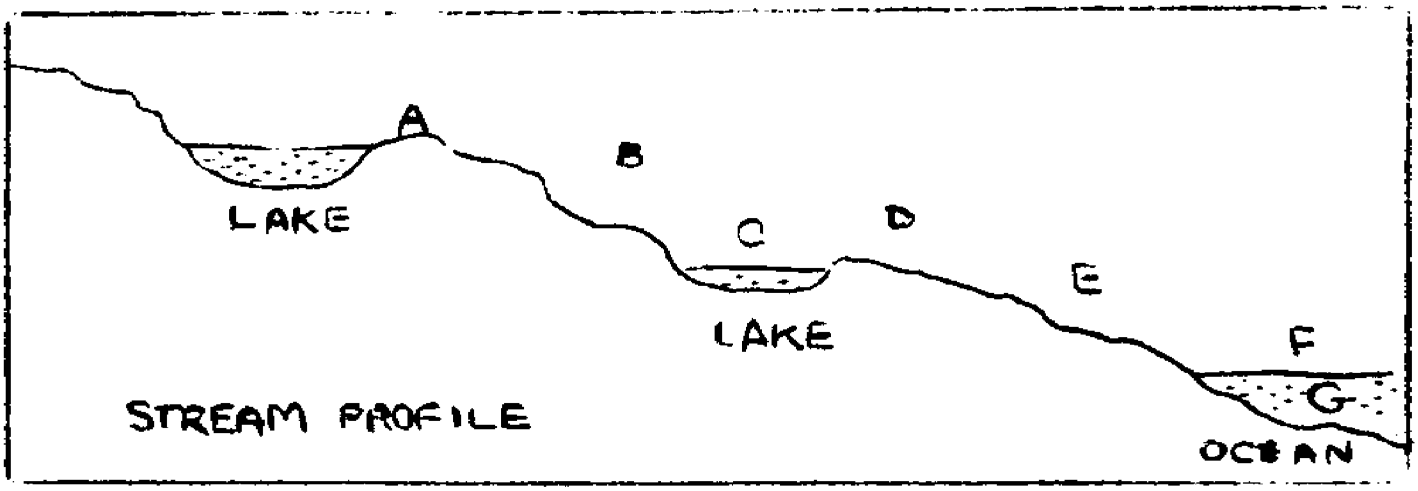
24. Which of the following conclusions can be made with these data?
    1. Pressure increases with temperature
    2. Pressure is dependent on temperature
    3. Melting point increases with pressure
    4. Melting point is directly proportional to pressure

25. The statement "the earth's core is composed chiefly of iron," is best described as
    1. A fact.
    2. an inference.
    3. an assumption.
    4. an observation.

26. One of the major problems in the study of the origin of life is that
    1. organisms, once developed, modify their environment.
    2. radioactive decay destroyed part of the record of life.
    3. the variation within a species is too complicated for study.
    4. too much time has passed for us to reconstruct what happened.

27. The most constant environment in the oceans is found on the
    1. abyssal sea floor.
    2. mid-ocean ridge.
    3. continental slope.
    4. continental shelf.

Questions 28 and 29 are based on the following diagram.



28. In which area would the potential energy of the stream be the highest?
    1. A
    2. C
    3. D
    4. E

29. In which area would the kinetic energy of the stream be at a maximum?
    1. A
    2. B
    3. C
    4. E

30. The sediments most likely to be deposited on the deep ocean floor are those carried by
    1. waves
    2. glaciers
    3. fast streams
    4. turbidity currents

31. Which of the earth's characteristics is LEAST likely to change in the next billion years?
    1. The earth's orbit
    2. Height of mountains
    3. Seawater composition
    4. Atmospheric composition

Questions 32-34 are based on the following information and table.

Four students determined the boiling point of pure water by boiling 5 beakers of water at sea level. The determinations were made during the same class period with following results in °C.

Trial	Student A	Student B	Student C	Student D
1	101	100	104.5	105.15
2	99	99	97.5	102.85
3	102	100	101.5	102.25
4	98	98	100.0	97.95
5	100	98	101.0	101.80
Average reading	100	99	100.9	102.00
Spread	4	2	7.0	7.20

32. Which student obtained the most accurate results?
    1. A
    2. B
    3. C
    4. D

33. Which student obtained the most precise results?
    1. A
    2. B
    3. C
    4. D

34. The differences in the results obtained by the four students are most likely due to variations in the
    1. atmospheric pressure within the room.
    2. boiling point of pure water at sea level.
    3. accuracy with which the thermometers were read.
    4. recording of the temperature to the nearest 0.01°C

35. A lake that stays at one level is considered to be in a state of
    1. static equilibrium.
    2. dynamic equilibrium.
    3. climatic stability.
    4. climatic instability.

36. What is the result of a decrease in the kinetic energy of a stream?
    1. Down-cutting will decrease
    2. Turbulent flow will develop
    3. .Suspended material will increase
    4. Dissolved material will increase

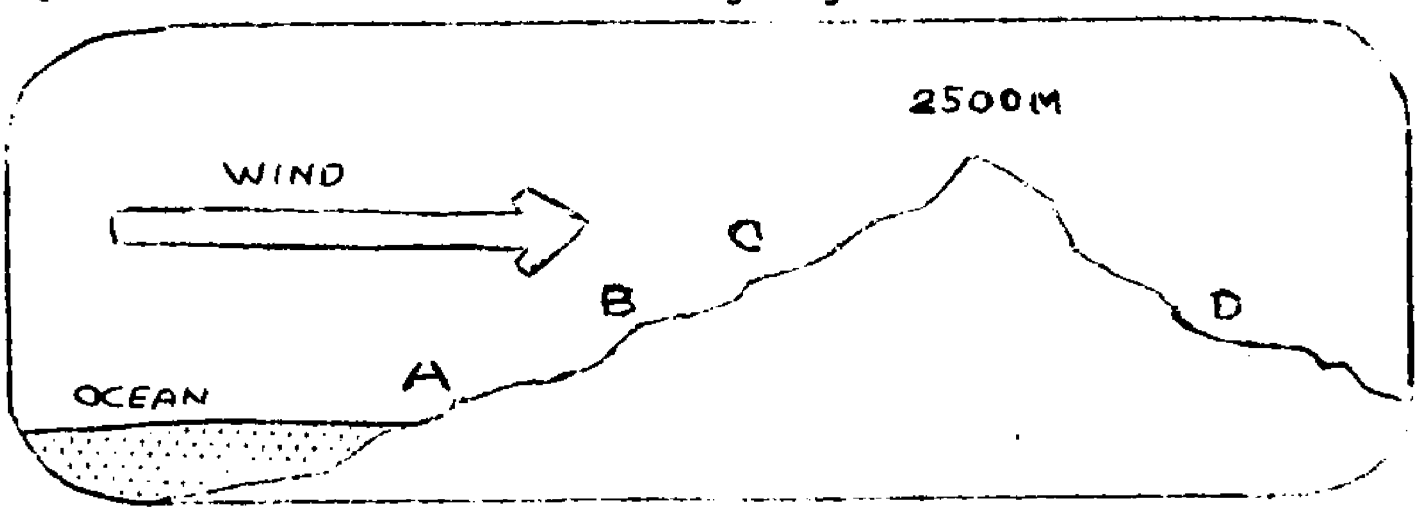
37. The two factors most responsible for the general shape of the earth are mass and
    1. density.
    2. rotation.
    3. revolution.
    4. precession.

38. Which of the following is the LEAST likely to destroy the identity of the minerals in a rock?
    1. Melting
    2. Crushing
    3. Weathering
    4. Dissolving

39. The physical and chemical stabilities of silicate minerals can be explained on the basis of
    1. mineral density and color.
    2. their chemical composition and color.
    3. oxygen-sharing between silicon-oxygen tetrahedrons.
    4. the number of silicon-oxygen tetrahedrons in a mineral grain.

40. Which fo the following factors can be changed without varying the amount of energy received from the sun?
    1. Mass of the sun
    2. Diameter of the sun
    3. Distance from earth to sun
    4. Speed of rotation of the sun

Question 41 is based on the following diagram.



41. Which location would probably have the greatest annual rainfall and which location would probably have the least annual rainfall?
    1. A-greatest and C-least
    2. B-greatest and A-least
    3. C-greatest and D-least
    4. D-greatest and B-least

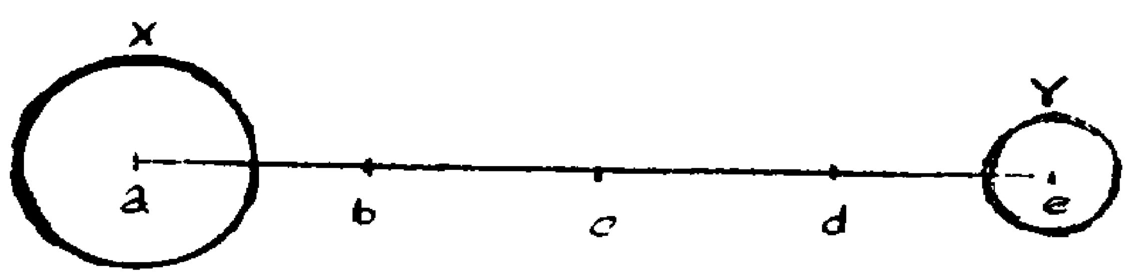
42. Which of these earth processes would be the first to cease if no solar energy reached the earth?
    1. Volcanism
    2. Weathering
    3. Infiltration
    4. Precipitation

43. In the spectrogram of a star, the shift of spectral lines toward the red is interpreted to mean that
    1. the object is composed of unusual atoms.
    2. astronomical bodies are moving away from the earth.
    3. the different kind of radiation is produced by distant stars.
    4. light from stars travels more slowly than light from the sun.

44. The refraction of waves as they pass from one material to another is caused by a change in
    1. velocity.
    2. thickness.
    3. transparency.
    4. reflectivity,

45. What are the major causes of ocean currents?
    1. Wind and differences in density
    2. Variations in turbidity and depth
    3. Differences in temperature and latitude
    4. Changes in salinity and oxygen content.

Questions 46 and 47 are based on the following diagram



46. If X and Y revolve about point d, then the mass of X must be
    1. less than the mass of Y.
    2. equal to the mass of Y.
    3. three times as great as the mass of Y
    4. nine times as great as the mass of Y.

47. If X and Y have equal masses and the same amount of material in their atmospheres then the atmospheric pressure on Y would be
    1. 1/16 as great as that on X
    2. 1/4 as great as that on X
    3. equal to that on X
    4. greater than that on X

48. What generally happens to the flow of ice when a glacier begins to recede?
    1. The ice stops moving
    2. The ice moves sideways
    3. The ice continues to move forward
    4. The ice reverses its direction of movement

49. Which of the following releases the greatest amount of energy?
    1. A hurricane
    2. A solar flare
    3. A major earthquake
    4. An explosive volcanic eruption

50. The development of mature soil is a good example of
    1. gradation
    2. modern farming
    3. adjustment of earth materials to their environment
    4. conservation of energy at the lithosphere-atmospheric interface.

51. The reason the oceans contain very little silicon or aluminum, whereas the crust contains large amounts of these elements, is that silicon and aluminum are
    1. more abundant in river water than in seawater
    2. not transported to the sea in large amounts.
    3. decomposed by chemical weathering on the land,
    4. not as soluble in water as the other abundant elements.

APPENDIX G

TEACHER LOGS

November 6, 1970

Memo to Carman ESCP teachers

From Del Mueller

This memo is a request for your assistance in the evaluation of the ESCP as implemented at Carman.

I believe you have been informed by Dr. Brehm regarding the 883 - 3 credit course offered as independent study through MSU. The following is an attempt to inform you regarding the organization and implementation of the course:

To better ascertain the objectives and content of ESCP at Carman, you will be asked to supply information to daily questionnaires regarding material covered during THREE separate FOUR WEEK intervals.

The three suggested log periods are:

November 16, 1970 through December 11, 1970
January 11, 1971 through February 5, 1971
March 1, 1971 through March 26, 1971

During each of these four week periods you will be asked to keep a brief daily log of your

a. general objectives for the day
b. pages referred to in the text
c. time devoted to this particular lesson approach
d. if lab exercise - the process(es) emphasized
e. brief statement of results, and
f. indication of students attitude toward science

This is in no way intended to be a lesson plan. However, we feel, and hope you agree, that it will help you to focus daily emphasis for your class, and help us to better understand the program as used in the Carman District. I say this, because as you know, each teacher focuses on certain aspects of the program; some following closely to the text, others selecting portions felt more applicable, and others augmenting with supplementary materials. There will be no attempt to evaluate the teacher. The present intent is to pool all reports into a general picture of what received greater emphasis and what recieved less emphasis at Carman. We want to be able to say, "Based on the sample r.. reports, these are the things we tried to do at Carman."

November 6, 1970

Memo to Carman ESCP teachers

Page 2

We will use this information to help us determine if the materials allowed us to do thejob the way we wanted it to be done.

The completion of the questionnaires will constitute the major part of the requirements for the independent study. We may find it necessary to ask for some additional information, but it is felt this will not entail any major effort on your part.

It may be that you are not interested in the three credits offered with 883. We would still appreciate your cooperation by providing feedback through the daily record logs. We hope you will be able to participate.

Beyond this I can only say, "Thank you for efforts above the call of duty."

If you have questions, Dick Cooper or myself are at your service. If necessary I will be glad to meet with you personally.

Sincerely,

Delbert Mueller
810B Cherry Lane
E. Lansing, MI 48823

Phone (517) 355-8149

TEACHER NAME________________________CLASS HOUR____DATE________________

LESSON TITLE____

CONCEPT TAUGHT____

TYPE OF LESSON

Lecture, demonstration, and/or discussion________number of minutes

Pages in text: From____to____Inv the Earth; From____to____Mod Ear Sci

- -

Laboratory lesson_________number of minutes

Pages in text: From____to____Inv the Earth; from____to____Mod Ear Sci

- -

If other sources were used, please indicate type of lesson, book,
and pages____

Additional comments____

____

IF YOUR LESSON WAS A LAB EXERCISE - to which of these AAAS Processes were the children exposed? Indicate ALL you believe applicable.

USE THIS SCALE to indicate emphasis given to each process taught:

3. strongly emphasized
2. moderately emphasized
1. slightly emphasized

_____observation

_____classification

_____using time/space relationships

_____using numbers

_____communication

_____measuring

_____inferring

_____predicting

- - - - - - - - - - - - - - - -

_____formulating hypothesis

_____making operational definitions

_____controlling and manipulating variables

_____interpreting data

_____experimenting

- -

General comments on how it all worked out______________________________

____

____

Please RANK your students on ATTITUDE TOWARD SCIENCE for today's class.

_____very enthusiastic; _____moderately enthusiastic;

_____average enthusiasm and interest

_____somewhat uninterested; _____very uninterested.

(use reverse side for additional comments)

DEFINITIONS FOR THE THIRTEEN AAAS PROCESSES

OBSERVATION - any or several of the senses; sight, touch, hearing taste, smell are used. Observation includes IDENTIFICATION OF PROPERTIES, ie., shape, color, weight, density, texture, etc.

Example: discussion of minerals involves identification of properties - shape, fracture, texture, specific gravity, etc.

CLASSIFICATION - using observable properties to separate materials into groups.

Example: classifying rocks as sedementary, metamorphic, and igneous; dividing all matter into over 100 elements using the periodic table.

USING TIME/SPACE RELATIONSHIPS - involves location in space and time; symmetry, motion and speed, vectors, km/hr, mi/hr, relative motion and position, planetary and satellite motion, etc.

Example: relative motion of earth and moon, or earth and sun.

USING NUMBERS - involves use of positive and negative numbers, exponents, scientific notation, number line, degrees, formulas, - mathematics as applied to science.

Example: expressing a certain wave length using scientific notation.

COMMUNICATING - involves preparing data sheets, tables, graphs, histograms, etc.

Example: student graphs temperature changes over a period of time.

MEASURING - involves use of METRIC system.

Example: student measures rainfall in cm; student measures weight of two equal volumes in grams.

INFERRING - an inference is something you think is true because of what you observe.

Example: Observation - you look out the window and see leaves on a tree moving.
Inference - there is a wind today.

Observation - a trilobite is found in Devonian rock.
Inference - the trilobite is 400,000,000 years old.

page 2 DEFINITIONS FOR THE THIRTEEN AAAS PROCESSES

PREDICTING - this is a special kind of inference. An inference derived from interpolation or extrapolation from a table of data or from a graph is called a prediction.

Example: Using data showing the mean temperature for the first day of each month the student can predict the temperature that existed for the fifteenth day of each month. (interpolation)

Using data of relative position of the big dipper over past years the scientist can predict the position of the big dipper 100,000 years from now. (extrapolation)

The following are called integrated processes for they involve the integration of one or more processes.

FORMULATING HYPOTHESES - a hypothesis is a general statement that includes all objects or events of the same class. It could be an explanation in which case it is a generalization of an inference.
It could be a generalization about observations -
Chalk is a poor conductor of electricity;
Chalk is a poor conductor of heat;
The hypothesis could be: all poor conductors of electricity are poor conductors of heat.
The process may include constructing or testing hypothesis.

MAKING OPERATIONAL DEFINITIONS - An operational definition explains what something is by what it does.
Non operational definition: Oxygen is an element composed of atoms having atomic number 8 and atomic weight 16.
Operational definition: Oxygen is a gas that causes a glowing splint to burst into flame (what you observe) when the splint is placed (what you do) into a container of the gas.

CONTROLLING AND MANIPULATING VARIABLES - a variable is a condition that changes. Remember the TV ad - the only condition that was different between the two cars was the kind of gasoline. Since car A went farther than car B before running out of gas, car A's gas must be better. In this experiment the kind of gasoline was the variable considered. When experimenting we try to keep all conditions the same except for one condition - the variable to be tested.

page 3 DEFINITIONS FOR THE THIRTEEN AAAS PROCESSES

INTERPRETING DATA - This refers to ability to get information from tables, charts, graphs, maps, pictograms, etc. It involves the ability to "read" such information and state what it means.

EXPERIMENTING - Is the process that encompasses all the basic and integrated processes. It begins with observations that suggest questions. A hypothesis MAY be formulated. A test is then constructed to answer the question, variables to be controlled are identified, operational data are collected and interpreted, The original hypothesis, if made, may be tentatively accepted or modified.

APPENDIX H

END OF YEAR EVALUATION OF PROCESS SKILLS TAUGHT WITH ESCP

Name______________________________

END OF YEAR EVALUATION OF PROCESS SKILLS TAUGHT WITH ESCP

Please rate each of the thirteen processes using as your criteria, EXPOSURE to the process.

Exposure is defined as a composite of time and emphasis given to each process during the laboratory experiences. If you feel there was a large degree of time and emphasis given to developing the process, observation, give observation a high rating (3). If you feel there was little time and emphasis given to this process, rate it low (1). If you feel, that when comparing observation exposure with the other twelve processes, there was an average amount, rate it average (2).

Rating scale 3. strong exposure
2. average exposure
1. low exposure

Assign numbers in such a way that the total score will equal 26. You may need to re-evaluate the ratings, adjusting some to reach a total of 26. It is most important that a total of 26 be found.

_____observing

_____classifying

_____using time/space relationships

_____using numbers

_____communicating

_____measuring

_____inferring

_____predicting

_____formulating hypotheses

_____making operational definitions

_____controlling and manipulating variables

_____interpreting data

_____experimenting

____

26 = total

APPENDIX I

END OF YEAR EVALUATION OF ESCP, 1970-1971, BY THE CARMAN TEACHERS

END OF YEAR EVALUATION OF ESCP 1970-1971 BY THE CARMAN TEACHERS

Please evaluate ESCP as you experienced it. The first nine questions apply ONLY as they relate to your ESCP experimental class(es).

Name of text____

1. How would you rate the reading level of the text?

   ___much too difficult ___difficult

   ___satisfactory ___easy ___very easy

2. How would you rate the concepts presented in the course?

   ___much too difficult ___difficult

   ___satisfactory ___easy ___very easy

3. About what percent of the total class time was devoted to direct laboratory experiences over the entire year?

   ___0 ___20 ___40 ___60 ___80 ___100

4. About what percent of the total class time was devoted to direct laboratory experiences during the first two months of school?

   ___0 ___20 ___40 ___60 ___80 ___100

5. About what percent of the total class time was devoted to direct laboratory experiences during the last two months of school?

   ___0 ___20 ___40 ___60 ___80 ___100

   Comments____

   ____

6. Do you feel more time should be devoted to direct laboratory experiences in the future?

   ____

   Why or why not?____________________________________

   ____

7. How would you rate the children's overall attitude toward science for the entire year?

___very enthusiastic ___moderately enthusiastic

___average enthusiasm and interest

___somewhat uninterested ___very uninterested

8. How would you rate the children's attitude toward science during the first two months of the school year?

___very enthusiastic ___moderately enthusiastic

___average enthusiasm and interest

___somewhat uninterested ___very uninterested

9. How would you rate the children's attitude toward science during the last two months of the school year?

___very enthusiastic ___moderately enthusiastic

___average enthusiasm and interest

___somewhat uninterested ___very uninterested

How would you rate the experimental group(s) you taught with the other ESCP classes you taught this year on - - -

10. attitude? ___experimental group much more enthusiastic

___experimental group moderately more enthusiastic

___both groups about the same

___experimental group much less interested

11. achievement in process skills? ___experimental group much higher achievement

___experimental group moderately higher achievement

___both groups about the same

___experimental group somewhat lower achievement

___experimental group much lower achievement

12. achievement of science knowledge
___experimental group much higher achievement
___experimental group moderately higher achievement
___both groups about the same
___experimental group somewhat lower achievement
___experimental group much lower achievement

13. How did the half-day schedule and the use of the high school effect progress of the STUDENTS?

___greatly improved progress ___moderately improved

___made little difference ___somewhat reduced progress

___greatly reduced progress

14. Please explain any differences.

____

____

15. How did the half-day schedule and use of the high school effect YOUR TEACHING?

___greatly improved my teaching

___moderately improved my teaching

___made little difference

___somewhat hindered my teaching

___greatly hindered my teaching

16. Please explain any differences.

____

____

17. Generally speaking, did you find that girls or boys experienced more success with ESCP?

____girls ____boys

Please explain:____

____

18. Do you think ESCP would be more successfully taught at ninth grade level rather than eighth?

___ninth ___eighth ___other grade level

Please explain:____

____

19. Assuming costs are no major factor and administration agrees, would you advise the same basic program next year?

___yes ___no Why or why not?______________________________

____

____

20. Assuming that ESCP will be taught next year, what specifically do you feel could be done to improve the course?

____

____

____

____

____

feel free to add additional comments on back

21. Did you cover all the material in the text?

___all ___3/4 ___1/2 ___1/4

22. If you did not cover all the material in the text, do you think this should be a major concern WHEN USING ESCP?

Explain:___

___

___

___

23. Will you attempt to cover the whole book next year?

___yes ___no

24. If you had to eliminate one unit from study next year, which would it be?

___

25. Which unit did the children seem to enjoy most?

___

26. Which unit did you enjoy most?

___

27. Which unit did you enjoy least?

___

28. Which unit did the children seem to enjoy least?

___

29. Did you have sufficient materials to assist you in your teaching?

___yes ___no If no, please explain:

___

30. Did you generally have sufficient time to prepare your lessons?

___yes ___no If no, please explain:

___

___

31. This may be difficult, but do the best you can. Please try to summarize the content covered during the past year. This may be done by simply stating, "We covered pages 1-312," if that is what you did. Perhaps you "jumped" around. Then indicate only those pages covered, not those "jumped" over. If you had activities not included in the text, would you list them with a brief explanation.

32. Try to indicate all laboratory experiences given. If they were all those included in the above report - please state, "All laboratory experiences found in pages listed above." If some were skipped, please indicate. If others were added, please indicate.

THANKS LOADS!

APPENDIX J

ACADEMIC BACKGROUND

CARMAN ESCP TEACHERS

Please list course hours you have related to science.

	BIOLOGY SCI	PHYSICAL SCI (Physics, Chem.)	EARTH SCI
UNDERGRADUATE			
GRADUATE			

What was your teaching major in undergraduate school?

Do you hold a Master's degree?

If yes, in what area?

List any special programs in which you were a participant that are related to your teaching of ESCP.

How many years of teaching experience?

How many years of teaching experience in all science areas?

How many years of teaching experience in earth science?

May 19, 1971

APPENDIX K

STUDENT EVALUATION OF ESCP CARMAN DISTRICT 1970-1971

STUDENT EVALUATION OF ESCP - CARMAN DISTRICT 1970-1971

Please answer the following questions about the ESCP science program you had this year. Be honest. Do NOT sign your name.

1. Was the text book too hard? ___yes ___no

2. Were the ideas taught in class too hard? ___yes ___no

3. Should more time have been spent in laboratory exercises? ___yes ___no

4. Do you feel you learned more valuable information in laboratory experiences or in regular class sessions?
   ___laboratory
   ___don't know
   ___class sessions

5. Compare 8th grade science with 7th grade science as to how DIFFICULT they were for you.
   ___8th harder
   ___about the same
   ___7th harder

6. Compare 8th grade science with 7th grade science as to how you ENJOYED each.
   ___enjoyed 8 more
   ___about the same
   ___enjoyed 7 more

7. Compare 8th grade science with 7th grade science as to your report card GRADES.
   ___8th higher
   ___about the same
   ___7th higher

8. If next year, the students have a choice between ESCP and another science program, will you advise a seventh grade FRIEND to take ESCP rather than the other science course?
   ___advise take ESCP
   ___don't know
   ___advise take other course

9. What did you like best about science this year?

____

____

10. What did you like least about science this year?

____

____

11. How do you think science could be improved?

____

____

____

APPENDIX L

RESPONSES TO STUDENT EVALUATION
OF ESCP 1970-1971

RESPONSES TO
STUDENT EVALUATION OF ESCP--CARMAN DISTRICT, 1970-1971

	Yes	No Reply	No	Total Responses
1. Was the textbook too hard?				
	76(41)*	3 (2)	105 (57)	184
2. Were the ideas taught too hard?				
	51 (28)	7 (4)	126 (68)	184
3. Should more time have been spent in laboratory exercises?				
	131 (71)	4 (2)	49 (17)	184
4. Do you feel you learned more valuable information in laboratory experiences or in regular class sessions?				
	Laboratory	Don't know	Class sessions	
	109 (59)	47 (26)	18 (15)	184
5. Compare eighth-grade science with seventh-grade science as to how difficult they were for you.				
	Eighth harder	About the same	Seventh harder	
	91 (50)	68 (37)	24 (13)	183

6. Compare eighth-grade science with seventh-grade science as to how you enjoyed each.

Enjoyed eighth more	About the same	Enjoyed seventh more	
79 (43)	50 (27)	54 (30)	183

7. Compare eighth-grade science with seventh-grade science as to your report card grades.

Eighth higher	About the same	Seventh higher	
48 (26)	65 (36)	69 (38)	182

8. If next year, the students have a choice between ESCP and another science program, will you advise a seventh-grade friend to take ESCP rather than the other science course?

Advise take	Don't know	Advise take other course	
69 (38)	74 (40)	39 (22)	182

*Parentheses indicate percent of response.

continued

9. What did you like **best** about science this year?

Name*	Number of Respondents		Percent
Laboratory experiences	108		59
Working in groups	3	74	
Laboratory reports	9		
Field trips	16		9
Working with interest groups	8		
Teacher	9		
Class movies	6		
Discussions	4		
Oceanography	3		
Geology	3		
Evolution	3		
Space	2		

*Responses are not given when there was only one respondent.

10. What did you like least about science this year?

Studying from textbook	58		32
Activities from textbook	12	38	
Tests	34		18
Teacher	8		
Geology	6		
Class reports	6		
Laboratory exercises	5		
Laboratory reports	3		
Ecology	3		
Weather	3		
Astronomy	2		
Mathematics in science	2		
Lectures	2		
Discussions	2		
Student behavior	2		

continued

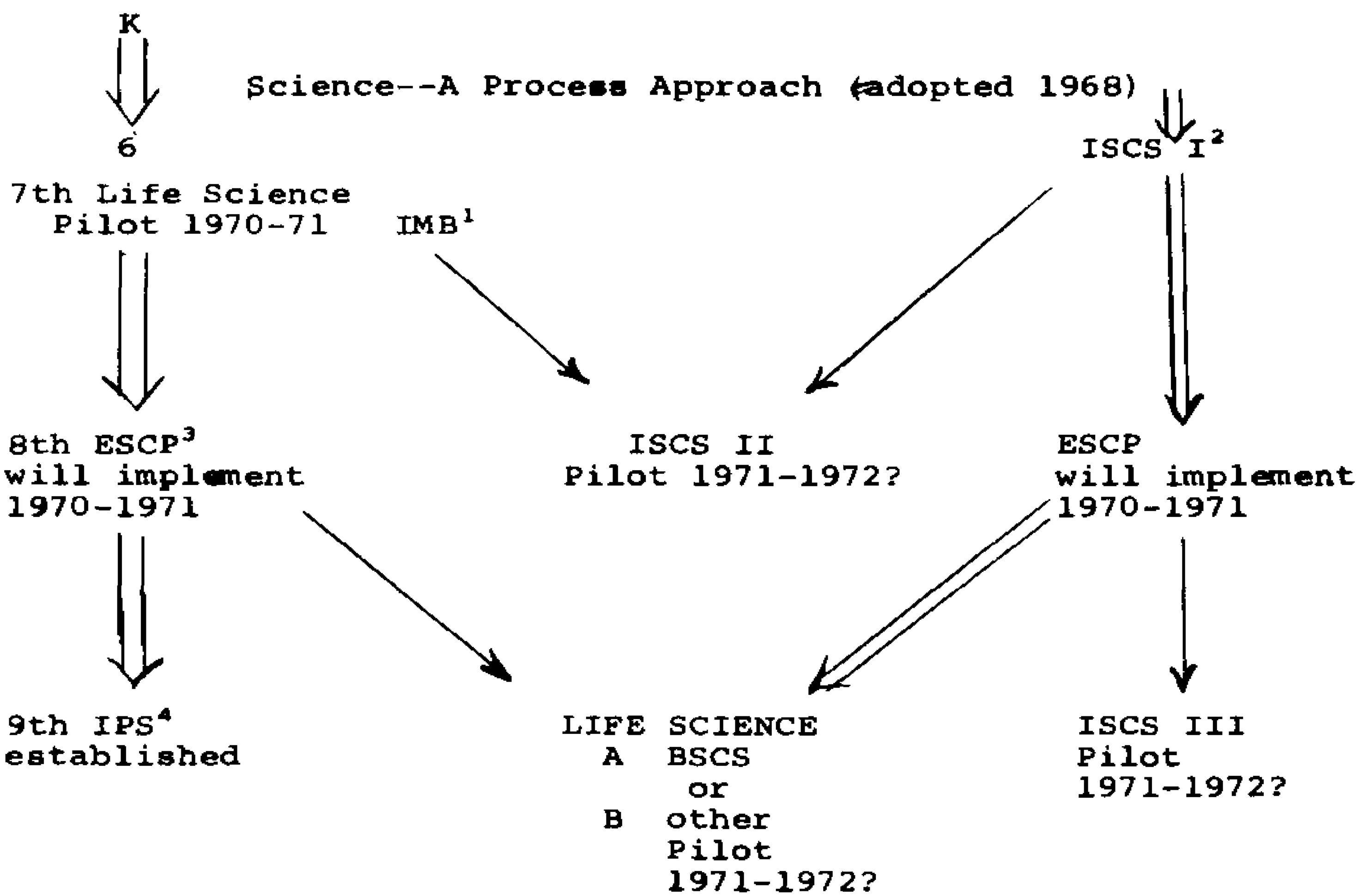
11. How do you think science could be improved?

More laboratory experiences	57		31
More field trips and outdoor activities	30	47	16
Less emphasis on the text	24	22	13
A better text	17		9
Let students choose area for study	10		
More discussion time	7		
Fewer tests	7	7	
Better written tests	6		
More textbooks per class	4		
Less emphasis on laboratory experiences	4		
More meaningful laboratory experiences	3		
More time for science class	3		
More group work	2		
Fewer students per class	2		
More class movies	2		
Fewer exercises from text	2		
More class reports	2		
Less lecturing	2		
Fewer laboratory sessions	2		
Different teacher	2		

APPENDIX M

TWO TRACK MODEL PROPOSED AS CARMAN SCIENCE SEQUENCE FOR JUNIOR HIGH SCHOOL

TWO-TRACK MODEL--PROPOSED CARMAN SCHOOLS' SCIENCE SEQUENCE FOR JUNIOR HIGH SCHOOL



Heavy arrows indicate major sequence
Single line arrows indicate possible alternatives

[1]IMB Interaction of Man and the Biosphere

[2]ISCS Intermediate Science Curriculum Study

[3]ESCP Earth Science Curriculum Project

[4]IPS Introductory Physical Science

[5]BSCS Biological Science Curriculum Study

APPENDIX N

RAW DATA FROM PRE- AND POST-TESTS: ATTITUDE TOWARD SCIENCE, ACHIEVEMENT OF SCIENCE PROCESSES, AND ACHIEVEMENT OF SCIENCE KNOWLEDGE CARMAN SCHOOL DISTRICT, FLINT, MICHIGAN 1970-1971

RAW DATA FROM PRE- AND POST-TESTS: ATTITUDE TOWARD SCIENCE, ACHIEVEMENT OF SCIENCE PROCESSES, AND ACHIEVEMENT OF SCIENCE KNOWLEDGE
CARMAN SCHOOL DISTRICT, FLINT, MICHIGAN
1970-1971

Sex	GPA	Room	Student	Attitude		Process		Knowledge	
				Pre	Post	Pre	Post	Pre	Post
M	H	A	01	85	82	39	43	35	33
M	H	A	02	85	85	32	52	37	48
M	H	A	03	74	86	29	34	34	38
M	L	A	04	86	75	27	33	25	26
M	L	A	05	83	77	29	40	28	30
M	L	A	06	58	55	19	27	16	12
F	H	A	07	83	84	23	47	49	56
F	H	A	08	77	56	16	34	36	41
F	H	A	09	79	86	48	58	37	54
F	L	A	10	86	84	27	35	26	27
F	L	A	11	81	34	19	±6	20	16
F	L	A	12	46	26	19	20	15	17
M	H	B	13	79	87	28	27	21	26
M	H	B	14	82	88	22	33	24	31
M	H	B	15	87	83	25	33	42	38
M	L	B	16	83	60	11	31	16	21
M	L	B	17	87	68	18	25	21	21
M	L	B	18	69	86	22	24	18	13
F	H	B	19	71	63	45	41	28	30
F	H	B	20	77	79	33	29	24	24
F	H	B	21	83	61	18	45	19	22
F	L	B	22	33	79	21	28	20	22
F	L	B	23	26	35	27	33	36	28
F	L	B	24	83	83	26	30	21	29
M	H	C [1]	25	81	87	36	50	44	46
M	H	C	26	83	79	25	35	29	28
M	H	C	27	86	86	48	55	51	43
M	L	C	28	86	87	21	31	33	32
M	L	C	29	85	83	24	24	24	28
M	L	C	30	76	75	42	39	36	38
F	H	C	31	61	61	22	26	28	27
F	H	C	32	60	84	25	34	24	24
F	H	C	33	78	79	35	31	33	38
F	L	C	34	29	27	26	26	22	26
F	L	C	35	88	83	26	26	18	27
F	L	C	36	84	84	15	25	14	25
M	H	C [2]	37	73	71	29	40	26	24
M	H	C	38	84	89	51	53	39	22
M	H	C	39	85	83	12	26	27	22

continued

Sex	GPA	Room	Student	Attitude Pre	Attitude Post	Process Pre	Process Post	Knowledge Pre	Knowledge Post
M	L	C	40	72	44	09	27	19	15
M	L	C	41	81	68	37	38	20	25
M	L	C	42	84	78	44	50	31	34
F	H	C	43	87	83	24	35	30	27
F	H	C	44	84	83	33	51	28	32
F	H	C	45	61	48	26	31	23	34
F	L	C	46	79	57	27	33	21	16
F	L	C	47	85	85	08	26	24	20
F	L	C	48	47	75	12	23	24	21
M	H	D 1	49	73	26	32	20	27	27
M	H	D	50	84	91	33	42	38	51
M	H	D	51	87	87	45	57	47	51
M	L	D	52	80	58	18	24	20	30
M	L	D	53	85	79	24	39	30	34
M	L	D	54	34	58	26	36	28	37
F	H	D	55	58	58	37	45	29	37
F	H	D	56	87	79	42	50	32	47
F	H	D	57	83	81	36	40	31	36
F	L	D	58	84	81	27	33	23	22
F	L	D	59	81	79	23	28	23	19
F	L	D	60	55	33	08	44	21	18
M	H	D 2	61	78	34	22	28	27	27
M	H	D	62	83	29	27	36	33	51
M	H	D	63	88	82	32	48	37	49
M	L	D	64	84	82	36	42	26	38
M	L	D	65	85	87	44	54	37	49
M	L	D	66	68	83	23	21	24	27
F	H	D	67	67	78	30	45	39	42
F	H	D	68	29	28	46	56	40	42
F	H	D	69	84	87	39	37	37	49
F	L	D	70	83	83	19	35	26	30
F	L	D	71	47	77	34	37	25	22
F	L	D	72	30	57	24	40	25	27
M	H	E	73	68	25	31	30	14	25
M	H	E	74	78	54	32	46	16	34
M	H	E	75	47	25	26	36	22	22
M	L	E	76	81	86	40	40	19	18
M	L	E	77	57	34	22	35	22	32
M	L	E	78	61	72	32	43	21	24
F	H	E	79	87	88	35	39	26	31
F	H	E	80	86	77	34	31	22	34
F	H	E	81	85	30	23	25	27	24
F	L	E	82	65	77	19	33	15	17
F	L	E	83	29	36	29	21	18	24
F	L	E	84	85	79	47	45	25	13

Sex: M--male, F--female; GPA: Grade point average in science from the previous year: H--high, A or B; L--low, C or lower. Room: student classroom, C_1 and C_2 same teacher, D_1 and D_2 same teacher.