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ABSTRACT

The activities developed for this project were based on the assumption that science teaching at the junior high school level becomes more meaningful if it is idea-centered and if the ideas selected for study: (1) cut across two or more fields of science, (2) are taught through open-ended laboratory experiences with subject matter introduced as needed, (3) will be significant at all educational levels beyond the point of introduction, and (4) can be approached through increasingly sophisticated experiences at each advanced level. Twelve cross-cutting ideas are listed, the first six of which are concerned generally with the broad concept of relationship, while the last six have to do with the general concept of change. The titles of the 49 laboratory experiences developed for this project are listed. The materials have been tried out in the classroom-laboratory to an extent sufficient to indicate that they can be used successfully at the junior high school level (especially seventh grade). Use of the materials is slowly spreading, especially in Michigan, and the study has received a great deal of publicity in that state. Publications resulting from the project and those discussing certain aspects of the project are listed. The bibliography includes 21 references used in the literature review for this report. (Author/PR)

THE DEVELOPMENT OF JUNIOR HIGH SCHOOL SCIENCE ACTIVITIES

Cooperative Research Project Number S-174-65

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1965-1966

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Problem on Which the Research was Focused

The purpose of this investigation was to develop laboratory experiences of a type that would furnish an approach to interdisciplinary ideas, and would constitute a vehicle for inquiry directed toward these ideas on the part of teacher and students.

The Michigan Science Curriculum Committee* is concerned with the problem of increasing the effectiveness of the science program offered at the junior high school level. They believe that its present lack of effectiveness is due to two related factors:

1. Students do not learn science taught at this level with a sufficient degree of personal meaning, and as a result

2. They do not carry beyond this level the interest in science that they exhibited in the elementary grades. This is reflected in decreased enrollments in senior high school and college science courses.

The Committee further believes that the present trend toward offering simplified versions of single-field science courses in the junior high school does not offer a complete answer to this situation. There is a definite place for a revitalized general science approach, especially in seventh grade. This general science, however, needs to be planned in terms of problems, ideas, and understandings, rather than a limited factual survey of conventional science fields. The Committee believes that at the junior high school level students should begin to make meaningful contact with some of the great ideas of science, and that these can and should be taught through experiences which will enable them to see science as process and inquiry, rather than simply as a body of facts to be learned.

*The Michigan Science Curriculum Committee operates under the Michigan State Department of Education (formerly the Michigan Department of Public Instruction). It consists of representatives of state universities, liberal arts colleges, public schools (administrators, science supervisors, and teachers at various levels), and industry. The principal investigator in the study is Chairman of the Subcommittee for the Junior High School Project.

The Committee believes that it is possible to select ideas or understandings of a cross-cutting nature, important for two or more fields of science, which can be introduced at the level of the junior high school, and which will continue to be valid in progressively more sophisticated fashion at each succeeding educational level. The junior high science program can then be built around a limited number of such ideas, as many as can be dealt with in the time available.

They also believe that the experiences which will prove most fruitful in approaching these ideas are those involving open-ended laboratory. For these, students should be given minimal directions, largely of procedural nature. Mainly they should be guided by questions at various levels of difficulty, asked either in the written directions or by the teacher. Students should also be encouraged to raise questions at all levels, not all of which need necessarily be answerable. All questions, whether in the directions or asked by teacher or students, should be pointed toward the idea toward which the laboratory experience is directed.

In the type of learning proposed here, the ideas to be taught must be made clear to the students and kept before them while the study is going on. To do this, a clear statement of each idea must be prepared and made available to the teacher. It is then the teacher's responsibility to translate the idea into student language. In doing this the teacher makes the idea a part of his own thinking.

Students are required to work in the laboratory with a minimum of direction, and are permitted wide freedom in pursuing problems derived from the original experience. Laboratory activities which are not directed toward the development of significant ideas or understandings, however, are considered to be of little value.

It is recognized that this approach constitutes a clear departure from conventional learning design. Subject matter is introduced as necessary in connection with the laboratory experiences, and becomes important only in terms of the ideas or understandings to which it contributes. This differs from subject matter centered learning in which the acquisition of knowledge is an end in itself, and laboratory experiences are generally illustrative in character; and also form the purely exploratory type of laboratory in which the activities are considered worthwhile as ends in themselves.

The problem in the investigation therefore has involved:

1. Selection of significant ideas of a cross-cutting nature
2. Preparation of clear statements of these ideas
3. Selection of laboratory experiences which will lead toward these ideas, and preparation of outline directions for them
4. Use of these experiences in the classroom, revising them if and as necessary
5. Evaluation of growth in student thinking as a result of these experiences, in terms of the ideas toward which they are directed

Prior to the beginning of Cooperative Research Project Number S-174-65, some progress has been made by the Committee on steps (1) and (3), though much additional work was needed. Steps (2), (4), and (5) remained to be taken. This was designed as a pilot study to attempt to determine the degree of success of the approach. If successful, application for support for continuation and expansion of the project was anticipated.

Objectives and Hypotheses

This project was based on the assumption that science teaching at the junior high school level becomes more meaningful and successful if it is idea-centered, and if the ideas selected for study (1) cut across two or more fields of science, (2) are taught through open-ended laboratory experiences with subject matter introduced as needed, (3) will be significant at all educational levels beyond the point of introduction, and (4) can be approached through increasingly sophisticated experiences at each more advanced level.

With the current increase in the sheer mass of scientific knowledge, we cannot expect to teach it all. Therefore we must concentrate on important scientific ideas and broad understandings if we are to retain and increase science interest, and educate a science-oriented citizenry. It is believed that if the ideas and understandings can be implanted, the pertinent facts will be learned and retained.

This study, therefore, proposed an exploration of the use of cross-cutting ideas and understandings, taught principally through open-ended laboratory experiences, as a basis for a reorganization of the teaching of junior high school general science.

It is believed that the development of a junior high school science program of this type will contribute toward a solution of the problem of motivation and retention of science interest among students at this level, and will increase the probability that they will continue in science courses at the senior high school and college levels.

Related Research

There is a relationship between this study and other studies dealing with (1) interest and motivation in science, (2) identification of the principles and ideas of science and their use in teaching, (3) inquiry procedures, and (4) problems of evaluation in courses organized and taught in a related fashion.

1. Interest and Motivation in Science

A number of research studies have been concerned with science interest at the elementary and secondary levels. Bradwein (1951, 1952, 1953), Mallison and Van Dragt (1952), Bingham (1956), Schenberg (1959), MacCurdy (1956, 1960), Strauss (1957, 1960, 1965), Strauss and Brechbill (1959), and Frankel (1960), while all primarily concerned with students of superior ability and their continuation in science, dealt also with the problem of retention of interest. Schenberg, MacCurdy, Strauss, and Frankel, in particular, attempted detailed analyses of academic, personality, and environmental factors relative to continued interest in scientific pursuits. While their works point to no single factor or combination of factors making for scientific interest, they all find a clear indication that the problem centers in the area of motivation, and that improvement is possible.

A further study of science motivation (Mallinson 1963) appears to indicate that the one controllable factor in the picture is good teaching. The earlier work of Strauss also points in the same direction. Although even this factor is only partially within our control, the provision of curricular materials which are challenging to teacher and students alike, will go a long way toward helping with the problem. The investigators believe that materials of the type being developed and tested in the present study will serve in this way.

2. Principles and Ideas of Science

Studies in the principles of science have constituted a major area of investigation in science education since the publication of the Thirty-First Yearbook (1932). Blanchet (1957) listed 24 studies which he considered outstanding, including a study by Smith (1952) of principles desirable for a course in junior high school general science. He indicated, however, that approximately twice this number had been carried out at the time he published his summary. Van Deventer (1956) showed that subject matter principles, of the type identified by Blanchet and others, rest on the facts of science, and in turn, furnish support for ideas or understandings of a broad nature which may belong to a single field of science, or may cut across two or more fields. He called these "area principles".

A close affinity to these ideas is found in the "nine themes" on which the Biological Sciences Curriculum Study is based. These are understandings or ideas similar to those with which the present study is concerned. Similar ideas or understandings can be identified in other major curriculum studies: the Physical Science Study Committee, the Chemical Bond Approach, the Elementary Science Study, the Science Curriculum Improvement Study, the School Science Curriculum Project, and the Junior High School Science Project. The "processes" of the Process Approach of the AAAS Commission on Science Education also exhibit a definite affinity. Showalter (1964) describes an experimental program in unified science in the Ohio State University School which is based on the teaching of ideas or concepts of the same type as those used in the present study.

Schultz (1961) describes an experiment in which the ideas of community ecology were taught successfully to second and sixth grade children. Atkin (1961) describes the teaching of concepts of modern astronomy to elementary school children. The work of Karplus in the Science Curriculum Improvement Study has involved teaching some of the ideas of modern physics at the early elementary level. Jerome Bruner holds that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development." The present study has proceeded on the assumption that relatively sophisticated ideas of science can be taught successfully at the junior high school level, and earlier, if

(a) they can be communicated to students in language that they can understand, and

(b) they can be related to experiences which are meaningful to students.

3. <u>Inquiry Teaching</u>

The literature in science education includes various uses and definitions of the term "inquiry." Alfred Novak (1964) says, "Inquiry is the total configuration of behaviors involved in the struggle of human beings for reasonable explanations of phenomena about which they are curious." Rutherford (1964) distinguishes between "inquiry as content," and "using the method of scientific inquiry to learn some science," which he calls "inquiry as technique." He says, "If all that is intended by the inquiry method is that we should encourage a student to be inquisitive, curious, to ask questions, and to try to find answers for himself, then we are advocating no more than what good teachers have long believed in and practiced."

J.R. Suchman, in telling about the Illinois Project in Inquiry Training, describes inquiry as the act of creating individual knowledge by gathering and processing information." Fish and Goldmark (1966) add that "the process of inquiry which Suchman has structured is a process of formulating theories and testing them through experimenting and data gathering."

In connection with the Biological Sciences Curriculum Study, which lists "Science as Inquiry" as one of the nine themes around which subject matter and laboratory experiences are integrated, Schwab (1963) says, "The essence of teaching science as inquiry would be to show some of the conclusions of science in the framework of the way they arise and are tested." In relation to laboratory experiences, he says, "They are not illustrative but investigatory. They treat problems for which the text does not provide the answers. They create situations in which the student may participate in the inquiry."

Strasser (1966), in presenting his view of inquiry, says that "The kinds of questions we use determine the kinds of operations the children will perform. The questions we use outline the kinds of thinking, observing, and other behaving responses of the learners for which we, their teachers, search." He suggests that we examine our teaching to see if we ask students only questions which demand recall, or only those which call for our answers. Do we ask a variety of kinds of questions that stimulate a range of behaviors which may be identified as aspects of "sciencing"?

The Michigan Science Curriculum Committee defines inquiry as the approach to an idea by students and teacher through questions asked of each other at various levels of difficulty. The Committee believes that much of the conventional educational process tends to stifle inquiry on the part of students rather than nurture it. Much of the natural curiosity of children during the elementary years is destroyed through emphasis on specific knowledge given in answer to questions, and consequently on the asking only of those questions that can be answered. This is true both of the questions that we ask students, and also of the questions which we allow them to ask us.

Emphasis on the retention of knowledge as an end in itself fosters this limitation. Teachers ask students questions which hopefully they can answer, and to which the teacher knows the answer. Questions that the teacher cannot answer, and which perhaps no one can, do not generally lead to approval when they are asked by students. Such questions are viewed, at best, as being useless or leading nowhere, and at worst, as an attempt on the part of students to lead the teacher astray from the prescribed work of the course.

Yet it is these unanswered, and sometimes unanswerable questions which form the heart of the inquiry process. It is at this point that the teacher can say, "I don't know the answer, and I doubt if anyone else does. We can look for the answer, collect evidence, and possibly make a judgment as to what the answer might be, but we cannot be sure. This is research!"

The Committee believes that questions should be asked (and allowed) at all levels:

(a) Those which can be answered readily from the experience and materials at hand, together with general knowledge

(b) Those which can be answered, but only after considerable investigation and thinking

(c) Those which cannot be answered by either students or teacher

(d) Those which probably cannot be answered at all with our present state of knowledge

Only by maintaining this questioning attitude as an approach to the materials and experiences of science can students be led to develop a research attitude, and a feeling of being on the frontier of the advance of knowledge.

The investigators believe that the laboratory experiences developed by the project, simple in themselves but constructed for open-ended procedure and guided with questions pitched at the four levels indicated above, constitute ideal vehicles for use by teachers and students in carrying on inquiry with reaction to the specific ideas toward which they are directed.

4. Problems of Evaluation

Smith (1963), in reviewing educational research related to science instruction for the elementary and junior high schools, noted the relative scarcity of evaluation studies at these levels, and indicated that inadequate research in the area of evaluation constitutes a major problem in elementary and junior high school science at the present time. This lack is particularly apparent in connection with the modern curriculum study projects. Hurd and Rowe (1964), reviewing recent research in science teaching in the secondary school, reported several studies showing that, insofar as the courses based on the modern curriculum studies are directed toward goals different from those of conventional courses, student achievement in them can be measured adequately only by using instruments designed specifically for them. Cooley and Klopfer (1963) pointed out the necessity of including the selection or development of testing instruments for measuring the specific objectives of new approaches in any research on the results obtained from using these approaches. Trump (1964) said that the use of conventional standardized tests and teacher-made tests often fails to differentiate meaningfully between new and conventional educational procedures.

Atkin (1963) discussed some of the problems of evaluation which arise in connection with the development of new curriculum materials. He stated that new approaches to learning, and the materials and activities appropriate for teaching them must first be identified, then tried out in classroom situations. Informal evaluation of the new approaches and materials must be carried on continually by those using them, in terms of the behavior of students in relation to them. Only when this has been done can adequate evaluation instruments be constructed and used effectively. These instruments may well need to be based on new and broader concepts of evaluation than those generally utilized in classical educational research.

Cooley and Klopfer (op. cit.) make the following statement: "In constructing a new test, the specification of the student outcomes to be measured is by far the most difficult task. This is especially true if the desired outcomes are other than the recall or application of subject matter content. However, if the innovation work is properly conducted, the development of new instruments is not so difficult as it might seem. The original statements of desired student behaviors can be used as the basis for writing test items also."

In the present study the investigators are not concerned at this point with measuring the acquisition or retention of factual knowledge, although there are informal indications that this is considerable. They are concerned with finding a way to determine the extent of the students' thinking in relation to the cross-cutting ideas toward which the experiences are directed.

They believe that the questions which students ask give a better indication of their thinking than any answers which they might give to questions which are asked of them. The experimental tests which have been constructed are based on questions raised by the students themselves. These tests ask students to differentiate between those questions which <u>are related</u> to the idea toward which the laboratory experiences have been directed, and those which <u>are not so related</u>.

So far, the tests have asked only for a simple two-way choice on the part of the students. It is anticipated that later tests will be so contructed that the students will be asked to make a further choice of foils to indicate <u>why</u> they considered the question to be related or unrelated to the idea. Still other possibilities of giving added dimensions to the tests, which in turn will allow further probing of student thinking, may well become apparent as the study progresses.

Procedure and Work Accomplished

As has been indicated, progress had been made by the Committee on some of the steps necessary for carrying out the objectives of the study prior to the beginning of Co-operative Research Project Number S-174-65. A statement of rationale for the study had been written; five cross-cutting ideas had been selected; a list of criteria for writing laboratory experiences had been prepared; and directions for 17 laboratory experiences looking toward one or more of the ideas had been written. These materials were published, prior to receiving the Cooperative Research Grant, by the Michigan State Department of Education (then the Michigan Department of Public Instruction) under the title of Open-Ended Laboratory-Centered Science for Grades 7-8-9, NDEA Title III, Bulletin No. 313, 1965.

A. Work that was proposed under the Cooperative Research Grant for the year 1965-1966 included the following:

1. Preparation of additional laboratory experience outlines, based on an expanded list of cross-cutting ideas, with necessary accompanying rationale.
2. Circulation of these materials to an already-established mailing list of approximately 300 correspondents.
3. Setting up testing centers at Ann Arbor, Lansing, Kalamazoo, and Grand Rapids, Michigan, for trying out the materials of the project in the classroom.
4. Beginning the development of an experimental evaluation program, based on the questions asked by students in connection with the laboratory experiences, directed toward the cross-cutting ideas on which the experiences are based.

Note: Page 13 omitted in numbering

B. Work that has been accomplished under the Grant:

1. Seven additional cross-cutting ideas (making a total of 12 altogether) have been selected for development. It is not the thought of the Committee that these 12 ideas are the only ones, or even necessarily the most worthwhile ones. No attempt has been made to determine how many such ideas there are, and no such study is contemplated. The intent of the Committee has been to select ideas which are amenable to the objectives of the study, and which exhibit a meaningful relationship to one another. A list of the 12 ideas follows. The original five are indicated with an asterisk:

*a. measurement as an expression of relationship

*b. interdependence in the natural world

c. interaction of heredity and environment

d. dynamic equilibrium

e. differential rates of processes

*f. tools, devices, and outside sources of energy as extensions of man's body and its capabilities

g. change and variation

*h. normal curves and warping factors

*i. gradients

j. extrapolation and interpolation

k. cycles and cyclic change

l. directional change in response to the challenge of the environment

The order of arrangement of the 12 ideas used here is an outgrowth of the year's experience in working with them. It is believed that the first six are concerned generally with the general concept of <u>relationship</u>, while the last six have to do with the general concept of <u>change.</u>

2. A statement called an "idea-bridge" has been developed for each of the 12 ideas. These idea-bridges are written for the teacher. It has been found necessary in using the ideas in the classroom to furnish the teacher with such a statement of each idea as the investigators interpret it. With this as a foundation, the teacher can make the idea a part of his own thinking. He is then in a position to "translate" it for the students, giving it meaning for them in terms of their experiences.
3. The general statement of rationale for the project, as originally published in the Michigan Department of Public Instruction NDEA Title III Bulletin No. 313 (op. cit.) has been revised and expended based on the year's experience.
4. Thirty-three new laboratory experiences have been developed, making a total of 49, including 16 of the original 17. (One of the original 17 was discarded.) In the list below, these laboratory experiences are given under the ideas toward which they point. In a few cases a laboratory experience is related to more than one idea, and is so used. Those which were published earlier in Bulletin No. 313 are indicated with an asterisk:

<u>Measurement as an Expression of Relationship</u>

*a. A Study in Measurement

*b. Measurement as an Expression of Relationship: A Simple Balance

*c. Measurement of a Relationship: Depth in Relation to Pressure

*d. Volume, Weight, Pressure, and Physical State

<u>Interdependence in the Natural World</u>

*a. A Study of Interrelationships: The Balanced Aquarium and the Pond Infusion Culture

b. Demonstrating Interrelationships: A "Field Trip" in the laboratory *c. Interrelationships of Physical Environmental Factors: The Evaporating Power of the Air

*d. Plant-Animal Communities are Everywhere: Forest Edge

e. Interrelationships: Communities and Environmental Factors on Your School Ground

f. Interrelated Processes in the Human Environment

<u>Interaction of Heredity and Environment</u>

a. Plants and Soil Nutrients

b. Plants and Light

c. Human Characteristics: Heredity or Environment?

<u>Dynamic Equilibrium</u>

a. Internal Equilibrium: Maintenance of Weight in Humans

b. Equilibrium in the Landscape: Erosion, Drainage Patterns and Valley Formation

*c. A Study of Interrelationships: The Balanced Aquarium and the Pond Infusion Culture

d. Theories of the Origin of the Universe: Two Approaches ty Dynamic Equilibrium

<u>Differential Rates of Processes</u>

a. Development of a Chick Embryo

b. Development of a Bean Plant

c. Differential Growth Rates in Humans

d. Differential Rates of Processes in the Development of the Landscape

<u>Tools, Devices, and Outside Sources of Energy as Extensions of Man's Body and Its Capabilities</u>

*a. Extending Man's Body With Tools

*b. Extensions of Man's Body: Simple Machines

c. Extensions of Man's Body: Complex Machines and the Utilization of Outside Energy

*d. Extensions of Man's Body: How They Have Evolved.

Change and Variation

a. Looking for Examples of Patternless Change

*b. Normal Curves and Warping Factors (extensively revised from the form in which it was originally published)

c. Relationships among Different Kinds of Change: Daily, Monthly and Annual Temperatures

d. The Emergence of Patterns

Normal Curves and Warping Factors

*a. Normal Curves and Warping Factors (revised)

b. Normal Curves Describe Variation in Nature

*c. Use of Normal Curves in Distinguishing Species

Gradients

*a. A Gradient: The Effect of pH on Yeast Activity

*b. A Growth Gradient in Nature: An Experience for Early Spring

*c. A Gradient for the Separation of Pure Chemical Substances: Paper and Thin Layer Chromatography

*d. A Simple Learning Curve

Extrapolation and Interpolation

a. Extrapolating and Interpolating from a Graph

b. Alternative Hypotheses: An Experience in Extrapolation

c. Looking for Patterns in Behavior

d. Extrapolation in Terms of a Problem: A Science Fiction Story

Cycles and Cyclic Change

a. An Animal Life Cycle: The Fruit Fly, Drosophila

b. Simple Plant Cycles: Common Molds and bacteria

c. The Water Cycle

d. Days and Nights, Moons and Years

Directional Change in Response to
The Challenge of the Environment

a. Normal Curves Describe Variation in Nature

b. Variability in Human Feet

c. Variation in a Population

d. Natural Selection at Work: A Field of Competition

e. Selection and the Gene Pool: A Working Model

f. Protective Colaration: A Mechanism for Survival

g. A Quantitative Study of Competition Between Species

h. A Mental Experience: Directional Change in the Human Species, the Long Line

i. Extensions of Man's Body: How They Have Evolved

5. Nearly all of these laboratory experiences have been tried out in preliminary fashion, either by the investigators, or in classes supervised by them, or in one of the five testing centers. (see below). It had been anticipated that each of the original 17 laboratory experiences would be tried out at each of the centers, with at least one class of approximately 30 students; and possibly replicated with classes at the same grade level and at different grade levels. This did not prove to be possible.

6. Five semi-formal testing centers were set up: at Kalamazoo, Grand Rapids, Lansing, Ann Arbor, and in the Flint-Saginaw area. This was one center in addition to the four originally planned. Fifteen teachers in these centers used various portions of the material under some degree of supervision, either by the Director or Co-director, or by a member of the Committee. Participation in the program was voluntary. No financial compensation was given, and no coercion was exercised.

It is estimated that about five times this many teachers (75) used portions of the material without supervision. About 400 people received the material at their own request, and used it in connection with a curriculum study or made it a part of their professional library.

7. A set of suggested procedures was prepared for these teachers and others who are using the materials of the project in the classroom. These are based on the experience in teaching the materials which has been accumulated so far.

8. Preliminary experimentation was carried on in the development of a type of test for measuring the extent of student thinking with relation to the ideas toward which the laboratory experiences are directed. Six experimental tests were developed and used.

9. Materials prepared by the investigators were sent to more than 400 teachers. These included the original mailing list of approximately 300.

10. The work of the project was reported by either the Director or the Co-director at the following national, regional, state, and local meetings:

    a. National Science Teachers Association, Denver, Colorado, March, 1965

    b. Michigan Science Teachers Association, Lansing, Michigan, March, 1965

    c. Great Lakes Regional Conference of the National Science Teachers Association, Detroit, Michigan, October, 1965

    d. Four regional meetings of the Michigan Education Association, Fall, 1965

    e. Staff meetings of four city school systems in Michigan, Fall, 1965

    f. Michigan Science Teachers Association, Lansing, Michigan, March, 1966.

    Following each of these reports, there were additional requests for the project materials.

11. The materials of the project were utilized by Miss Phyllis Carnes, University of Georgia, Athens, Georgia, as the basis for her doctoral research under the direction of Dr. J. C. Bledsoe. This research was carried on under a Co-operative Research Grant from the U.S. Office of Education. Miss Carnes chose four of the Committee's ideas, and selected certain laboratory experiences directed toward each of them. She constructed linear programs for these laboratory experiences, and taught experimental and control classes at the seventh grade level on the basis of them. Along with other types of evaluation technique suggested for teachers using the materials of the project. The Director of this project worked informally with Miss Carnes during her research. Her test is included with the project materials, and her thesis is included among the publications resulting from the project listed in (12) below.

12. The following list of publications resulting from the project includes titles published prior to receiving the grant under Cooperative Research Project Number S-174-65, as well as those published during the year the study has been supported by the grant.

    a. Van Deventer, W. C., "Laboratory Centered Science Teaching". Metropolitan Detroit Science Review 24:105-107; September 1963.

    b. Ibid., "Michigan Prepares Project on Junior High Science". The Science Teacher 31: 29-30; November 1964.

    c. Ibid., "The Michigan Science Curriculum Committee Junior High School Project". Newsletter of the Michigan Science Teachers Association 13:14-16; June 1966.

The principal investigator also has discussed certain aspects of the project in the following articles published or prepared for publication during the year:

    d. Van Deventer, W. C., "New Horizons in Curriculum Development". Newsletter of the Michigan Science Teachers Association 13:11-18; February 1966.

    e. Ibid., "Toward a 'Comparative Anatomy' of the Curriculum Studies". Science Education (in press).

    f. Ibid., "New Developments in the Sciences for Elementary and Secondary Schools". Michigan School Boards Journal (in press).

The following publications are also based on the materials produced by the project:

g. Open-Ended, Laboratory-Centered Science for Grades 7-8-9. Committee on Science of the Michigan Cooperative Curriculum Program, NDEA Title III, Bulletin No. 313. Michigan Department pf Public Instruction, Lansing, Michigan, 1965.

h. Carnes, Phyllis E., An Experimental Study in the Use of Programmed Materials for Seventh-Grade, Open-Ended Laboratory Experiences. Doctor's thesis. Athens, Georgia: The University of Georgia, 1966.

Summary , Conclusions, and Implications

At the end of the year of support under Cooperative Research Project Number S-174-65, the status of the junior high school general science study begun earlier by the Michigan Science Curriculum Committee is as follows:

1. Most of the basic written material needed by the study (ideas, idea-bridges, rationale, laboratory experiences) has been prepared. Possibly one additional cross-cutting idea (Templates and Transference of Pattern),and a few additional laboratory experiences, are needed to round out the picture. The present material runs to 260 pages of mimeographed material. It is not planned to increase the total amount of material above 300 pages. The principal work of writing that is now necessary, and that is planned for 1966-1967, consists of revising and necessary rewriting following further trial in the classroom and laboratory.

2. The materials have been tried out in the classroom-laboratory to a sufficient extent to indicate that they can be used successfully at the junior high school level (especially seventh grade). More trial is necessary, however, especially more formal, supervised trial, before the materials can be considered to be in definite form.

3. A recommended procedure for teaching the materials, looking toward development of the ideas in students' thinking, has been worked out. This has been done on the basis of the semi-formal tryouts that have been possible. This teaching procedure appears to be workable and adaptable.
4. A theory of testing has been developed, and a very limited number of tests have been constructed and utilized experimentally. In no case, however, has there been sufficient trial of evaluation instruments of the type recommended to yield reliable statistics. Indications are that the instruments are measuring to some degree understanding of the ideas by students, but a vast amount of work is needed before any dependable statements can be made as to either the validity of the theory or the reliability of instruments. Further experimentation in the area of evaluation is definitely planned for 1966-1967 and succeeding years.
5. Use of the materials is slowly spreading, especially in Michigan. The study has received a great deal of publicity in the state, and there is much interest in it. In general, teachers who have used the materials have reacted favorably to them and have continued to use them. Teachers invariably report that students find the laboratory experiences interesting, and are highly motivated by them. More difficulty has been encountered in getting teachers to understand the ideas than in getting students to understand them. The idea-bridges which were written to meet this problem seem, however, to have done much to remedy the difficulty.
6. The investigators have applied to the U.S. Office of Education for a grant to continue the project for a period of five more years. It is believed that by the end of this period, with support, the study can be brought to a successful conclusion, and the materials can be prepared for publication.

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2. Ibid., "Some Evaluation Problems in a Course Content Improvement Project." Journal of Research in Science Teaching 1:129-132; Issue 2, 1963.

3. Blanchet, Waldo W. C., "Principles of Science: A Look Ahead." Science Education 41:1-9; February 1957.

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Appendix A. Materials of the Project

Materials prepared by the project: The Development of Junior High School Science Activities (Cooperative Research Project Number S-174-65), integrated with materials prepared earlier by the Michigan Science Curriculum Committee, and published by the Michigan Department of Public Instruction under the title: Open-Ended, Laboratory-Centered Science for Grades 7-8-9, NDEA Title III, Bulletin No. 313, 1965.

(See accompanying set of bound materials.)