DOCUMENT RESUME

ED 047 158 08 VT 012 626

AUTHOR Champagne, Audrey; Albert, Anne
TITLE Development and Evaluation of an Experimental Curriculum for the New Quincy (Mass.) Vocational-Technical School. The Science Curriculum.
INSTITUTION American Institutes for Research, Pittsburgh, Pa.; Quincy Public Schools, Mass.
SPONS AGENCY Office of Education (DHEW), Washington, D.C. Bureau of Research.
REPORT NO TR-14
BUREAU NO BR-5-0009
PUB DATE Sep 70
CONTRACT OEC-5-85-019
NOTE 82p.

EDRS PRICE EDRS Price MF-$0.65 HC Not Available from EDRS.
DESCRIPTORS *Curriculum Design, *Curriculum Development, *Experimental Curriculum, High School Curriculum, *Science Curriculum, Science Education, Vocational High Schools
IDENTIFIERS *Project ABLE

ABSTRACT

Activities concerning the development of the science curriculum of Project ABLE are summarized. The science curriculum attempts to relate science content to vocational areas where applicable, but emphasizes generalizations which the student will apply in his specific vocational field. Intended for 10th, 11th, and 12th grade students, the curriculum consists of units in behavioral science, biological science, sex education, chemistry, and physics. Twenty students were chosen to participate in the implementation of the science material which began with a perceptual unit. Due to a number of difficulties, the science program has achieved only initial stages of its plan. Tasks remaining are the analysis of student and teacher evaluations and the implementation of the remaining part of the prepared curriculum and its revision. Several project materials are appended. [Not available in hard copy due to marginal legibility of original document.] (SB)

FOURTEENTH TECHNICAL REPORT

Project No. 5-0009

Contract No. OE-5-85-019

DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL CURRICULUM FOR THE NEW QUINCY (MASS.) VOCATIONAL-TECHNICAL SCHOOL

The Science Curriculum

SEPTEMBER 1970

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL CURRICULUM FOR THE NEW QUINCY (MASS.) VOCATIONAL-TECHNICAL SCHOOL

The Science Curriculum

Project No. 5-0009
Contract No. OE-5-85-019

Audrey Champagne
Anne Albert

SEPTEMBER 1970

The research reported herein was performed pursuant to a contract with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment of the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

American Institutes for Research
Pittsburgh, Pennsylvania

TABLE OF CONTENTS

FOREWORD

This report, submitted in compliance with Article 3 of the contract, reports on technical activities of Project ABLE during the time of 1 January 1968 through 30 June 1969. A brief overview of the project is presented first, followed by a report summary. The major sections of the report concern (a) the statement of the rationale for grades 10, 11, and 12, (b) the derivation of objectives for grades 10, 11, and 12, and (c) the development of activities for grades 10 and 11.

OVERVIEW: Project ABLE

A Joint Research Project of: Public Schools of Quincy, Massachusetts and American Institutes for Research

Title: DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL CURRICULUM FOR THE NEW QUINCY (MASS.) VOCATIONAL-TECHNICAL SCHOOL

Objectives: The principal goal of the project is to demonstrate increased effectiveness of instruction whose content is explicitly derived from analysis of desired behavior after graduation, and which, in addition, attempts to apply newly developed educational technology to the design, conduct, and evaluation of vocational education. Included in this new technology are methods of defining educational objectives, deriving topical content for courses, preparation of students in prerequisite knowledges and attitudes, individualizing instruction, measuring student achievement, and establishing a system for evaluating program results in terms of outcomes following graduation.

Procedure: The procedure begins with the collection of vocational information for representative jobs in eleven different vocational areas. Analysis will then be made of the performances required for job execution, resulting in descriptions of essential classes of performance which need to be learned. On the basis of this information, a panel of educational and vocational scholars will develop recommended objectives for a vocational curriculum which incorporates the goals of (1) vocational competence; (2) responsible citizenship; and (3) individual self-fulfillment. A curriculum then will be designed in topic form to provide for comprehensiveness, and also for flexibility of coverage, for each of the vocational areas. Guidance programs and prerequisite instruction to prepare junior high school students also will be designed. Selection of instructional materials, methods, and aids, and design of materials when required, will also be undertaken. An important step will be the development of performance measures tied to the objectives of instruction. Methods of instruction will be devised to make possible individualized student progression and selection of alternative programs, and teacher-training materials will be developed to accomplish inservice teacher education of Quincy School Personnel. A plan will be developed for conducting program evaluation not only in terms of end-of-year examinations, but also in terms of continuing follow-up of outcomes after graduation.

REPORT SUMMARY

This report describes the activities concerning the Science Program of Project ABLE in the Quincy Vocational-Technical School.

1. In accordance with the principles and purposes of Project ABLE, a Rationale was established, upon which the Science Program is based.
2. The next step was a statement of course objectives which relate to the Science areas incorporated in the program.
3. After the scope and the content of the Program were established in these two statements, a number of guidelines, techniques and rules of educational application had to be clarified for writing the curriculum. The use of audio-visual media, the selection of text and reference books, and the incorporation of experiments constituted an integral part of the development.
4. The individual Learning Activities were structured, a method of evaluation worked out and an instrument for measurement devised.
5. At the beginning of the school year 1968/69, the implementation of the first sets of developed material--Perception and Biological Science--was begun and continued through the school year. Concurrently in 1968/69, the writing of the Physics curriculum was continued and made ready for implementation.
6. Tasks remaining at the end of the reporting period were: (a) the analysis of student and teacher evaluations and its application in the procedure of revisions, and (b) the implementation of the remaining part of prepared curriculum and its revision.

RATIONALE FOR SCIENCE

One of the purposes of the Quincy Project is to more adequately prepare the student for the roles he will assume as a member of a family, a member of a community, and as a contributing member of the economic society. Among the functions of the school, the curriculum is an important part of the design by which this purpose is to be achieved. Prior to writing the curriculum, it was necessary to examine the student's present and future needs in the roles he is to assume, and decide what information and skills will be of value to him. Specification of learnable skills, desired knowledge and behavior after graduation had to be established.

Certain skills and information are of value to all students and others are of use only in special vocations. Problem solving, learning, and self-evaluation are examples of skills or processes that are of value to all people regardless of the specific activities in which they are engaged. There are other processes common to all people, but it is these three that are considered in some detail.

The exact nature of the problem with which the individual is faced differs from family to family, job to job, and community to community, but the basic nature of the problems is the same. How many children shall we have? How can I get a raise from my boss? Should I vote for increased school taxes? The way in which the individual attempts to solve his problem is a learned one and so much a part of living that the individual is seldom conscious of doing it. Much of an individual's success in life depends on how well he has learned to solve his problems.

There are many problem-solving techniques. Most human problems are solved on an emotional level. Science uses a process called the "scientific method(s)" with great success. Social sciences suggest still other ways in which man can face

and solve his problems. None of these methods are applicable in all situations. The technique selected depends on the situation and the person who is faced with the problem. The school should provide the student with information and practice in all these methods and allow him to make the choice of a specific technique for a specific situation.

Science, and to a much greater extent the technology evolved from science, pervades our society. It was logical, therefore, to study the process of the scientific method to help the student cope with his society, as well as to present to him an opportunity to learn to use this method as a way of problem solving.

A second process in which all humans engage is the process of learning. Schools often take so much of the responsibility for the individual's learning, that the individual never examines the process and thinks that the learning process ends when he leaves school. The school should attempt to inform the student about how he learns (simple learning theory), and help him to develop processes by which he can consciously continue his learning, as well as making him aware of his responsibility to continue his own learning.

A third process that the school should consider is the process of self-evaluation. Society will judge the individual's success, but the individual himself must evaluate his own successes and failures, so that he can take action to assume the responsibility for setting his future course for fitting himself into his niche in society. The individual who has developed an objective evaluation of his own capabilities can set his own limits, be self-directed rather than other directed, and have a realistic self-image. The course provides the student with criteria which he can use to evaluate his progress in the course. He will gradually depend on his own evaluation rather than the teacher's to make decisions about his future activities in the course.

Specific skills will be more dependent on the exact nature of the individual's activities in life. The carpenter must be

able to saw a board, and decide whether to use pine or birch to make a cabinet. The housewife must be able to bake a cake, and decide whether baking powder or baking soda should be used in a recipe. Specific skills like sawing and baking require specific information, and are applicable in narrow areas. The job analysis used in selecting subject matter for the vocational areas has provided that the students will learn those skills specific to their vocational area. The science program attempts to relate the science content to these vocational areas where applicable, but emphasizes generalizations and theories which the student will apply in his specific field. These generalizations and theories also constitute a core that will facilitate a student's mobility within one job family and among various job families.

The selection of specific subject matter in any science course is an arbitrary one. The second portion of this paper will attempt to rationalize the selection made for this science program.

The science studies for the tenth and eleventh grades were written as a single unit. The topics to be studied in this unit are selected from physics, chemistry, biology, and behavioral science. The selection was made on the basis of the applicability of the factual information and conceptual scheme of the topic to vocational areas studied by the Quincy student, and to problems likely to be encountered in day-to-day living. The study of each topic provides the student with the basic vocabulary of that topic, and the laws, concepts, and generalizations that will make his vocational studies of the technology of that area easier and more meaningful to him. The workman who has this basic scientific information for the technology in which he works will have tools at his disposal for the continuation, on his own, of the development of skills and continuation of the learning process.

The subject areas selected also have applicability in the lives of individuals who are not actively engaged in a vocation to which that area is related. For example, the concept of momentum has general applicablilty to anyone who drives. An understanding of the concept might make the difference between life and death to the driver faced with the unfortunate choice of hitting either a 10-ton truck or a Volkswagen. It is not assumed that the student will automatically be able to apply such concepts to practical situations. The instruction provides opportunities to make such applications.

Materials presented in the introductory unit in physics are complete enough to serve as an introduction to the study of both physics and chemistry. There has been a coordination between the math and science curricula so that the math curriculum includes units to teach the specific math skills that are necessary for the study of science.

The material studied in the first physics unit is useful vocationally to boys studying areas like auto mechanics. The material to be studied in the first chemistry unit is largely preliminary, in that its immediate applications to vocational studies or daily living are limited. This material is necessary as a base for the studies in physics and chemistry that follow.

The study in behavioral science should be of special value to those entering vocational areas where dealing with people is especially important. For example, students of the health services occupations, such as practical nurses, child nurses, and dental hygienists should find these studies a useful introduction to the complexities and problems of studying and applying generalizations to specific human behavior. The importance of dealing with other humans and understanding oneself cannot be over-emphasized no matter how the individual occupies himself. The general applicability of such a study seems obvious.

The student is actively engaging in scientific processes. As these studies progress, the student will be asked to answer questions about the processes in which he has engaged. This prelimininary work provides the material on which a study of

the scientific method will be based.

The second unit in chemistry provides material applicable in vocational areas where chemical means of producing electricity are used, and in those areas where general information about certain common classes of chemical compounds is needed. This unit also provides an introduction to the second unit in physics which will concentrate on electricity. It is impossible for the urban dweller to spend a day without coming into contact with some electrical device. A knowledge of the general principles of electricity may not only be useful but essential to the individual's well being. The unit on mechanics introduces the basic knowledge of the principles of functioning of nature and the mechanical environment of man in civilization. It is, therefore, a must in education.

The first unit in biology attempts to provide information and allow the student to develop attitudes in preparation for his role as a family member. It attempts to provide the student with information concerning the anatomy and physiology of human reproduction, genetics, and evolution, so that he can make intelligent decisions concerning these aspects of human life. The unit touches on areas that many schools try to avoid, such as contraception and venereal disease. That these areas concern the student, and that the trend in sex education is toward examining attitudes on these subjects, is evident by the space that articles on this topic are commanding in professional education journals and in popular magazines. The unit is written so that the student can study the subject matter at home with his parents or with another responsible adult of his choice. The teacher is not responsible for attitude development unless the student chooses to discuss the problem with the teacher as the responsible adult. The material can be easily withheld from the students. A letter might be sent to parents giving them an invitation to come to the school to preview the units, and telling parents who don't want the unit studied by their children to simply write a statement to that effect to the school. The unit can cause some minor

administrative problems, but the importance is well worth the trouble.

The twelfth grade science program should be elective. For the student who is interested or requires further preparation in physics, it can be a study of topics in physics not covered by the first two units. For the student interested in chemistry and laboratory technology, it can be a comprehensive study of basic qualitative analysis and human physiology with emphasis on function. A long-range objective might be to write a third elective twelfth grade course which would examine topics in sciences not covered in this course. For example, topics might be selected from astronomy, geology, and history of science to provide a general information course for those with a general interest in science.

COURSE OBJECTIVES

Tenth, Eleventh, Twelfth Grade Science Program

When the student completes the eleventh grade science program he will have increased his skills in the processes of problem solving, learning, and self-evaluation and will use these skills with greater frequency and success in his day-to-day life.

In addition to these skills, the student will have increased his factual knowledge in certain areas and will demonstrate increased skill in applying this information to problems where it is pertinent.

1. The student, when confronted with a problem which is new to him, will be able to plan a strategy to solve the problem using the scientific method as a basis.

2. The student, when given certain scientific information, can apply the information in suggesting solutions and developing attitudes towards contemporary problems.

3. The student, when given certain laws, theories, and generalizations of science, will be able to apply them in solving problems that he encounters in the home and on the job.

4. The student will demonstrate increased ability in finding scientific information for which he has need, written on a level which he can understand.

5. The student will demonstrate increased ability in evaluating his own achievement and progress in his science studies.

6. The student will be able to analyze certain aspects of his own learning process and relate his own learning process to his successes and failures in learning situations in which he finds himself.

Course Objective One: The student, when confronted with a problem, will be able to plan a strategy to solve the problem using the scientific method as a basis.

After having completed the unit on the scientific method;

a. The student will be able to select problems from daily living which may be solved using the scientific method.

b. The student will be able to categorize problems according to whether they would be more suitable to solution using the methods of the sciences, the social studies, or the behavioral sciences.

c. The student will be able to identify the factors in a problem which make the problem applicable to solution by one of the three methods suggested above.

d. The student will be able to list the activities in which scientists engage that make up the scientific method.

e. The student will be able to describe each of these activities, tell in what scientific area each is emphasized, describe special difficulties the scientist encounters in carrying out the activity, and tell how the scientist attempts to overcome the difficulties.

Course Objective Two: The student, when given certain scientific information, can apply the information in suggesting solutions and developing attitudes towards contemporary problems.

After having completed the Human Reproduction, Genetics, and Evolution Units;

a. The student will be able to describe the process of human reproduction using generally acceptable terminology.

b. The student will be able to give the name and function of the portions of the male and female anatomy which play a role in the reproduction process.

c. The student will examine his own attitudes toward the purpose of the sexual act in terms of its function as the means of propagating the race, as a pleasurable activity , and

as an expression of love towards a member of the opposite sex.

(The student will examine his attitudes by exchanging ideas with his contemporaries, his family, and his religious leaders and will then write a statement of his attitudes which he can then have another individual read or not as he wishes. If it is the student's desire, this document can be destroyed immediately on completion. The only requirement is the discipline of having done the writing.)

d. The student will be able to discuss certain factual aspects of the population explosion and to cite opposing opinions on this problem.

e. The student will examine his own attitude toward birth control using the information on reproduction and population. The method of the examination and performance are as described above.

f. The student will be able to list Mendel's Laws and to apply them to simple genetic problems.

g. The student will be able to list and define or describe the function of genetic factors.

h. The student will be able to list and describe tests that can be applied to determine if an individual is a carrier of detrimental genes.

i. The student will be able to discuss and give examples of the application of probability to genetics.

j. The student will be able to do simple statistical problems.

k. The student will examine by the method described above his own attitudes towards an individual's having or not having children on the basis of genetic and statistical probabilities. (For example, should a woman who knows she carries a gene for multiple sclerosis have children?)

l. The student will be able to write a simple description of the evolutionary process giving examples of evidence that Darwin used in the formulation of the theory and describing how Darwin used the evidence in the formulation of the theory.

m. Using the information on genetics and evolution, the student will be able to comment on the theory proposed by some biologists that we are committing race suicide by increasing our pool of undesirable genes, and express his own attitude on how he would react if confronted with a situation where a decision on a matter of this nature were facing him.

Course Objectives Three: The student, when given certain laws, theories, and generalizations of science, will be able to apply them in solving problems that he encounteres in the home and on the job.

a. The student will be able to apply the laws of EMI to the operation of certain specific types of motors, generators, and transformers.

b. The student will be able to give an acceptable theoretical description of electromagnetic induction.

c. The student will be able to define terms applicable to the study of EMI and use the terms properly.

d. The student will be able to apply his knowledge of the laws and principles of EMI to some problems that are new to him which he encounters in his home and on the job.

After having completed the chemistry unit:

a. The student, when given the name (common or chemical) or formula of one of a specified list of chemicals, will be able to classify the chemical into one of several categories, list its important chemical and physical properties, indicate safety precautions to be considered in the use of the chemical, and suggest other chemicals that might be substituted in specific cases in the event that the proper chemical is not available.

b. The student, when given the name and formula of a chemical (of certain classifications) which is new to him, will be able to classify the chemical into its proper chemical classification and make generalizations as to the physical and

chemical properties of the new chemical, and suggest precautions that he would follow in handling the new chemical.

c. The student will be able to list the general properties of certain classifications of chemicals and give some simple theoretical discussion of why certain compounds display certain properties.

d. The student will be able to write the chemical symbols for a few specified elements and compounds.

e. The student will be able to explain how the notations for simple chemical formulas are arrived at, why chemical formulas and symbols are used, and why using proper nomenclature is important to chemists and those who use chemical compounds.

Course Objective Four: The student will demonstrate increased ability in finding scientific information for which he has need, written on a level which he can understand.

a. The student will be able to give the names and general content of certain technical handbooks, popular magazines of science, and books and series of books about science that he can read, understand, and use.

b. The student will demonstrate increased ability in finding information in technical handbooks.

c. The student will be able to list criteria on which he decides:
   (1) If scientific literature is written on a level which he can understand.
   (2) If the scientific literature is internally consistent.
   (3) If certain scientific literature can be considered a scientific authority.

Course Objective Five: The student will demonstrate increased ability in evaluating his own achievement and progress in his science studies.

During the course in eleventh grade General Science;

The student will be able to make a list of those areas

of a topic on which he will be tested before he sees the test.

b. The student will show increasing ability in the estimation of his grade after a test.

c. The student will be able to list the criteria on which the teacher decides his grade for the course and on which the teacher decides whether or not he should proceed to the next topic.

c. The student will more generally make the same estimate as the teacher as to whether or not he has achieved sufficient in one unit to go on to the next.

e. The student will be better able to estimate what portion of the material with which he is presented, he is capable of learning.

Course Objective Six: The student will be able to analyze certain aspects of his own learning process and relate his own learning process to his success or failure in learning situations in which he finds himself.

After having studied visual perception;

a. The student will have increased his ability to visually perceive accurately as demonstrated by a pre-test and a post-test.

b. The student will be able to differentiate between what is "actually there," what he perceives, and inferences he makes about what he has seen.

c. The student will be able to operationally define "actually there", perceptions, and inferences.

d. The student will be able to discuss a specific class incident or an incident in his own experience associated with perception, as an example of the extreme complexity of studying human behavior.

e. The student will be able to provide oral or written examples

c. Incidents where the limitations of human perception:
   (1) are important in day-to-day living,
   (2) are critical in scientific investigation,
   (3) strongly influence the student's ability to solve problems.

After having studied the learning process;

a. The student will be able to write an analysis of his own learning, including:
   (1) those factors which have most influenced his own learning,
   (2) those factors which have most affected his own attitude toward learning,
   (3) how his increased knowledge of the learning process has affected his own learning process.

b. The student will be able to give an operational definition of learning.

c. The student will be able to list the variables on which an assessment learning is based. (Example: amount, rate, retention.)

d. The student will be able to list the factors that affect the learning process and for certain factors be able to describe a specific example of how the importance of this factor was made real to him. (Example: teacher lecture versus inductive teaching.)

GUIDELINES AND TECHNIQUES

After the matter of "what to develop" was clarified as stated in the Rationale and the Course Objectives, many concerns of "how to develop" the curriculum were taken into consideration. The development of Project ABLE material had to cope with two new conditions.

The one condition lay in the characteristics of the student body. It is constituted of vocation-bound and technical-minded high school students. They are of normal distribution in the IQ rating; not many are interested in academic studies.

The other condition is the method of individualized or self-instruction. In lieu of oral presentation by the teacher the use of multi-media instructional devices and individual reading by the student has to be depended on heavily. Reading, alas, is not one of his preferred activities.

These conditions seem predestined to forestall success. Even with employment of audio-visual aids and incorporation of diversified student activities, the main source of intake still remains the student's reading. This apparent obstacle must be a constant warning to an alert curriculum developer.

Individualized instruction, while serving the students' different speeds in learning, presents another limiting aspect: the reduction or elimination of group interaction. Discussion within groups of co-working students provides stimulus. If the learning activity is pursued together by a group, welcome discussion will certainly take place. If the student works alone, however, the exchange of thoughts among students will not occur automatically. The value of group interaction is certainly not doubted by any educator in modern civilization. The developer of a science curriculum suggests cooperation and discussions of groups of students, wherever feasible. Discussion in larger groups or activities or demonstrations to the whole class cannot be preplanned by the developer, but must be left to the classroom teacher's discretion, since students work at individual speeds and can be "gathered" only at some points of the procedure. Yet the intrinsic value of

stimulation from group work and group discussion should not be overlooked, and is one of the responsibilities of the implementing classroom teacher.

The curriculum developer has to bear in mind that he is not writing another textbook, but that he is laying out a plan for a road to follow on a map. The objectives are the learner's "destination" on the map. In continuation of his education, they form the core for objectives on a higher level, the destination of his continued "trip".

A great number of researchers have assembled pertinent advice. M. P. Crawford[1] states seven typical points.

1. Meaningfulness of material promotes learning.
2. The learner should be kept active in making responses.
3. Distributed practice tends to be more efficient than massed practice.
4. Immediate knowledge of results should be provided.
5. Stimulus material should be varied.
6. Accurate records of the learner's progress should be maintained.
7. Early guidance is useful.

The very conscientious awareness of these rules was a definite help and guidance for the developer. At the beginning of the course the student is expected to develop an understanding of methods of learning. The first part of Behavioral Science, preceding Biology, Physics, and Chemistry, makes the student aware of the need of scientific methods and knowledge in order to solve problems. Preceding the Physics curriculum is another introduction for the student (see Appendix A).

Frequently during the course a reminder, a rule, or a set of hints are given to reinforce the student's work habits. Again, printed words cannot substitute for the teacher. Individual observation and guidance are expected of him in the implementation.

---

[1]Crawford, M. P. Concepts of training. In R. M. Gagné (Ed.), Psychological principles in system development. New York: Holt, Rinehart, & Winston, 1963.

SOURCES

The proposed Science course is made up of five parts:

1. Behavioral Science
2. Biological Science
3. Sex Education
4. Chemistry
5. Physics

The materials were selected by the developer with regard for their appropriateness for the student population and for achievement of the course objectives.

Sources for Behavioral Science

Materials were adapted from an "Experimental Program" developed for a high school honors psychology course by Carnegie-Mellon University in Pittsburgh.

Reasons: The course is oriented toward laboratory experience; the generalization from laboratory experiences has practical applications.

Sources for Biological Science

Patterns and Processes: Biological Sciences Curriculum Study

Reasons: The approach is an integration of laboratory with text; the materials provide basic information necessary for sex education, well adapted for the non-academically oriented student.

Sources for Sex Education

Julian and Jackson: Modern Sex Education

Reasons: The book offers frank discussion of problems of immediate and future concern to high school age students. It makes no attempt to moralize or set standards for the student.

Sources for Chemistry

Cotton, F. A., & Lynch, L. D.: Chemistry, An Investigative Approach

Reasons: The book uses text-laboratory integrated approach. The topics that were selected for this course were especially well presented in the text.

Sources for Physics

The search for basic texts, laboratory guides, films and other equipment was begun in the summer of 1968, rather late in the projected duration of Project ABLE development.

Of the many high school textbooks for general student use two were selected as main source and reference guides. They are the ones that are used in the Quincy high schools: Physics: A Basic Science by Burns, Verwiebe, Hazel, Van Hooft; and Exploring Physics by Brinckerhoff, Cross and Lazarus.

Existing programmed instruction and packaged courses were examined. Among these sources one seemed especially outstanding and partly applicable: Harvard Project Physics, which at that time was still in the stage of development.

Harvard Project Physics (HPP)

> "... in a period of rising total school enrollment, the percentage of high school students taking physics has been dropping almost continuously since the 1890's, ... Between 1958 and 1962, the share of high school seniors taking physics decreased further by about 20 percent. Thus, while in 1958 about one student in four took physics, by 1962 the fraction was down to one student in five.
>
> "It is one of the aims of Harvard Project Physics... to help to increase the nationwide enrollment in high school physics courses." (Harvard Project Physics Newsletter, #1, Fall 1964)
>
> "Harvard Project Physics, combining the efforts of a group of scientists, scholars and teachers from all parts of the country, has developed and tested a set of instructional materials for a new kind of introductory physics course. Designed for secondary schools and junior colleges, the course is intended to appeal to a wide variety of students, from the science-oriented to the science-shy, and above all to the growing majority of students who are now taking no physics course at all. Financial support is being provided by the United States Office of Education, the National

Science Foundation, the Carnegie Corporation, the Ford Foundation, the Alfred P. Sloan Foundation and Harvard University." (Harvard Project Physics Newsletter, #6, Fall 1967)

"The Project designed a course that permits and indeed encourages variation... allows a teacher to complement his strengths and supplement his weaknesses, that makes it possible for him to take into account student differences, and that is workable within a wide variety of school situations... The teacher (or his students, if the teacher wishes) will be able to select significant portion of the content of the physics course; he will have available a large variety of integrated instructional materials from the various media; and he will be able to adapt the course to his preferred mode of instruction even--especially--if his preference is for a highly individualized, student-centered approach.

"The course is composed of some number of instructional units joined together. Typically, each unit is made up of a wide variety of printed, audio-visual and laboratory components. ... a student textbook, study guide, laboratory guide, a physics reader, programmed instruction booklet, transparencies with overlays, cartridged film loops, teacher guides and achievement tests.

"The primary objective of the programs is to teach certain skills and concepts. Their style is, however, designed to assist the student to learn how to learn." (Rutherford, 1967, pp. 215-221)[1]

These statements by Dr. F. James Rutherford, Professor of the Harvard Graduate School of Education, Cambridge, Administrator of HPP, led the developer to the study of the material, which at that time was completed and available only in some parts. HPP material is now available only to schools whose implementing teachers have gone through the specific training provided for them in special seminars.

Due to the kind permission granted by HPP through Dr. L. S. Swenson, Project ABLE curriculum incorporates parts of text, laboratory, and guidance material from Unit I, "Concepts of Motion" and Unit III, "The Triumph of Mechanics" into its course.

[1] Flexibility and Variety in Physics: The Physics Teacher, Vol. 5, Number 5, May 1967.

A RATIONALE: TEACHING PHYSICS

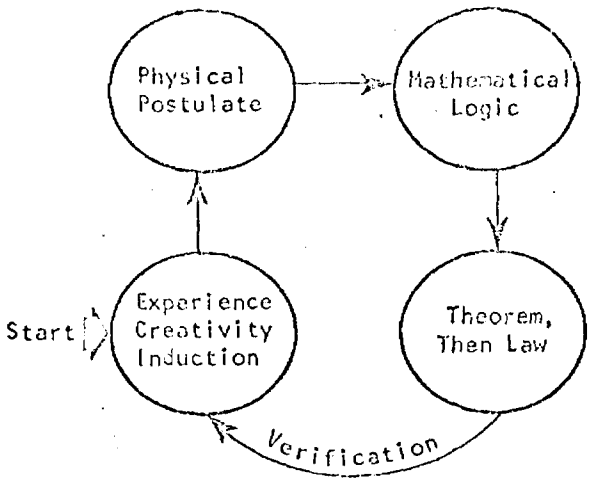
The developer is well aware of the fact that the great majority of students who are of concern to Project ABLE cannot be made into science investigators (although the possibility should not be excluded, but rather hoped for).

It is the aim, however, of every course given in high school, to further young people's cognitive and affective development, that is: to teach them how to learn and how to do.

In physics they are to employ observation, develop skills in experimenting and gain insight and knowledge into the developed science, together with applied logic and mathematics. So equipped, the young people should be able to interpret many of the natural phenomena and much of the technology that confronts them in life.

The elements of teaching physics are clearly structured:

1. The starting point lies in experience. A high school student may be credited with a fair amount of experience. Laboratory work and reading will supplement it.
2. Communication must be clear and must avoid ambiguities. Basic primitive terms must be contrasted with technical terms, undefined concepts with defined meanings.
3. Physics originates with some assumptions about the nature of reality; many laws are postulates. The difference between evidence and proof must be shown clearly. The founders of physics: Galileo, Newton, Maxwell, Einstein, and others clarified the basic postulates.
4. Exercise of logic and mathematics enables us to deduce consequences from these postulates, to prove statements and establish theorems.
5. The last step is verification, explaining the experience and thereby closing the logical cycle.



As stated in the objectives of the project, the course outline would be task related. Such an outline is easier to follow in the vocational and technical subjects than in the academic area. Yet it would have been gladly attempted in the development of the physics curriculum, had a statement of task objectives--cognitive and skill related--been available to the developer.

In the absence of the statement of task objectives, a somewhat conventional development of the sequence had to be undertaken, adapted to the level and interests of the students.

THE LEARNING UNIT

See Appendix B

A. Structure

The first statement of a learning unit is the behavioral objective, telling the student which action, mental or physical, he will be able to perform at the successful completion of the unit.

The following overview calls on the student's knowledge and previous experience and cites a new situation or problem, which relates as closely as possible to the student's interest and demonstrates his need for further knowledge.

The learning experience is best started with an experiment. The observations, results and computations are organized into a sequence leading to the objective. Often a note to the student (Appendix C) is attached to give special guidance; directions and references are given throughout the unit. Sometimes, unfortunately, an actual experiment is not available; reading, film and other aids are used as experiences. Occasionally, some programmed instruction is used. The student must fill in the provided spaces and is encouraged to check his answers with the enclosed answer sheet.

A list of references and learning aids helps the student to assemble his own materials.

A short summary serves as reinforcement.

The student evaluation is a self test which is given to the student after completion of the learning unit. For this the student is individually responsible; not supplied with an answer sheet. The test is to be checked by the teacher and individually discussed with each student. If the teacher finds it necessary, he may refer the student back to repeat the learning experience.

B. Evaluation

Each learning unit is followed up by a student evaluation (Appendix D), which shows the student whether he achieved the objective. In the study of physics the expected behavior is an

explanation, a description, or a computation. In this course the achievement of knowledge, intellectual ability and skill, comprehension and application are desired as designated by B. S. Bloom as categories 1, 2 and 3.[1]

Another self evaluation is provided after a group of learning units to confirm the student's achievement of the concepts, on a level higher than the knowledge of specifics, confirming his comprehension of theories and structures. (Appendix E)

C. Measurement

To measure the student's achievement of the behavioral objectives, an "Academic Achievement Record" (Appendix F) was constructed, which correlates to the "Performance-Behavior Checklist" of the vocational area.

Measures of proficiency--performance behavior or academic achievement--are "criterion referenced", as opposed to "norm referenced".[2] Criterion does not refer to final achievement, but is established at each level at any point in the individual's learning procedure. The specific behavior implied by each of these levels can be identified and used to describe the specific tasks a student must be capable of performing. (Appendix G)

The achievement code is stated in behavioral objectives as:

L for limited achievement

M for moderate achievement

S for satisfactory achievement

---

[1]Bloom, B. S., et al. Taxonomy of Educational Objectives I: Cognitive Domain. Longmans, Green and Co.

[2]Glaser, R., & Klaus, D. J. Proficiency Measurement: Assessing Human Performance. In R. M. Gagné (Ed.), Psychological principles in system development. New York: Holt, Rinehart and Winston, 1962.

INITIAL TESTING

Writing of curriculum was begun in 1967 by members of the faculty of the Quincy High School. Due to newness of the concept and difficulties in preparation, many problems arose and the produced material was not used.

In 1968 the writing of a new set of science curricula was initiated. Its tryout began in the fall of 1968. During the summer of 1968 one of the teachers from Quincy, who participated in the program, spent a week in Pittsburgh for the purpose of guidance in curriculum writing.

Knowledge of the rationale and techniques of the program and its implementation were to be explained and discussed with the teachers in the program in a sequence of seminar-type sessions in Quincy. It is hoped that such sessions will take place before the next tryout. In an analysis of research on instructional procedures in secondary school science[1] Ramsey and Howe state:

> "The background and philosophy of the teacher is important if a new course is being taught. Any given student will achieve more in a traditional course with a traditionally oriented teacher than he would have if the traditional teacher had taught a new course. Thus, new courses can only be successful if the teacher is adequately prepared and philosophically oriented to teach the course.
>
> Teacher characteristics seem more significant in deciding outcomes than any imposed external arrangement..." (Ramsey & Howe)

Twenty students from among those enrolled in the Project ABLE vocational program were selected at random to participate in the first tryout of the science material. The material could not be pretested because of time and other limitations.

---

[1] Ramsey, G. A., & Howe, R. W. An Analysis of Research on Instructional Procedures in Secondary School Science. In The Science Teacher, March 1969.

To the selected students and also to a control group the "Step"[2] pre-test was given, supervised by the curriculum developers. The planned use of the post test was cancelled by the project administrators because of problems in the implementation.

The implementation was begun with the Perception Unit and continued through a large part of Biology. At the time of this report the students' work is being gathered. It should be scrutinized for indications of the results.

A first tryout of the material with a small group of students gives the developer the best opportunity to observe weaknesses of the curriculum which were not discovered in development. It is the implementor's role to discuss and suggest and cooperate with the developer to decide on the best method of revision.

A continued program of tryout of the science material will be run in the school year 1969-70 with the physics curriculum.

A manual for the implementing teacher: Information on the Implementation and the Management of the Physics Program (Appendix H) is included in the course material.

The next steps, as planned, are outlined in the section of recommendations: Scientific structure of a developmental program.

---

[2]Cooperative Test Division: Sequential Tests of Educational Progress.

RECOMMENDATIONS

At the time of this report the science program has achieved only initial stages of its plan. This is due to several circumstances. The development of academic courses in Project ABLE was begun rather late, after the vocational subjects had had several years of a head start. Difficulties in the personnel management, a turnover there and in the field of technologists caused time-consuming delays. When the curriculum development was now attempted for the second time, only a part of it could be tested. If two additional years were available to follow the systems approach through, the demonstration program would, to a high degree of certainty, prove to be a success.

Following here is a recommended systems approach, which has been successfully used in recent educational developments.

Planners of a systems design for an educational program are concerned with effecting a change in students' learning behavior. The model for an instructional systems design is independent of content and media; it is a presentation form to be adapted to specific education requirements with the use of selected media.

It is important to examine all the steps leading to the design of the operational system as outlined here:

Step 1: Establishment of general goals.

Step 2: Determination of specific behaviors to be established.

Step 3: Determination of entering behavior of the students.

Step 4: Design of the presentation (behavior modification) including the Development of operational system (variety of media).

Step 5: Implementation

Step 6: Evaluation

Step 7: Validation

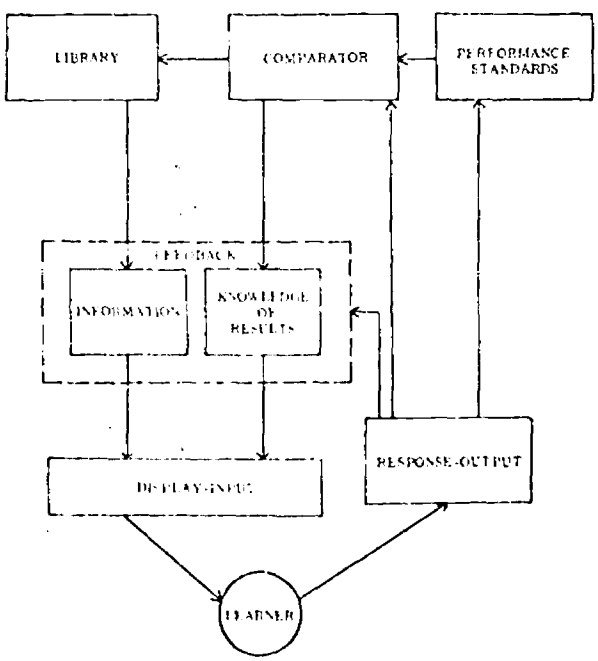
At the time of this report the last two steps are expected to be effected in the future, and a review of the past can be summarized here.

Step 1: The general goals are established in the objectives of Project ABLE and the specific goals for science are outlined in the Course Objectives.

Step 2: The specific behaviors are stated in the "Behavioral Objectives" for each course in the sciences.

Step 3: The entry capabilities of the students are to be determined by a diagnostic test, for which the instruments are to be constructed. As a temporary alternative the post-test can be utilized as a pre-test.

Step 4: The design of the presentation is the entity of procedures for student shaping. It is one of the most important parts of the system. Various approaches have been designed, one of which seemed appropriate for use here. Stolurow[1] states seven components of a model for an instructional system:



[1]Stolurow, Lawrence M., Systems Approach to Instruction, Technical Report #7, July 1965. Training Research Laboratory, University of Illinois, Urbana, Illinois.

The science courses in Project ABLE have attempted to logically follow a model of this type. Information and Display as input are given by experiments, audio-visual aids and text to be read by students; the response output occurs during the learning experiences as either covert, selective, constructed, verbal, motor or affective responses by the student.

The Phases of Construction of Input:

Phase 1: Orientation meetings with classroom teachers take place, in which the Project is described, practical problems discussed and the form in which the teachers' assistance is to take place.

Phase 2: The first draft of the material is completed and teachers are asked to review and edit it.

Phase 3: Preliminary trials outside the school with small student groups are conducted.

Phase 4: The test results of these trials are to be examined, difficulties detected by the students. At this time ambiguities are to be removed, gaps filled, redundancies eliminated and errors corrected.

Phase 5: A selection of portions for pilot experiments is to be made.

Phase 6: Criterion measures are developed for these experiments.

Phase 7: The pilot experiments are conducted with several small groups.

Phase 8: Another evaluation of the material is made.

Phase 9: Criterion tests are prepared. Test items from the pilot studies are used. It is important in the construction of the pre-test to eliminate items which are more indicative of aptitude rather than knowledge. The test items are to be reviewed by judges and are to be classified by level of educational objective (factual, understanding, application).

Evaluation of the criterion test is suggested according to Hammock[1]. The test items should be selected on the basis of their ability to discriminate between students who have and students who have not received the train-

[1] Hammock, Joseph: Criterion Measures: Instruction vs. Selection Research. Murray Hill, N. J. Bell Telephone Laboratories, September 1960.

ing. This, rather than among students all of whom have received training.

Phase 10: The main experiment is to be conducted. The teacher's role as the implementor is described in another part of this report.

These phases constitute the main tasks in the construction of the input material. Now the next step can be undertaken, which is:

Step 5: The implementation.
The most important condition for the success of the implementation is the implementor's thorough acquaintance with the system and with the material that is to be used. His responsibility in the process of implementation is twofold: one toward the student and the second toward the program. As far as the student is concerned, the implementor assumes the status of monitor and, in the beginning stages, of tutor. He has to examine the student's errors, upon which a decision of action is made: repetition or alternate instruction. This responsibility toward the program demands correct recording the reappraisal of the material. This will be most important for the materials revision, for selection of media, aids, etc.

Step 6: Evaluation is to be undertaken, using the collected data, for which instruments have to be constructed.

Step 7: Validation is to be expected after several steps. The pilot program may be evaluated and the presentation form revised. Text as well as all aids are to be reviewed. Then a demonstration program is to be set up and run, whose outcome is to be evaluated and measured with instruments devised for this purpose.

APPENDIX A

INTRODUCTION

INTRODUCTION

Now you are going to learn physics.

You have been living with physics; you benefited from its applications (machines of all kinds); you had to obey its laws (for instance--gravity). Now you will proceed to understand and learn its basic laws.

It will be helpful to you to clarify in your mind the meaning of "learning". Teachers and psychologists have found principles that will assure successful learning. Think about these principles and you will find that they are applied in your Physics Learning Activities.

Principle 1: Learning must satisfy a need.

The "Objective" and the "Overview" in each Activity try to relate your own personal real life experience and your curiosity to a fact and theory of physics.

Principle 2: Learning should be active.

Every Activity contains experiments and calls for your active participation (reading a text, writing answers to questions, computing mathematical problems, etc.).

Principle 3: Learning tasks should be arranged in a logical sequence.

Each Learning Activity uses the knowledge you have acquired in preceding activities or uses some facts you are expected to know already.

Principle 4: Learning must be broken down into small steps.

Each Activity offers you one specific item of knowledge to be taken in and mastered by you, just as food is taken in small bites and digested.

Principle 5: Learning should include repetition.

You know from experience that you understand and remember things better when you hear them repeated once or twice. Have an open mind and do not be annoyed by repetition. You

may think you remember everything after one "getting acquainted" session, but good learning requires repetition.

Principle 6: Learning should include knowledge of results.

The answers to the Learning Activities are included so that you can check your own achievement. If your own answer is wrong, repeat the learning experience. Your honesty is your only insurance for success.

The Student Evaluation, which follows each Activity, will show you whether you learned what you were expected to learn.

If after honest efforts you cannot answer the questions, ask your teacher for help.

APPENDIX B

SAMPLE LEARNINC UNIT

SUBJECT AREA: BEHAVIORAL SCIENCE

Topic: Perception

Activity VI

OBJECTIVE: When you have completed this activity, you will be able to describe an activity which demonstrates how visual clues affect your perception of weight and you will be able to apply this generalization to a practical situation.

OVERVIEW: So far, you have concentrated your study on visual perception. You know that it depends on previous experience and have investigated the question of how much of perception is learned and how much is innate. You have also briefly studied how one's perception in one situation is consistent with one's perception in another situation. Today's activity will enable you to learn more about the relationships between reality and your perceptions.

LEARNING EXPERIENCE:

Class Estimation

1. You will find two wooden blocks at the front of the room. The weight of the larger block is about 300 grams. You are to estimate the weight of the smaller block without actually weighing the blocks. Record the estimated weight of the smaller block below without conferring about its weight or the method of estimation with your classmates.

   Estimate of weight of smaller block: _____

   My method of estimation was: _____

   _____

   _____

2. When the whole class has finished estimating the weight, record the class's data on the board with the boys in one column and the girls in another.

Boys	
Name	Estimate

Girls	
Name	Estimate

3. After the data have been recorded, weigh both blocks on a balance or devise another means of comparing their weights and discuss how closely your estimate agrees with the actual weight of the smaller block. _____

_____

_____

Are there any significant differences in the estimates of the boys and girls? What are they if ther are any? Why the difference? _____

_____

_____

_____

Since the one block looks so much larger (in volume) than the other block, it is probable that the visual appearance is a factor in the error of estimation. Usually when we are confronted with two objects made of the same material, the larger one is the heavier one.

4. What two kinds of clues do you use when estimating the size of objects?

   a. _____

   b. _____

5. Which of these clues do you think has the greater influence on estimations of weight? _____

6. You estimate the size of an object by looking at it, using visual clues, or by feeling it, using tactile clues. We get tactile clues by _____ the object.

7. To test which of these has the greater influence in one's perception of the weight of the object, you will need some naive subjects. Naive subjects are those who know nothing about the experiment. See if you can get some people from a study hall to act as guinea pigs in a test for your class. What two types of clues are you testing for their influence in weight perception?

   a. _____

   b. _____

You will have to do two investigations. In one, the visual clues must be removed and in the second, both the visual and tactile clues must be removed.

8. How can you prevent the block from being seen by the subject who is estimating its weight? _____

_____

9. How can you prevent the block's size from being felt by the subject who is estimating the weight? _____

_____

For the first investigation, you can blindfold the subjects, present them with the larger block, tell them its approximate weight, give them the smaller block and ask them to estimate its weight.

Do this and record your results below:

Investigation I (No Visual Clues)

Boys	
Name	Estimate

Girls	
Name	Estimate

For the second investigation, the subjects must again be blindfolded and the blocks suspended from strings. Give the subject the string and tell him a block that weighs 300 grams is suspended from it. Then give him the string from which the second block is suspended and ask him to estimate the weight of the second block using the weight of the first as a guide.

Investigation II (No Visual Clues, No Direct Tactile Clues)

Boys	
Name	Estimate

Girls	
Name	Estimate

1. Which group (one or two) gave the most accurate estimate of the weight of the block? _____
2. Which type of clues do individuals seem to rely on more, visual or tactile? _____
3. Are there any significant differences between the estimates of the boys and the girls? _____

4. Remember the film, A World to Perceive, where the girl was strongly influenced by visual clues. Do the girls in your class and the girls tested seem to be more generally influenced by visual clues than the boys? _____

5. What have you learned in this demonstration that is of practical value when you want to estimate the weight of an object? _____

_____

_____

_____

Since seeing the object and feeling its size seem to lead one into making bad estimates, closing one's eyes and not feeling the size of the object may help one to make more accurate estimates.

BEHAVIORAL SCIENCE

Student Evaluation Perception VI Name_____

1. Complete the following outline for the investigations you did.

(Class Estimation Section)

Purpose: _____

_____

_____

_____

Equipment: _____

_____

_____

_____

Procedure: _____

_____

_____

_____

Observations: _____

_____

_____

_____

Conclusions: _____

_____

_____

_____

_____

(Investigation I)

Purpose: _____

_____

_____

_____

Equipment: _____

_____

_____

_____

Procedure: _____

_____

_____

_____

Observations: _____

_____

_____

_____

Conclusions: _____

_____

_____

_____

_____

(Investigation II)

Purpose: _____

_____

_____

_____

Equipment: _____

_____

_____

_____

Procedure: _____

_____

_____

_____

Observations: _____

_____

_____

_____

Conclusions: _____

_____

_____

_____

_____

2. Of what practical use is the generalization that our perceptions of weight depend on visual and tactile clues? _____

_____

_____

QPS/AIR/ABLE
SCIENCE

Unit #42

Date/Time Started _____

Date/Time Completed _____

Student _____

PHYSICS: PRESSURE AND VELOCITY IN FLUIDS

Activity XLII: Bernouilli's Principle

OBJECTIVE: After you have completed this activity, you will be able to explain Bernouilli's Principle, on which many devices we use are based.

OVERVIEW: In preceding activities you have studied the pressure of fluids, comprising liquids and gasses, in stationary condition. Now you will observe the relation between velocity and pressure in fluids which are in motion. Why does the wing of an airplane lift up? What makes a ball fly a curved path? How does a spray gun work? How does the carburetor work? What creates a tornado?

LEARNING EXPERIENCE:

Do the following experiment: Hold a strip of paper, approximately 3 inches wide and 10 inches long, below your lips and blow over the top of the paper. Describe what happens and explain it:

(1) _____

_____

The moving of air decreased the pressure above the paper.

Now do experiment 15-21 on p. 201 in EXPLORING PHYSICS. Describe and explain:

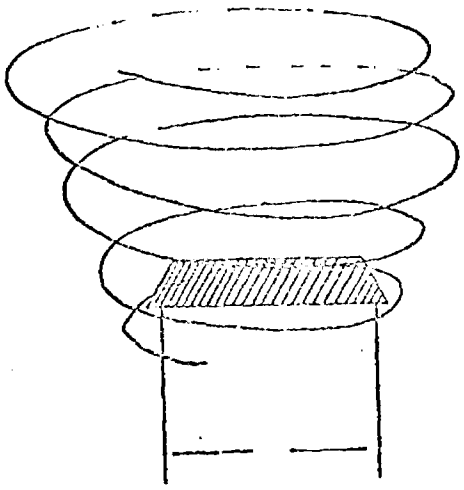
(2) _____

_____

If you attach two such strips of paper at the end of a piece of wood or on a ruler, about 3 inches apart from each other and blow hard in between them, what do you observe?

(3)_____

The air pressure is lower on the inside, therefore, the papers are pressed together by the greater outer pressure.



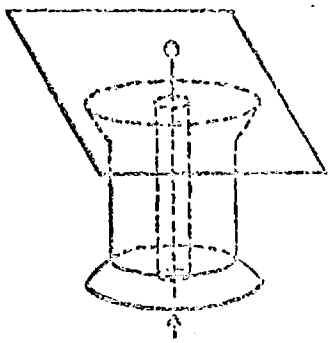
In a tornado, a wind that is created by differences in air temperature increases its speed in a whirling funnel. Through the increased speed of air in the funnel the pressure is (4) _____ rapidly and objects within the tornado's funnel such as houses may burst apart from the (5)_____ side. What could one do to lessen the effect of an approaching tornado? (6)_____

_____

Read: EXPLORING PHYSICS, p. 197-198 . . . 15. Lift on the upper surface. The speed in the narrow part of the tube is (7) _____ than in the wide part. If the speed is greater, the pressure is (higher or lower) (8) _____.

This fact was observed and measured for the first time by Daniel Bernouilli (ber-noó-lee) in the 18th century and is called "Bernouilli's Principle": The pressure within a moving fluid is greater where it is moving slowly and less where it is moving rapidly.

Do the following experiment:



Card-and-spool Experiment. A pin is struck through the middle of a card and is inserted in the hole of a wooden spool to prevent sideways motion. When you blow through the bottom hold, the card does not fly off but presses against the spool.

Explain: _____

_____

If a large metal disk with central hole connected to a large compressed air outlet or tank of carbon dioxide gas is used, a similar disk is held to it with sufficient force to support a heavy weight.

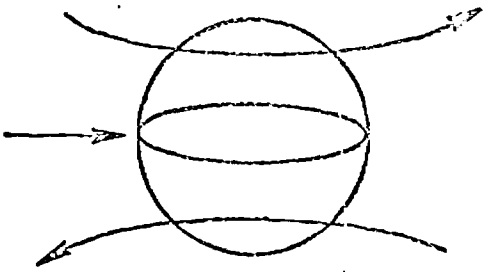
Give the name of the principle on which these effects are based: (9) _____.

State Bernoulli's Principle: (10) _____

_____

_____

A spinning baseball follows a curved path. Why?



The ball, which is given a counterclockwise spin, drags the air around with it. At the top of the ball this air current is moving forward, at the bottom it is moving against the direction. The air at the top moves faster and the pressure is (11) _____. The ball will, therefore, fly (upward or downward) (12)_____. Explain in your own words, why a spun ball will follow a curved path:

_____

_____

How does a spray gun or an atomizer work?

Read p. 66 in PHYSICS, A BASIC SCIENCE. The Bernouilli principle. Draw a sketch and explain in your own words how a spray gun works:

(13) _____

_____

_____

_____

_____

With the help of Bernouilli's principle you will be able to explain how the pilot controls the lift of his plane.

Read p. 196 in EXPLORING PHYSICS . . . . The Airplane. Read carefully, so you will be able to answer the questions which will follow. If you do not know the answer, read again.

Make a diagram of the wing. Mark the angle of attack.
(14)

Explain the lift on the lower part of the wing: (15) _____

_____

_____

_____

Why is the upper svrface of the wing curved? (16) _____

_____

_____

What is the stalling angle? (17) _____

_____

_____

How does the pilot regulate the angle of attack? (18) _____

_____

_____

How does a carburetor work?

The carburetor forms the explosive mixture of (19) _____ and gasoline. The tube through which the air rushes into the carburetor is narrowed down at the point of entry and therefore creates a (low, high) (20) _____ pressure. This permits a more rapid evaporation of the gasoline.

SUMMARY: You have studied Bernouilli's principle, which states: The pressure within a fluid is greater where it is moving slowly, and less where it is moving rapidly.

REFERENCE: EXPLORING PHYSICS
PHYSICS, A BASIC SCIENCE

LEARNING AIDS: Paper, ruler, or block of wood
Spool, pin

ANSWERS:

1. The paper will be blown upward, because the air pressure on top of the paper is decreased by your blowing.
2. The pressure below the paper is reduced by your blowing and the paper is pushed down by the higher air pressure on top.
3. The strips come close together.
4. lowered
5. inside
6. Open all windows and doors.
7. greater
8. lower
9. Bernouilli
10. The pressure within a moving fluid is greater where it is moving slowly, and less where it is moving rapidly.
11. increased
12. upward
13. The stream of air blown across the opening of the upright tube reduces the pressure and makes the liquid rise from the container to the top of the tube where it is blown away in a spray.
14. 

15. The air which strikes the bottom of an inclined wing pushes the plane upward under the proper angle of attack.
16. It acts as one side of a narrowing tube; speed of air is increased and the pressure is lowered.
17. The stalling angle is that angle of attack at which air breaks away from the upper surface of the wing and whirlpools of air cause a great loss of lift.
18. Pulling the stick backwards increases the angle of attack and pushing the stick forward lowers the angle of attack.
19. air
20. low

STUDENT EVALUATION

OPS/AIR/ABLE
SCIENCE: Physics: Pressure and Velocity in Fluids

Date/Time Started _____

Student _____

Date/Time Completed _____

1. How does the pressure exerted by a flowing fluid vary with its speed?

2. What is the name of the principle that states this fact?

3. Name three applications of this principle:

4. How is an airplane wing designed to increase lift force?

5. What is the purpose of the narrow air passage at the point where gasoline is mixed with air in a carburetor?

6. Why does a spinning baseball travel a curved path?

SUBJECT AREA: BIOLOGY

Topic: Reproduction and Development

Activity III

OBJECTIVE: When you have completed this unit, you will be able to describe the experiments and conclusions drawn by the two biologists, Spallanzani and Pasteur, in their attempts to disprove spontaneous generation.

OVERVIEW: Early observers of nature noticed the appearance of living things in places where there had been no previous sign of any living things. They concluded that the living things had been spontaneously generated from the nonliving matter in which they appeared. This explanation was not accepted by the Italian scientist, Lazzaro Spallanzani (18th Century), or Louis Pasteur (19th Century), the famous French biochemist.[1] In this activity, you will see the experiments like those performed by these two men, draw the conclusions from the experimental evidence as they did, and study the criticisms of their experimental design.

LEARNING EXPERIENCE:

1. A. Turn to page 136 in Patterns and Processes and look at the diagram of the experiments of Spallanzani and Pasteur.

   B. Read the description (p. 144, Teacher's Handbook) of how the flasks were prepared. If possible, make up your own set of flasks. You will put your data on the charts on the following page.

   C. After you have read how the flasks were prepared (or actually prepared a set), fill in the spaces on the charts. Observe the appearance of flasks that were just prepared and those that have been around for three weeks. Fill in the appropriate spaces on your charts.

   The liquid in the flasks is bouillon.[2] Bouillon is a substance on which micro-organisms, bacteria, and others can grow. The bouillon becomes cloudy as the bacteria grow in it. This you must take on faith. All these assumptions can be demonstrated, but it would take too much time to do.

---

[1] one who studies the chemistry of living things

[2] bull-yun

Spallanzani

Flask #	Method of Preparation			Appearance	
	liquid	treatment with heat	air supply	immediately after preparation	after three weeks

Pasteur

Flask #	Method of Preparation			Appearance	
	liquid	treatment with heat	air supply	immediately after preparation	after three weeks

II. Answer the following questions and check your answers with the key as you go along.

A. Spallanzani's Experiment

Flasks two and three represent flasks like the ones Spallanzani used to try to disprove that spontaneous generation could occur. Spallanzani knew that boiling destroyed most micro-organisms.[3] To kill the microorganisms in the flasks, the bouillon in the flasks was (1) _____. One flask was left open to air. The other was closed. Spallanzani believed that micro-organisms were present in the air. By placing a stopper on one flask, he was keeping the air and the (2) _____ away. Spallanzani was testing the hypothesis that there would be no evidence of the growth of microorganisms in the flask that was boiled and (3) _____. (4) _____ the flask should kill all the microorganisms that were present in it. Stoppering the flask should prevent any new microorganisms from entering the flask. If evidence of growth of micro-organisms had been observed in flask three that was boiled and (5) _____, it would have been the result of spontaneous generation because all the microorganisms had been destroyed in flask three by (6) _____ and no new microorganisms could enter because the flask had been (7) _____.

Do your experimental results support the hypothesis that in a flask of bouillon that is boiled and stoppered, no evidence of the growth of microorganisms should appear? If not, why not? (See if you can find an answer below if your experiment did not "work".)

_____

_____

_____

_____

Objections to Spallanzani's Experiment: Critics of Spallanzani's experiments believed that there was no evidence of life in flask three because no air could get into the flask.

[3] an organism too small to be seen with the naked eye

These people believed that air was necessary for all life. Today, we know that certain kinds of life, for example, certain microorganisms, can live without an air supply. Louis Pasteur designed an experiment which attempted to satisfy the critics of Spallanzani's experiment.

B. Pasteur's Experiment

(1) _____ destroys microorganisms, but many microorganisms produce spores[4] which are heat resistant and may not be destroyed by boiling. Autoclaving or heating under pressure produces temperatures much higher than 212°F. Heating under pressure, which is called (2) _____, produces temperatures higher than (3) _____°F and will kill microorganisms as well as their heat resistant spores. Pasteur used the process of (4) _____ which produces higher temperatures than boiling so that both the microorganisms and their heat resistant (5) _____ would be destroyed.

Look at flasks five, six, and seven. Which flasks allow air to enter? (6) _____. Microorganisms "ride" around in air currents on dust particles. (You can see these dust particles when the sunlight shines through a hole in a shade in a dark room.) These dust particles "fall out" of the air as evidenced by the dust that forms on furniture.

As flasks five and seven sat exposed to air, in which flask would dust particles more easily fall? _____

Since flask five has a tube which is straight up and down, the falling dust particles would fall right into the bouillon.

What would happen if a dust particle fell into the open end of the "S" shaped tube in flask seven? _____

_____

_____

The particle would fall and be trapped in the curve.

Is it likely that the particle would be moved along the tube? Why? _____

_____

_____

[4] spō-r a tiny one celled body, capable of producing a new organism

No, since dust particles are carried on air currents and there is no way for currents to develop in the flask, unless the tube is blown into or shaken. Therefore, it is unlikely that a dust particle would get beyond the first "U" shaped turn in the tube.

In which flasks would you expect evidence of the growth of microorganisms? _____

_____

_____

Flasks four and five because both flasks are exposed to the (7) _____ and are opened in such a way that falling dust particles with microorganisms on them could fall into the bouillon.

Flask six should not produce evidence of life because it has been (8) _____ to kill microorganisms and their (9) _____, and there is no way for microorganisms to get into the flask. The flask allows air to get in, but falling dust particles with (10) _____ cannot get in the flask because they are trapped in the "U" shaped curve of the tube.

Pasteur had thus shown that spontaneous generation would not occur in a flask in which all (11) _____ and their spores had been destroyed by (12) _____ and in which no new microorganisms could be introduced by exposure to falling dust particles. By allowing the flask that had been (13) _____ and protected from falling dust particles to be exposed to the air, he had demonstrated to Spallanzani's critics that the absence of air was not the reason that (14) _____ had not occurred in the flask that Spallanzani had boiled and stoppered.

Controls

Flask one was not boiled or (15) _____ but was (16) _____ to prevent its exposure to microorganisms in the air. Flask one should show evidence of growth. This demonstrated that unboiled bouillon has (17) _____ in it which must be destroyed by (18) _____ or autoclaving in order to show that spontaneous generation does not occur.

Look at flask four. Is there evidence of life in the flask?

_____

If there is evidence of life in the flask, it demonstrates that the process of autoclaving does not destroy the ability of the bouillon to support microorganismic life.

The experiments of Spallanzani and Pasteur demonstrated that microorganisms or their spores must be present for more microorganisms to be produced. Since microorganisms are examples of living things, we can generalize and say that living things must be present for more living things to be produced or simply that life comes from life. This idea is basic to the study of reproduction.

REFERENCE: Patterns and Processes, Student and Teachers' Handbook (144).

LEARNING AIDS: Patterns and Processes, Student and Teachers' Handbook (144).

SUMMARY: You have just carried out the experiments that attempt to disprove the theory of spontaneous generation. The disproving of the theory of spontaneous generation is important because a basic assumption of the reproductive process is that life comes from living things in the present system of things. This presented scientists who were trying to develop a theory of the very beginning of life on earth with a problem. Because in the beginning there was no life, one must assume that the beginning of life came from nonliving matter, but this is the only presently accepted case of spontaneous generation.

Answers

A.
1. boiled
2. microorganisms
3. stoppered
4. boiling
5. stoppered
6. boiling
7. stoppered

B.
1. boiling
2. autoclaving
3. 212
4. autoclaving
5. spores
6. five, seven
7. air
8. autoclaved
9. spores
10. microorganisms
11. microorganisms
12. autoclaving
13. autoclaved
14. spontaneous generation
15. autoclaved
16. stoppered
17. microorganisms
18. boiling

BIOLOGICAL SCIENCE

Student Evaluation Activity III Name_____

1. What is the basic assumption of the reproductive process that makes the disproving of the theory of spontaneous generation so important? (5 points) _____

2. How did Spallanzani try to disprove the theory of spontaneous generation? (5 points) _____

3. What factor in Spallanzani's experimental design did his critics say made his conclusion invalid? (5 points) _____

4. How did Pasteur overcome the criticism of Spallanzani's experiment? (5 points) _____

5. What do you estimate your grade will be on this quiz? (2 points) _____

SUGGESTIONS FOR FURTHER STUDY: Read about the theory of the origin of life by Oparin and the experiment of Miller in Biology, John W. Kimble, Addison Wesley, 1967.

Notes to the Teacher

Preparation for this activity must be made three weeks in advance of the activity. See page 144, Teachers' Handbook--Patterns and Processes.

APPENDIX C

NOTE TO THE STUDENT

NOTE TO THE STUDENT

In this activity you were asked to perform three experiments. They are simple and most likely confirm what you know already. Yet they showed you the important steps in conducting an experiment.

These steps are:

1. Decide what facts or action you want to observe. Why?
   You understand actions or happenings better when you observe them.
2. Assemble the equipment. Why?
   A good baker or carpenter has all his tools ready when he starts on the actual job.
3. Prepare the table in which you will enter your observations. Why?
   You want to record (write down) your observations as soon as possible.
4. Perform the experiment.
5. Read the measurements and enter them in the table. Why?
   The results of your experiment will help you understand the fact or the action you observed and will also be used in tables and problem solving.
6. Repeat the experiment at least three times. Why?
   Judging from a single performance may lead to a mistake in judgment. Three or more similar results are reassuring. Researchers often repeat an experiment even hundreds of times, before they accept its result.
7. Formulate and write down conclusions and answers to questions. Why?
   This is the actual profit you have from the experiment.
8. Think for yourself: What did I learn from this experiment? What would a practical application be?

APPENDIX D

STUDENT EVALUATION

Student Evaluation PHYSICS XXXIV Name _____

1. Mention three examples of the use of the wheel-and-axle:

_____

_____

_____

2. Mention three examples of the use of gears: _____

_____

_____

_____

3. Mention three examples of the use of pulleys: _____

_____

_____

_____

4. One turn of the pedals of a bicycle causes the bicycle to move a great distance. Draw a diagram and explain:

_____

_____

_____

5. Write both expressions for the mechanical advantage of wheel-and-axle and pulley: _____

_____

_____

*6. Calculate in the space below the missing information for the following wheel-and-axle machines and fill in the spaces:

Effort arm	Resistance arm	Mechanical Advantage	Resistance force	Effort force
20 in	4 in		15 lb	
	2 ft	7		28 lb
40 cm		8		10 g

*from EXPLORING PHYSICS, page 87.

APPENDIX E

TEST

Test for Units 21-30 3-11-69

QPS/AIR/ABLE
SCIENCE

Date/Time Started _____

Date/Time Completed _____

PHYSICS: TEST NUMBER THREE

Activities XXI - XXX

1. State Newton's Third Law: _____

_____

_____

2. What drives a rocket forward? _____

_____

_____

3. An object's travel on a circular path is called _____

An object's turning around an axis is a _____

4. An object in circular motion (radius = 2 feet) has the frequency of 3 per minute. What is the object's speed?

5. Is the friction between extremely smooth surfaces greater or less than between moderately rough surfaces? _____

6. Explain how rolling wheels (ball bearings) reduce friction:

_____

_____

_____

_____

7. How do you compute the gravitational force between two objects of mass m_1 and m_2 a distance d apart from each other?

8. State the law of conservation of mass. Give an example:

9. Which conversion does an atomic bomb achieve?

10. You are thrown forward, when you are in a moving car which stops suddenly. Explain the cause in terms of physics.

11. State the law of conservation of momentum and explain an example in your own words.

12. How is "work" defined in physics? _____

_____

13. What work must a motor in a bottling machine perform in order to lift a platform holding twelve 8-oz. bottles of soda 4 inches high?

14. What is an object's potential energy? What is its kinetic energy?

15. Does velocity of a moving body influence its kinetic energy? How?

16. State the principle of conservation of Mechanical Energy.

APPENDIX F

ACADEMIC ACHIEVEMENT RECORD

ACADEMIC ACHIEVEMENT RECORD

This academic achievement record lists the specific objectives the student is expected to fulfill in the course and also indicates the level of his achievement of each objective. The code explaining the levels of achievement is given below. The student who receives this document has the fundamental skills and knowledge to advance in the subject area.

Key to Achievement Code

Limited Achievement:

The student recognizes the terms, tools, skills, information sources, and basic concepts necessary to minimum level tasks. He performs minimum level tasks with direction.

Moderate Achievement:

The student applies his knowledge of terms, tools, skills, and information sources to given tasks and problems. The student can state the relationship of the tasks or problems to the concepts of this course. In some situations he performs well on his own; in others he needs some assistance.

Satisfactory Achievement:

The student transfers his knowledge and application of these terms, tools, skills, and information sources to unfamiliar tasks and problems. He is able to explain the concepts of this course and requires little assistance to complete assignments successfully.

APPENDIX G

BEHAVIORAL OBJECTIVES

BEHAVIORAL OBJECTIVES

After completion of activity:	The student is able to:	
I. Behavior of Matter:	Describe the action of different matter and of different mass, when a force acts on them.	☐
II. Speed:	Describe and explain an experiment in which you observe measure, graph and compute the speed of an object.	☐
III. Acceleration:	Explain the meaning of acceleration and describe Galileo's experiment on the inclined plane.	☐
IV. Galileo's First Law:	Distinguish between terms of velocity; compute velocity, time and distance of accelerated motions with the help of Galileo's First Law.	☐
V. Galileo's Second Law:	Compute distances by application of Galileo's Law and the earth's gravitational force g.	☐
VI. Accelerated Motions:	Explain other kinds of accelerated motion and compute their path, time, velocity and acceleration.	☐
VII. Mass & Weight:	Explain the difference between an object's mass and weight.	☐
VIII. Weight in English Metric System:	State an object's weight in the English and in the Metric System.	☐
IX. Measurement in English Metric System:	State an object's size in the English and Metric System.	☐

X.	Conversion from the English to the Metric System:	Convert weight and space measurement from the English to the Metric System.	☐
XI.	Archimedes' Principle:	Describe the experiment and explain the principle.	☐
XII.	Density and Gravity:	Compute the density of matter and explain the meaning of specific gravity.	☐
XIII.	Force:	Explain the meaning of dynamics and force as the cause of motion.	☐
XIV.	Vectors:	Express a force, a combination of forces or other quantity as a vector.	☐
XV.	Equilibrium:	State the condition under which an object is in equilibrium.	☐
XVI.	Newton's First Law of Motion:	Explain Newton's First Law of Motion or the Law of Inertia.	☐
XVII.	Newton's Second Law of Motion:	Derive and explain Newton's Second Law.	☐
XVIII.	Newton's Second Law of Motion:	Define the units of force and solve problems.	☐
XIX.	Mass, Weight, and Gravitation:	State the definition of an object's weight and an object's mass.	☐
XX.	The Concept of Momentum and the Conservation of Momentum:	Use the Concept of Momentum in solving problems.	☐
XXI.	Newton's Third Law:	Explain how forces cause motions such as propulsion of a bullet, a motorboat or a rocket.	☐
XXII.	Circular Motion:	Explain centrifugal and centripetal forces.	☐

XXIII.	Air Resistance:	Explain the effect of air resistance on motion.	☐
XXIV.	Friction:	Explain friction between objects and compute the coefficient of friction.	☐
XXV.	Universal Gravitation:	Explain and apply Newton's Law of Universal Gravitation.	☐
XXVI.	Conservation of Mass:	Describe conservation of mass in a closed system and compare with the law of conservation of mass-energy.	☐
XXVII.	Conservation of Momentum:	Discover and explain the law of conservation of momentum; apply it to solution of problems.	☐
XXVIII.	Work and Energy:	Define the physicist's term of work and compute work in two kinds of units.	☐
XXIX.	Mechanical Energy, potential and kinetic:	Compute potential and kinetic energy of an object.	☐
XXX.	Conservation of Mechanical Energy:	Explain the principle of conservation of mechanical energy and compute special cases.	☐
XXXI.	Watt's Steam Engine and Units of Power:	Explain Watt's steam engine and define units of power.	☐
XXXII.	Law of Conservation of Mass and Energy:	State and explain the Law of Conservation of Mass and Energy.	☐
XXXIII.	The Lever:	Express mechanical advantage in figures, solve problems in the use of levers and distinguish between three kinds of levers.	☐
XXXIV.	Wheel and Axle, Pulley:	Demonstrate the mechanical advantage of simple machines.	☐

XXXV.	The Inclined Plane:	Demonstrate and compute the mechanical advantage of the inclined plane, the difference between the ideal and the actual mechanical advantage.	☐
XXXVI.	The Wedge, the Screw, and Combined Machines:	Explain wedge and screw, compute their mechanical advantage and efficiency.	☐
XXXVII.	Matter and Pressure:	Explain origin of pressure in solids, liquids and gasses. Compute value of pressure.	☐
XXXVIII.	Barometers, Manometers:	Explain functioning of barometers, manometers and define the unit of atmosphere.	☐
XXXIX.	Pascal's Law and the Hydraulic Press:	Explain the principle and working of the hydraulic press, compute its mechanical advantage.	☐
XL.	Boyle's Law for gasses:	Describe Robert Boyle's experiment, distinguish between absolute pressure and gauge pressure, and solve problems.	☐
XLI.	Kinetic Molecular Theory of Gasses	Explain the Kinetic Molecular Theory of Gasses.	☐
XLII.	Bernouilli's Principle:	Explain Bernouilli's Principle.	☐
XLIII.	Temperature and Volume:	Explain heat and temperature, temperature scales, thermometers. Define heat units and specific heat.	☐
XLIV.	Brownian Motion, Charles' Law, General Gas Law:	Explain Brownian Motion; state and use Charles' Law and the General Gas Law.	☐
XLV.	Transportation of Heat, Change of State of Matter:	Distinguish among three kinds of transportation; explain change of state by molecular theory, explain concepts of fusion, vaporization, condensation; use the law of heat exchange.	☐

APPENDIX H

INFORMATION ON THE IMPLEMENTATION AND THE MANAGEMENT OF THE PHYSICS PROGRAM

PREPARATION

Individually prescribed Learning Activities imply not only the prescription to the student to learn alone, but also to the teacher to teach individually.

The teacher is freed of the work of outlining a curriculum, researching for learning aids, devising a timetable, and preparing a lesson plan. He must use his preparation time to study the Activities and their perusal. In this time, he is to read all the included and referenced material and must check that a fair number of copies of this material are available in the classroom.

He is responsible for assembling and readying the learning aids, needed supplies, and equipment for experiments. He must ascertain that all is in working order.

ACTIVITY

The teacher removes the Evaluation Test from the Activity, hands the Activity to the student, and retains the Evaluation Test. At the very beginning of the program, the following procedure is suggested:

First: Invite the students to leaf through the Activity for a few minutes. Ask them to remove the answer sheet from the back of the Activity and place it beside the Activity.

Then: Explain to the students the meaning of:

1. Objective
2. Overview
3. Learning Experience
4. Summary
5. Learning Aids

1. The Objective is the goal of your student's learning. It is stated in "behavioral terms", which means his performance at the end of the Activity will be observed and measured.

The Objective states the "what" he learns.

2. The Overview explains the student's need for this knowledge and also recalls experience and information he is expected to have.

The Overview states the "why" he learns.

3. The Learning Experience gives the step-by-step procedure to be followed by the student.

The Learning Experience states the "how" he learns.

Exhort the student not to leave any question unanswered; tell him that every line prepared for him must be filled. But answers like: "I don't know"; "I don't understand"; and "I forgot" are not acceptable. In this case, the student must return to the beginning, or turn to the reference

source for information and at the very last turn to the teacher for help.

> At this point the teacher's function is crucial. He leads the student back to the last point of understanding and uses his judgment in giving tutorial help. Only the teacher who is honestly convinced of the advantages of individual learning will perform a good job. If, after answering the same question from different students several times, he thinks "Why can I not explain this thing to the whole class at one time?" he has two alternatives: either to gather the class, if the majority is working on that activity, and discuss the point in question; or, if this is not feasible, make a notation for revision of the material.

The student is to check each of his responses immediately with the answer sheet. Exhort the student that use of the given answer instead of producing an answer himself will only do him harm, because there will be no answers supplied for his Evaluation Test.

During the students' work, the teacher is to circulate about the room and give them the assurance that he is available.

4. The Summary serves the student as reinforcement.
5. The Learning Aids are to be prepared before the start of the Activity and returned after their use.

When the student has completed the Activity, he hands it back to the teacher and receives the Evaluation Test which, unless stated otherwise, is to be used without Learning Aids.

EVALUATION

The teacher checks the Evaluation Test. In its present form, it places the judgment of the level of achievement--L for limited, M for moderate, S for satisfactory--at the teacher's discretion. These levels are the basis of the teacher's report on the "Academic Achievement Record." (See Appendix F)

There is a possibility envisioned for the future that this and other tests can be restructured for the use of a device similar to the "Trainer-Tester Response Card" used in non-academic areas. This device, however, would not leave any room for open-ended answers and for judgment of the student's thinking procedure. Therefore, the recommendation is to structure evaluations which provide for immediate feedback, few opportunities for cheating, and not demanding of the teacher's time to the point where it interferes with his tutorial role.

After the teacher has checked the Evaluation Test and finds it acceptable, he signs the student's Activity and retains it in a file. This file should be accessible to the student at any time, if he has to refer back.

After a series of Activities, a test (e.g. Test 1, Activities I-X) is given to show the student's knowledge; test results to be integrated into the Academic Achievement Record.

ADDITIONAL REMARKS ON THE USE OF THE MATERIAL

1. The preceding orientation is a weak substitute for an intensive oral demonstration-orientation program. The implementing teacher's dedication and good will bear fruit in the program's success. Therefore, a systematic, critical contribution from the teacher, in form of marginalia, personal observations, and suggestions is highly desirable.
2. It should be pointed out here that the Activity can very well be used by two or more students as a group if they work together successfully. This will give an opportunity for discussion and cooperation, which is of additional value. The art of communication and the effect of learning can only be strengthened by oral use of proper terms and is of great value in the stimulation of motivation.
3. In order to strengthen the Science teacher's judgment in the curriculum's relevance, he is reminded of the National Objectives of Teaching Science, as stated in the "National Assessment Program" developed in 1969 for Science:

   "1. Know fundamental facts and principles of science.

   2. Possess the abilities and skills needed to engage in the processes of science.

   3. Understand the investigative nature of science.

   4. Have attitudes about the appreciations of scientists, science, and the consequences of science that stem from adequate understandings."