THE COMPILATION AND EVALUATION OF INSTRUCTIONAL OBJECTIVES FOR INTRODUCTORY GEOLOGY COURSES TAUGHT BY THE AUDIO-TUTORIAL APPROACH AT INSTITUTIONS OF HIGHER LEARNING IN THE UNITED STATES

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Edward E. Miller
Major professor

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ABSTRACT

THE COMPILATION AND EVALUATION OF INSTRUCTIONAL OBJECTIVES FOR INTRODUCTORY GEOLOGY COURSES TAUGHT BY THE AUDIO-TUTORIAL APPROACH AT INSTITUTIONS OF HIGHER LEARNING IN THE UNITED STATES

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In 1963 the Geological Education Orientation Study (GEO-Study) made a survey of the quality of education in the introductory courses at colleges and universities in the United States and concluded that these courses were not meeting the needs of the students.[1] Since that time one form of renovation in these courses has followed the audio-tutorial approach as first developed by S. N. Postlethwait at Purdue University in the field of botany.

Goals or objectives are essential to an effective pre-designed course of instruction, such as the audio-tutorial approach, so that students and others will know exactly what is being taught and on what the evaluation will be based. But objectives have not always been given serious attention by the developer of pre-designed instruction and the following study to determine if this were true for developers in the area of geology was made.

Reasons for omission of objectives were sought, as well as relationships between objectives and effectiveness of the courses. Any other factors that had an effect on the development of objectives were noted.

A number of colleges and universities in the United States using the audio-tutorial approach have been identified in "Audio-Tutorial Instruction: A Strategy for Teaching Introductory College Geology."[2] Nine of these twelve schools were contacted for materials to determine which had used objectives in their programs. Five schools which did not state objectives in the materials given to the students were: Macalester College (Minnesota), College of Marin (California), University of Notre Dame (Indiana), Ohio State University, and Pennsylvania State University. (Ohio State used objectives, but did not give them to the students.) The four schools which made objectives available to the students were: Lansing Community College (Michigan), University of Michigan, State University College at Buffalo (New York), and Principia College (Illinois).

The objectives from these four schools were studied and evaluated mathematically based on completeness in conjunction with Mager's concept of a behavioral objective.[3] None of the schools had their objectives written completely in behavioral terms. Principia College had the highest objective rating and State University College at Buffalo the lowest of the four schools. These two schools were then chosen for a more detailed look at their programs to determine why they were more or less effective in their objective development. Personal interviews with the developers were arranged at each of these schools during July, 1970.

All the programs using the audio-tutorial approach were influenced by Postlethwait's work at Purdue University; those most nearly like his used objectives, and those least like his did not use objectives. Some programs listed as audio-tutorial did not fit the definition as used by Postlethwait.

An interesting observation is that three of the five schools that used objectives had been developed with the aid of a professional educator. Whether this made the programs more effective was not evaluated, but it is apparent that this did contribute to the formulation of the objectives, as no school without objectives had such involvement. In the other two schools, innovative professors had developed objectives realizing the importance of them intuitively.

Since objectives are difficult to write and consequentially time-consuming, it is wise to involve the cooperation of other interested faculty in the department. The objective bank that compiles and correlates objectives to be used by others has been done on other levels, but remains to be adapted to college level geology courses.

Objectives are shown to be a necessary ingredient in the effective development of pre-designed instruction. Schools that exhibited negative attitudes towards such development or those that had been unsuccessful or less than enthusiastic about such renovation were invariably those who had not formulated objectives to give to their students.

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[1] "GEO-Study Questionnaire," Geotimes, X, No. 3 (October, 1965), 14-15.

[2] Peter Fenner and Ted F. Andrews, eds., Audio-Tutorial Instruction: A Strategy for Teaching Introductory College Geology, CEGS No. 4 (Washington, D.C.: American Geological Institute, 1970).

[3] Robert F. Mager, Preparing Instructional Objectives (Palo Alto, Calif.: Fearon Publishers, 1962).

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Michigan State University
East Lansing, Michigan

Neill H. Nutter

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CHAPTER I

THE PROBLEM

Need

In 1963 a survey was taken by Geological Education Orientation Study (GEO-Study) of what geology departments were doing and what they thought they should be doing to meet the changing requirements of geological education.[1] It can be concluded from the results of the study that the introductory courses in geology were not meeting student needs. A number of institutions have since utilized the audio-tutorial approach in attempting to compensate for inadequacies in the introductory courses.

Pre-designed instruction, such as the audio-tutorial approach, requires well-defined goals or objectives to make clear to teachers, students, and other interested persons what needs to be taught, or what has been taught. Goals or objectives have not always been given serious attention by the developer of pre-designed instruction, suggesting that reasons for this omission

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[1] "GEO-Study Questionnaire," Geotimes, X, No. 3 (October, 1965), 14-15.

should be identified, and that either specific guide lines or general rules (heuristics) are needed to minimize the occurrences of such omission.

Results of this study may identify some of the reasons that well-defined goals or objectives are omitted. The study also should indicate directions that will aid the developer of introductory courses in geology to identify such goals or objectives for effective pre-designed instruction.

Purpose

Approximately twenty-five institutions of higher learning in the United States are currently teaching introductory courses in geology using the audio-tutorial approach.[2] The purpose of this study is to answer the following questions regarding this specific area of curriculum development:

1. To what extent have behavioral objectives been utilized in the development and use of these audio-tutorial approaches?
2. What are some of the reasons that some of these programs have been particularly effective in the utilization of behavioral objectives, while other programs have not?

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[2]Peter Fenner, Executive Director, Council on Education in the Geological Sciences, American Geological Institute, personal telephone communication, March 17, 1970.

3. Would a compilation of the objectives be useful to institutions planning curriculum improvement or renovation?

Statements to be Investigated

A series of six statements have been made to direct attention to the preceding questions and to assist in evaluating the development and effectiveness of the role of behavioral objectives in pre-designed instruction in geology of the audio-tutorial type. They are:

1. Institutions who have developed an A-T approach to teaching introductory courses in geology will have developed course objectives.
2. Course objectives can be categorized into levels, i.e., general through behavioral.
3. The objective level of each institution can be categorized.
4. The level of objective development at some institutions will be higher that at other institutions.
5. Institutions with either a very high or very low level of objective development can provide valuable information on the reasons for success or lack of it in the development of objectives.

6. A composite of course objectives for the introductory courses of geology will be useful to other institutions planning curriculum development in the area of introductory geology.

Overview of the Study

Chapter II

The literature pertinent to this study will be reviewed. Due to the scope of the study, this chapter will be divided into three major areas:

1. The audio-tutorial approach in the field of geology.
2. Objectives and their relationship to the audio-tutorial approach.
3. The "Objective Bank" concept.

Chapter III

This chapter will be a description of the methodology employed in this study. The order in which the methodology will be described is as follows:

1. Definitions.
2. Method
   a. The selection of the colleges and universities considered in the study.

b. A comparison of the objectives of the introductory geology courses of the selected colleges and universities.

c. An evaluation of objective development in the introductory geology courses of two selected schools.

3. Summary.

Chapter IV

The results of the analyses of the objective development of the various colleges and universities studied as well as the results of the detailed evaluation of objective development in the two selected schools will be described. The order in which the results are presented will be:

1. A general look at the introductory geology programs using the audio-tutorial approach of the schools being considered and their use of objectives.
2. The level of objective development for the introductory geology courses using the audio-tutorial approach at each school and a comparison between schools of the objective development for these courses.
3. An in-depth look at the objective development in the introductory geology courses of the two selected schools.

4. Summary.

Chapter V

This chapter consists primarily of a summary of the discussion and conclusions made from the information obtained in this study. Some suggestions for future study are also considered.

CHAPTER II

THE REVIEW OF LITERATURE

Overview

The material in this review of the literature, because of the cross-disciplinary character of this study, is presented in the following four broad categories:

1. The audio-tutorial approach as developed at Purdue University.
2. The audio-tutorial approach in the field of geology.
    - A. The need for curriculum improvement in the field of geology.
    - B. The application of the audio-tutorial approach to geology.
3. Objectives and their relationship to the audio-tutorial approach.
    - A. The case for objectives.
    - B. The value of the behavioral or instructional objective.
    - C. Types and classifications of objectives.
    - D. The audio-tutorial program and objectives.

4. The objective bank concept.

    A. Development.

    B. Use.

    C. Relationship to curriculum development in the introductory courses in geology.

The Audio-Tutorial Approach as Developed at Purdue University

The early 1960's ushered in an era of experimentation in education at many colleges and universities in the United States, for it was said then that, "There is good evidence that more significant experimentation is taking place in higher education today than has ever taken place at any other time in our nation's history."[1]

One aspect of experimentation frequently called by such names as the audio-tutorial approach, SLATE (systems learning and teaching environment), audio-visual-tutorial, etc., received little enthusiasm or fanfare at its conception, but has had an increasing impact on innovation or renovation of teaching methodology, particularly in higher education. This area of development was brought by: (1) frustration with the inefficiency of conventional teaching techniques, which prompted many to discard the traditional structure as a starting point and to look for

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[1]Samuel Baskin, "Preface," in Higher Education: Some Newer Developments, ed. by Samuel Baskin (New York: McGraw-Hill Book Company, Inc., 1965), p. vi.

a solution based on a definition of objectives;[2] and (2) the use of instructional technology for programmed individualized instruction.

The best known of these developments is the audio-tutorial system which was discovered, or perhaps better described as developed, in 1961 because of a sensitivity to student needs. Dr. Samuel N. Postlethwait, a professor of botany at Purdue University, began making supplementary lectures on audio tape to help students with poor backgrounds to keep up with the class. From this beginning the program has undergone constant revision and has become increasingly successful. As described by Postlethwait:

> Emphasis on student learning rather than on the mechanisms of teaching is the basis of the audio-tutorial approach. It involves the teacher identifying as clearly as possible those responses, attitudes, concepts, ideas, and manipulatory skills to be achieved by the student and then designing a multi-faceted, multi-sensory approach which will enable the student to direct his own activity to attain these objectives. The program of learning is organized in such a way that students can proceed at their own pace, filling in gaps in their background information and omitting the portions of the program which they have covered at some previous time. It makes use of every educational device available and attempts to align the exposure to these learning experiences in a sequence which will be most effective and efficient. The kind, number, and nature of the devices involved will be dependent on the nature of the subject matter under consideration.[3]

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[2]S. N. Postlethwait, J. Novak, and H. T. Murray, Jr., The Audio-Tutorial Approach to Learning (Minneapolis: Burgess Publishing Company, 1969), p. 1.

[3]*Ibid.*, p. 7.

Specifically, Postlethwait's biology course at Purdue consists of the following elements: (1) an independent study session that is carried out in booths or carrels at the student's convenience with materials presented by audio tape, printed material and projected visual and other teaching aids that are appropriate to the student's work; (2) a general assembly session that meets once a week for an hour to present guest lecturers, exams, long films, etc.; (3) a small assembly session for oral and written quizzes; and (4) other activities that include research papers, field trips, etc.[4]

To summarize the advantages of the audio-tutorial approach:

1. Emphasis is placed on student learning rather than on teaching.
2. Students can adapt the study pace to their ability to assimilate the information. Exposure to difficult subjects are repeated as often as necessary for any particular student.
3. Better students are not a "captive audience" and can use their time most effectively. Their interests are not dulled by unnecessary repetition of information already learned but they are free to choose those activities which are more challenging and instructive.
4. The student can select a listening time adapted to his diurnal efficiency peak.
5. Tapes demand the attention of the students, and they are not distracted by each other.
6. Students have more individual attention, if they desire it.
7. Scheduling problems are simplified. The four hours of scheduled time from which the students are relieved under the new system can now be distributed throughout the week as necessary to adjust to the student's activities.

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[4] _Ibid._, pp. 10-16.

8. More students can be accommodated in less laboratory space and with less staff.
9. Make-up labs and review sessions can be accommodated with a minimum of effort.
10. The student feels more keenly his responsibility for his own learning.
11. Each student is essentially "tutored" by a senior staff member.
12. Potentially, the system can be used to standardize instruction where desirable, e.g., between the university and the university centers.
13. Opportunities for research on learning processes is enhanced.[5]

The Audio-Tutorial Approach in the Field of Geology

The Need for Curriculum Improvement in the Field of Geology

In 1963 William Hambleton stated in Geotimes that the discipline of geology has in the past been charged that it lacks purpose and direction, and that its curricula are outmoded, obsolete, and static and that it no longer attracts gifted students.[6] The American Geological Institute (AGI), a non-profit federation consisting of seventeen societies in geology and geophysics, organized a Geological Education Orientation Study (GEO-Study) supported by a two-year grant from the National Science Foundation to investigate these charges. On July 25-27, 1963, the first GEO-Study conference was held in Boulder, Colorado, to discuss

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[5] *Ibid.*, p. 96.

[6] William W. Hambleton, "The Status of Undergraduate Geological Education," *Geotimes*, VIII, No. 4 (November-December, 1963), 1.

the problems of geological education in some detail, outline possible solutions to these problems, and provide direction for future GEO-Study activity. The tentative objectives of GEO-Study as originally stated by the Steering Committee were:

1. To make an objective analysis of the present status of education in the geological sciences.
2. To identify significant trends and to develop new ideas and concepts for improving education in the sciences.
3. To provide guidance by predicting changing requirements in the geological sciences for the next several decades.
4. To consider means of identifying students who can contribute to the advancement of the geological sciences and to determine ways to encourage them to pursue careers in the geological sciences.
5. To consider ways and means of aiding faculties to meet changing requirements of education in the geological sciences.
6. To effect the broadest possible involvement of the geological profession in the study so that a large sample of ideas can be obtained, and to invite the advice and ideas of people in other disciplines.[7]

During the winter and spring of 1963, forty-five university and college geology departments were visited by three-man teams from GEO-Study. Their purpose was to find out what geology departments were doing, what they thought they should be doing, and to consider ways of helping faculties meet the changing requirements of geological education. Because many geology faculty members were not reached by the team visits, a questionnaire was sent to all geology departments inviting response from any interested person to its twelve questions. Nearly a hundred

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[7] *Ibid.*, pp. 1-2.

answers were received from all segments of the academic profession. Three of the twelve questions which were asked that are pertinent to this study and the replies received are given below:

1. Question:
   What suggestions do you have about the aims, character and improvement of the introductory course?

   Answers:
   The general reaction was that the course should be tailored to student needs. Independent study was recommended by many. Other specific comments: "Some facts are needed to build on." "Avoid purposeless memory work." "Relate basic geology to examples of other things a student sees in everyday life."

2. Question:
   Do you think any major innovations in teaching methodology such as programmed instruction, increased emphasis on independent study, problem-oriented courses, undergraduate research and use of closed-circuit television are desirable?

   Answers:
   "Closed-circuit TV is in my opinion a step backwards." "Programmed instruction and closed-circuit television are rubbish." "Perhaps several revisions and editings will be necessary, but eventually a series of good TV tapes might be far superior to live presentations."

3. Question:
   In view of the widespread criticism of geology faculties reported in GEO-Study, what would you suggest to improve the competence of present teaching staff, and the training of new college teachers?

   Answers:
   Among the many suggestions: Time off to take courses on campus; observation of teaching performance by other teachers; count courses taken on campus as part of teaching load, and consider these in salary and promotion considerations; work more closely with faculties in other

> departments; take a course in teaching methods; "It isn't enough to require our students to take collateral courses in other departments. We as faculty must become prepared to work with the faculties of other departments and to take an interest in their problems." "I doubt if much can be done to upgrade present teachers. If they have slid into a rut they are probably of a type that is hopeless, and they should be squeezed out by freezing their salaries, passing them over with newer and better men." "It is the responsibility of the school to grant an opportunity for the teacher to refresh and renew his training, and the teacher's responsibility not to abuse it by loafing."[8]

These questions and answers suggest that there was in 1963, on the part of some educators in the geological field, an increasing awareness of the inadequacies of the content, methodologies, and teacher preparation in the field of geology. This awareness is summarized in the following manner:

1. Introductory courses are not meeting student needs.
2. Innovations in the teaching of geology courses are not being seriously considered (probably because the average teacher of geology was unaware of the contributions such innovations could make, and were generally distrustful of those they knew about).

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[8]"GEO-Study Questionnaire," GeoTimes, X, No. 3 (October, 1965), 14-15.

3. Teachers do not have the proper training, though there was no consensus as to what should be included in proper training.

The Application of the Audio-Tutorial Approach to Geology

The success since their conception of Postlethwait's audio-tutorial system and other similar systems developed independently across the country has resulted in some application of the audio-tutorial approach to the introductory geology courses in response to the primary concerns as indicated in the questionnaire of 1963.[9]

A number of programs utilizing the audio-tutorial format have been developed in the area of geology. Two of these were described in Volume XVII of the Journal of Geological Education, 1969.

The first of these, the Lansing Community College, Lansing, Michigan, has a program for the teaching of earth science (one quarter of a physical science course). The program is termed an audio-visual-tutorial approach to instruction and is patterned after that developed by Postlethwait at Purdue, but with major modifications made in light of the subject matter. All subjects meet one hour each week for a mandatory lecture. The use of this hour is flexible permitting communication with the entire group or major exams. A discussion of one hour is also a

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[9] Ibid.

fixed part of the students' schedule. Fifteen students per discussion group result in what is considered to be the optimum number for interaction between instructor and student. The laboratory time is spent in learning carrels and other activities in the lab and is not scheduled, allowing the student to come at his optimum time. Evaluation has shown that this program is preferred to conventional lecture-laboratory scheduling.[10]

The second of the examples is somewhat less like the audio-tutorial approach of Postlethwait's than that at the Lansing Community College. The program is called the "Audo-Paced Laboratories" and was used the summer of 1968 at State University of New York at Buffalo. In this case the laboratory was the only portion changed and consisted of a modified version of the audio-tutorial process but differing from it in that the emphasis was on learning in short steps with immediate reinforcement of correct responses. The programming of teaching material consisted of taping the instructor's comments, directions, and questions. Whenever a bell was heard, the student would respond by following the directions that immediately

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[10]Richard D. Yarger and K. R. Cranson, "Application of the Audio-Visual-Tutorial Approach to Earth Science Instruction," Journal of Geological Education, XVII, No. 2 (April, 1969), 43-46.

preceded the bell. The approach was statistically evaluated with the results suggesting a significant difference.[11]

Objectives and Their Relationship to the Audio-Tutorial Approach

The Case for Objectives

A program such as the one developed by Postlethwait at Purdue University requires a great deal of planning, for its effectiveness is directly dependent upon its organization. James Nord writes in his doctoral dissertation: "Pre-designed instruction with its requirement for pre-planned materials and relatively slow and delayed feedback system appears to require predetermined and explicitly stated objectives."[12] Others have said essentially the same thing but perhaps none as succinctly as Nord. One who implies the same thing is Joseph D. Novak who worked closely with Postlethwait at Purdue during the development of the audio-tutorial approach. Dr. Novak is now the chairman of Science Education at Cornell University and is engaged in research and development of a wide variety

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[11] Francis T. Siemankowski and Charles J. Cazeau, "Auto-Paced Laboratories in Physical Geology," Journal of Geological Education, XVII, No. 2 (April, 1969), 38-42.

[12] James Richard Nord, "An Exploratory Study Into the Criteria by Which Educational Objectives May be Evaluated" (unpublished Ph.D. dissertation, Michigan State University, 1969), p. 151.

of learning experiences in many subject-matter areas using the audio-tutorial mode of instruction.[13] His comments on the problems and pitfalls in the audio-tutorial approach to instruction contain many thoughts on the necessity of objectives for successful A-T instruction:

> The clear specification of instructional objectives, as suggested by Mager is the element most often absent in unsuccessful A-T instruction. When instructional objectives are clearly specified, it is possible to identify optimal sequences of auditory, visual, olfactory, tactile, and other experiences. Preceding an instructional sequence with a general statement that has meaning for the student can serve as an organizer and facilitate subsequent learning. To design effective organizers for instructional sequences requires clear instructional objectives. Organizers should not be confused with statements of objectives.[14]

Anthony Oettinger in his book, Run, Computer, Run, takes a very critical view of many of the innovative things being done in education today. His reasons are many, but they can be summarized by saying that most developments, while they are new in terminology or description, reveal upon a closer look at the actual programs being used in the classroom that they are little changed, if at all. Oettinger's comments on Postlethwait's A-T program considered in this light are very interesting. He says:

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[13] Joseph D. Novak, "Problems and Pitfalls in the Audio-Tutorial Mode of Instruction," in Audio-Tutorial Instruction: A Strategy for Teaching Introductory College Geology, ed. by Peter Fenner and Ted F. Andrews, CEGS, No. 4 (Washington, D.C.: American Geological Institute, 1970), p. 18.

[14] Ibid., pp. 18-19.

> Some further perspective is gained by looking at an experiment in which the process is created by custom tailoring and applied through an ingenious combination of tailoring and mass production. The goals are prescribed but, since they apply to a group self-selected for homogeneity, the distinction between the universal and the particular is less important than otherwise. Learning takes place through a combination of lone and group activities. The result I observed is a harmonious, balanced mix of human and technological resources applied under Postlethwait's expert and energetic leadership. . . . Postlethwait carefully, if intuitively, spells out objectives, following the old-time rhetorical rule of telling the students what you're going to tell them, telling them, then telling them what they've been told.[15]

Oettinger attributes the success of the program to "Postlethwait and his enthusiastic crew,"[16] but how often are energies wasted by lack of direction or randomness in intent? What Oettinger does not admit is that Postlethwait has had the good judgment and wisdom to use deliberately well-defined instructional objectives.

The Value of the Behavioral or Instructional Objective

Elliot W. Eisner of Stanford University states:

> The concept of educational objectives holds a central position in the literature of curriculum, yet the way in which educational objectives should be formulated--if at all--continues to be the subject of professional debate.[17]

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[15]Anthony G. Oettinger, Run, Computer Run (Cambridge, Mass.: Harvard University Press, 1969), pp. 150-55.

[16]*Ibid.*, p. 155.

[17]Elliot W. Eisner, "Instructional and Expressive Educational Objectives: Their Formulation and Use in Curriculum," Instructional Objectives, Monograph of American Educational Research Association (Chicago: Rand McNally, 1969), p. 1.

Nearly all educators hold the position that objectives are important, but probably no other feature or concept of education has been so misused. Certainly the greatest misuse of objectives in education is that of the "lesson plan" imposed upon many teachers for a variety of reasons, but seldom adherred to and more often completely ignored once they have been written. Paulson states:

> The majority of educational objectives are fundamentally fraudulent. They have the capacity to deceive both those expressing them and those to whom they are expressed. They may be used both to camouflage our confusion and to propagandize the public.[18]

That objectives have been frequently misused is accepted but it in no way limits the effectiveness of their proper use. Paulson goes on to state:

> Although the improper use of statements of instructional objectives has probably led to widespread skepticism and suspicion, on the one hand, the misplaced confidence on the other, the hard fact remains that any substantial and durable improvement in instruction would probably be impossible without them. Just the use of the term "improvement" implies that we will achieve something more fully, frequently, or efficiently, or something not previously achieved. When we have described this "something" and set out to achieve it, we have an "objective."[19]

In almost no area of life is an individual's destiny left to random chance or fate except perhaps in the field of education, for over the years educators in

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[18]Casper F. Paulson, "Specifying Behavioral Objectives," National Research Training Institute Manual (Monmouth, Oregon: Teaching Research, 1967), p. II-2.

[19]Ibid.

general have held a mystique about the student and about the "how, when, why, and where" of his learning. "Some educators consider it more democratic and humanistic to simply introduce content or let the children select it and see what behavior changes, if any, occur."[20]

This "we must not interfere" attitude has been too frequently the guiding philosophy in the learning process as if examining the process of learning will cause it to cease to function or be destroyed. Tyler is regarded as one of the first modern educators to cut through this superstitution about planning for instruction. In 1950, he wrote:

> . . . if an educational program is to be planned and if efforts for continued improvement are to be made, it is very necessary to have some conception of the goals that are being aimed at. These educational objectives become the criteria by which materials are selected, content is outlined, instructional procedures are developed and tests and examinations are prepared.[21]

There are two logical steps to take in attempting to develop learner capabilities which are desired outcomes of a particular course of instruction: (1) to list those capabilities that the learner should acquire from the course, and (2) to attempt to develop these learner

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[20]Howard J. Sullivan, "Objectives, Evaluation, and Improved Learner Achievement," Instructional Objectives, Monograph of American Educational Research Association (Chicago: Rand McNally, 1969), p. 68.

[21]Ralph W. Tyler, Basic Principles of Curriculum and Instruction (Chicago: University of Chicago Press, 1950), p. 3.

capabilities through appropriate instructional experiences.[22]

Mager took the initiative in the campaign for pre-planning for instruction when he in 1962, published a programmed text entitled, Preparing Instructional Objectives.[23] He very cleverly makes his point clear in this text and for his summary he makes the following five suggestions:

1. A statement of instructional objectives is a collection of words or symbols describing one of your educational intents.
2. An objective will communicate your intent to the degree you have described what the learner will be DOING when demonstrating his achievement and how you will know when he is doing it.
3. To describe terminal behavior (what the learner will be DOING):
   a. Identify and name the overall behavior act.
   b. Define the important conditions under which the behavior is to occur (givens or restrictions, or both).
   c. Define the criterion of acceptable performance.
4. Write a separate statement for each objective; the more statements you have, the better chance you have of making clear your intent.
5. If you give each learner a copy of your objectives, you may not have to do much else.[24]

These three aspects--performance, criterion, and conditions--must be all present in order to have a good instructional or behavioral objective. This study defines

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[22] Sullivan, "Objectives, Evaluation, and Improved Learner Achievement."

[23] Robert F. Mager, Preparing Instructional Objectives (Palo Alto, Calif.: Fearon, 1962).

[24] Ibid., p. 53.

an instructional or behavioral objective as an objective that states: (1) what it is that a student who has mastered the objective will be able to do, (2) under what conditions he will be able to do it, and (3) how well he will be able to do it.

At the national meeting of the American Educational Research Association in 1968, held in Chicago, the Committee on Instructional Objectives met and discussed the many aspects of various kinds of objectives. At this meeting Elliot W. Eisner from Stanford University made a number of introductory remarks about the value of instructional objectives similar and in support of Mager:

> . . . educational objectives should describe pupil behavior, not teacher behavior; that is, they should describe how pupils are to perform after having had educational experience . . . objectives should describe both the behavior to be displayed and the content in which the behavior is to occur.
>
> . . . objectives should be stated at a level of specificity that makes it possible to recognize the behavior should it be displayed.

Thus,

> . . . a clear statement of educational objectives gives direction to curriculum planning, . . . they provide criteria for selecting content and organizing curriculum activities, . . . they provide cues for formulating evaluation procedures inasmuch as evaluation should proceed from specifications set forth by objectives.[25]

A fairly good case has been built for the utilization of instructional or behavioral objectives, yet

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[25]Eisner, "Instructional and Expressive Educational Objectives," p. 1.

there are some who would minimize the usefulness of such objectives and belittle the attempts of educators who would make their objectives more precise. Popham reviews some of these objections to behavioral objectives and the following is a list of ten of such objections and a summary of his comments to each objection.

1. Trivial learner behaviors are the easiest to operationalize hence the really important outcomes of education will be underemphasized.

   "Making behaviors explicit permits the teacher and his colleagues to scrutinize them carefully and thus eliminate them as unworthy of our educational efforts."

2. Prespecification of explicit goals prevents the teacher from taking advantage of instructional opportunities unexpectedly occurring in the classroom.

   "Prespecification of explicit goals only tends to make the teacher justify these spontaneous learning activities in terms of worthwhile instructional ends."

3. Besides pupil behavior changes, there are other types of educational outcomes which are important, such as changes in parental attitudes, the professional staff, community values, etc.

   "All modifications in personnel or external agencies should be justified in terms of their contribution toward the promotion of desired pupil behavior changes."

4. Measurability implies behavior which can be objectively, mechanistically measured, hence there must be something dehumanizing about the approach.

   "It is currently possible to assess many complicated human behaviors in a refined fashion. Developmental work is under way in those areas where we now must rely on primitive measures."

5. It is somehow undemocratic to plan in advance precisely how the learner should behave after instruction.

"Instruction is by its very nature undemocratic and to imply that freewheeling democracy is always present in the classroom would be untruthful."

6. That isn't really the way teaching is; teachers rarely specify their goals in terms of measurable learner behaviors; so let's set realistic expectations of teachers.

   "There is obviously a difference between identifying the status quo and applauding it. The way teaching really is at the moment just isn't good enough."

7. In certain subject areas, e.g., fine arts and the humanities, it is more difficult to identify measurable pupil behaviors.

   "Sure it's tough. Yet, because it is difficult in certain subject fields to identify measurable pupil behaviors, those subject specialists should not be allowed to escape this responsibility."

8. While loose general statements of objectives may appear worthwhile to an outsider, if most educational goals were stated precisely, they would be revealed as generally innocuous.

   "We must make clear exactly what we are doing . . . and to defend our choices."

9. Measurability implies accountability; teachers might be judged on their ability to produce results in learners rather than on the many bases now used as indices of competence.

   "A teacher should not be judged on the particular instructional means he uses to bring about desirable ends."

10. It is far more difficult to generate such precise objectives than to talk about objectives in our customarily vague terms.

   "The difficulty of the task should not preclude its accomplishment."[26]

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[26]W. James Popham, "Objectives and Instruction," in American Educational Research Association Monograph Series on Curriculum Evaluation: Instructional Objectives, ed. by R. E. Stake (Chicago: Rand McNally, 1969), pp. 46-51.

While there are elements of truth in each of the above objections as Popham would admit, it is obvious that to halt the haphazard approach to education and its resultant dubious results, it is imperative that precise objectives be defined and adherred to.

If instructional objectives do have the merit ascribed to them by educators such as Tyler, Paulson, Mager, Eisner, Popham, and others, then for maximum results for a given objective, it should be able to answer affirmatively the questions that Mager asks to test educational statements for clarity and completeness:

1. Does the statement describe what the learner will be doing when he is demonstrating that he has reached the objective?
2. Does the statement describe the important conditions (givens or restrictions, or both) under which the learner will be expected to demonstrate his competence?
3. Does the statement indicate how the learner will be evaluated? Does it describe at least the lower limit of acceptable performance?[27]

Types and Classifications of Objectives

A classification can thus theoretically be built upon Mager's three aspects of: (1) performance, (2) criterion, and (3) conditions to evaluate any given objective. The loss of any one of these three aspects would result in an objective that would be somewhat less

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[27]Mager, Preparing Instructional Objectives, p. 52.

effective and the resultant educational product would be less precise.

It must be added that Mager does not indicate that once objectives are stated in the suggested format that the task of objective development is complete. There are a number of further considerations that should be made once the objectives are stated in behavioral terms. For instance, statements of objectives should include all intended outcomes, whether related to content or not,[28] and he also suggests that one of the classifications of instructional objectives dealing with categories or levels of behavior be consulted.[29] The best known and most widely accepted of these is A Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain developed by Bloom and his colleagues (1956). This taxonomy makes no value judgment on whether one objective is better than another, but rather evaluates the hierarchial level of what is commonly referred to as knowledge, intellectual abilities, and intellectual skills. The taxonomy contains six major classes:

1.00 Knowledge
2.00 Comprehension
3.00 Application
4.00 Analysis
5.00 Synthesis
6.00 Evaluation[30]

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[28] Ibid.

[29] Ibid., p. 50.

[30] Benjamin S. Bloom, ed., Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain (New York: David McKay Company, Inc., 1956), p. 18.

Gagné also has a classification of objectives which are dependent upon his eight major categories of behavior. These can be arranged into a hierarchy from simple to complex:

1. Signal Learning
2. Stimulus-Response Learning
3. Chaining
4. Verbal Association
5. Multiple Discrimination
6. Concept Learning
7. Principle Learning
8. Problem Solving[31]

Both of these classifications are useful for developing strategies of learning once the behavioral objectives are stated, but aside from this value their use is limited. Sullivan has this to say about the Bloom *Taxonomy*:

> Despite the popularity of the *Taxonomy* and its success in stimulating interest in educational objectives, its usefulness as a tool for effective curriculum planning and development is quite limited. Any attempt to use the *Taxonomy* in the formulation of objectives must take into account its lack of precision in indicating either specific overt behaviors to be performed by the learner or the conditions under which they will be performed.[32]

A similar criticism could be made of Gagné's eight categories of behavior.

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[31] Robert M. Gagné, *The Conditions of Learning* (New York: Holt, Rinehart and Winston, Inc., 1965), pp. 33-57.

[32] Sullivan, "Objectives, Evaluation, and Improved Learner Achievement," p. 71.

The Audio-Tutorial Program and Objectives

Instructional or behavioral objectives have been discussed so far in only a theoretical sense, but the proper application of objectives in the day-to-day classroom routine is where significant improvement in instruction begins. Postlethwait gets right to the crux of the matter when he says:

> Obviously, guidance is one of the most important roles of a teacher. Yet frequently, the meetings of students and teachers are occasions of a "cat and mouse" game where the teacher tries to camouflage the topics which are likely to make good exam questions and the student tries to discover the subtle connotations or mannerisms by which the teacher discloses them. The careful writing of behavioral objectives is a revealing experience to most of us. It helps in the writing of test questions related to what has been taught and it helps in determining study activities which will enable the student to achieve the objectives. It is a depressing fact that most of us have never even thought of objectives, and certainly have never taken the trouble to write them in behaviorial terms. Somehow students are supposed to move forward purposefully and vigorously through an "ocean" of words; inventing the compass, drawing the map and constructing the ship. Vague goals such as "to provide an understanding of . . . " provide no constructive basis for structuring study activities or guide lines for the student. A typical reaction to behavioral objectives is illustrated by the remarks of a professor who discovered the mimeographed handouts of objectives in an audio-tutorial learning center. "What's this?" she said in a shocked voice. "Objectives." "You don't let the students see these, do you?" "Yes." "My goodness, they will learn it all!"[33]

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[33]Postlethwait, Novak, and Murray, The Audio-Tutorial Approach to Learning, p. 2.

The Objective Bank Concept

Development

Because of the difficulty of writing behavioral objectives (that is, putting the objectives into performance terms, describing the conditions under which the objectives are to be performed and stating how well the objectives are to be performed), many educators are repelled by the mere thought of such an effort. For this reason, many well-intended and much needed designs for curriculum improvement and/or renovation fail to be as effective as hoped for and frequently revert to the conventional static style and delivery that permeates much of education today. As suggested by Popham, when he comments on the difficulty of identifying measurable pupil behaviors in certain subject areas, there is no way to short-cut the process of developing such objectives.[34] However, with practice, a certain facility in the writing of behavioral objectives will occur, but at best the writing of objectives in operational terms remains a difficult chore. Even with the interest in objectives that is now found in education, it appears to be primarily a superficial interest with a very low level of resultant application. Also, most teachers simply do not have the time to generate their own

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[34] Popham, "Objectives and Instruction," pp. 49-50.

operationally-stated instructional goals.[35] For these reasons: (1) the difficulty of the task, and (2) the lack of time, the Center for the Study of Evaluation at the University of California at Los Angeles (sponsored by the U.S.O.E.) established the Instructional Objectives Exchange (IOX) in 1969. The IOX was created to perform the following functions:

1. Serve as a clearinghouse through which the nation's schools can exchange instructional objectives, thereby capitalizing on the developmental efforts of other educators rather than being obliged to commence afresh the development of objectives.
2. Collect and, when necessary, develop measuring techniques suitable for assessing the attainment of the objectives available through the Exchange.
3. Develop properly formulated instructional objectives in important areas where none currently exist, that is, fill the gaps not covered by available objectives.

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[35]W. James Popham, "Instructional Objectives Exchange," Instructional Objectives Exchange Catalog (Los Angeles: Center for the Study of Evaluation, Instructional Objectives Exchange, University of California at Los Angeles, 1969), p. 3.

Use of the Objective Bank Concept

There are two ways to participate in the IOX program: (1) by contributing objectives, and (2) by using those objectives currently available. Educators are urged to make use of the services offered by the exchange and suggestions to improve these services are encouraged. Eventually a computer retrieval system will be used for locating and compiling objectives for a particular subject at a specific grade level, but at the present time the available objectives are arranged in multilithed collections such as mathematics, grades 4 to 6; and auto mechanics, grades 10 to 12.

Relationship to Curriculum Development in the Introductory Courses in Geology

As of June, 1970, no objectives were available from IOX at the college or university level, including the courses of interest to this study, physical geology, historical geology, or the equivalent. There is a great potential in having behavioral objectives available in geology for these objectives would increase the probability that the needed curriculum changes would occur by reducing the time and effort for planning and thus permitting those involved to move into the more exciting portion of curriculum development much sooner than would otherwise be possible.

The question that must be addressed at this point is, would teachers at the college or university level avail themselves of such objectives if they are available or would the general availability of behavioral objectives cause them to feel threatened? There is no evidence available at the present time to answer this question.

Summary

To review what has been stated in this chapter about the relationships between geology, the audio-tutorial approach, and objectives, the following statements are made:

1. Postlethwait's audio-tutorial approach to learning with its emphasis on the student and his needs and its resultant success has become a model for schools and disciplines to follow.
2. There is a need for curriculum development in the discipline of geology--particularly in introductory courses, physical geology, historical geology, or their equivalent.
3. The audio-tutorial approach has been adapted by some institutions for the presentation of the introductory courses in geology.
4. Behavioral or instructional objectives are very necessary, if not imperative, for preplanned instruction.

5. The more nearly an objective fulfills the three requirements of: (1) being stated in performance terms, (2) describing the conditions under which it is to be performed, and (3) giving the criteria for how well it is to be performed, the more useful the objective becomes.
6. Classifications of objectives such as Bloom's Taxonomy and Gagné's Categories of Behavior provide a useful function only after the three requirements are fulfilled.
7. The key to the success of the audio-tutorial approach is the use of objectives that fulfill the three requirements.
8. A source of behavioral objectives in the various disciplines and at the various grade levels would facilitate curriculum development and renovation.
9. The Instructional Objectives Exchange (IOX) has been established to provide such a source of objectives to the various disciplines at the various grade levels.
10. Geology at the present time (1970) has no objectives in IOX and the question remains unanswered whether they would be used if available.

CHAPTER III

METHODOLOGY

The description of the method used in carrying out this study will be more meaningful if the basic terms employed are defined. These terms and phrases are widely used and can be interpreted in different ways, so are here defined in order that the specific meaning intended is understood.

Definitions

Pre-designed instruction.--Instruction that has been preplanned to accomplish a specific purpose or purposes, and/or fulfill a predetermined need or needs.

The audio-tutorial approach.--A mode of instruction that has been given a variety of names, i.e., audio-tutorial instruction, audio-tutorial system, A-T instruction, audio-visual tutorial instruction, SLATE (systems learning and teaching environment), auto-paced teaching, and others. The name "audio-tutorial" was first given by Dr. S. N. Postlethwait of Purdue University who is generally regarded as the founder of this approach.

A. As used in this study: An approach to instruction that uses the prerecorded audio mode for instructions and information (usually interpreted as tutoring) and a variety of other media to supplement the audio to best meet the specific need. The student has the opportunity to repeat the lesson as often as necessary in an environment that is restricted to the inputs required to accomplish its purpose.

B. As used by Dr. S. N. Postlethwait: The term audio-tutorial approach as used by Postlethwait is called the audio-tutorial system for it is a system with the emphasis on student learning rather than the mechanisms of teaching.[1] The role of the student is considered as the important factor, thus the term "study session" is used for most student activities. These are the: (1) independent study session, (2) general assembly session, and (3) integrated quiz session.

In the independent study session (ISS) the student participates in activities as described in Part A above, taking as little or as much time as necessary. An instructor or tutor is available at all times to answer questions and offer suggestions on a one-to-one basis.

The general assembly session (GAS) meets one hour per week and is designed to cover activities which can

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[1]Postlethwait, Novak, and Murray, The Audio-Tutorial Approach to Learning, p. 7.

best be done in a large group, i.e., guest lecturers, long films, exams, etc.

The integrated quiz session (IQS) terminates a week's work and involves eight students for forty-five minutes in a variety of evaluation tasks with the instructor providing immediate feedback.

Other activities, i.e., projects, etc., are required of the students and these usually require some contact with the instructor.[2]

Well-defined goals and objectives.--Goals and/or objectives that leave no doubt in the minds of students, teachers, or other interested persons about what is expected of the student, where it shall be performed, and how well it should be done. Such objectives are said to be written in behavioral terms and are hence called "behavioral objectives."

Behavioral objectives.--An objective that is written in performance terms and also expresses the criteria and conditions of the performance (also see "well defined goals and objectives").

Performance terms.--Performance infers action, so the key to determining if an objective is in performance terms is in the verb usage. Mager has indicated that some

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[2] *Ibid.*, pp. 10-16.

words are open to many interpretations--and these are to be avoided, while others are open to fewer interpretations which are acceptable. His lists are as follows:

Words open to many interpretations:
- to know
- to understand
- to appreciate
- to grasp the significance of
- to enjoy
- to believe
- to have faith in
- to fully appreciate

Words open to fewer interpretations:
- to write
- to recite
- to identify
- to differentiate
- to solve
- to construct
- to list
- to compare
- to contrast[3]

Note that the verbs to write, to recite, etc. are those that can readily be identified by performance.

Paulson also includes a list suggestive of useful verbs:

- to identify
- to order
- to describe
- to state a rule
- to interpret
- to name
- to demonstrate
- to construct
- to apply a rule
- to distinguish[4]

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[3] Mager, Preparing Instructional Objectives, p. 11.

[4] Paulson, "Specifying Behavioral Objectives," p. II-10.

Criterion.--The rule or test of how well the objective is to be done.

Condition.--The condition or situation under which the learner is expected to perform the objective.

Instructional objective.--Another name for and synonymous with behavioral objective.

Method

The method employed to provide the insights and/or answers to the questions asked in Chapter I[5] consists of:

1. The selection of the colleges and universities to be considered:
    a. the identification of the colleges and universities using the audio-tutorial approach for teaching the introductory courses of geology,
    b. the selection of the colleges and universities to be considered in this study.
2. The comparison of the objectives of the introductory geology courses of the selected colleges and universities:

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[5](1) To what extent have behavioral objectives been utilized in the development and use of these audio-tutorial approaches? (2) What are some of the reasons that some of these programs have been particularly effective in the utilization of behavioral objectives while other programs have not? (3) Would a compilation of the objectives be useful to institutions planning curriculum improvement or renovation and if not, why not?

a. the determination of a method for evaluating each school's objectives,

b. the evaluation and comparison of the objectives of each school.

3. An evaluation of objective development in the introductory geology courses of two selected schools:

a. the selection of: (1) the one school having the best objectives, and (2) the one school having the poorest objectives,

b. the analysis of why the two selected schools differ in their use of objectives.

The Selection of Colleges and Universities

The Identification of the Colleges and Universities Using the Audio-Tutorial Approach for Teaching the Introductory Courses of Geology

In 1970 the Introductory Course Program (ICP) of the Council on Education in the Geological Sciences (CEGS) published a paper entitled, Audio-Tutorial Instruction: A Strategy for Teaching Introductory College Geology which deals with the audio-tutorial approach to solving some of the problems in geological education and explores the depth and breadth of the use of the A-T approach at a selected group of institutions in their teaching of geology. The schools which were identified in the CEGS paper are:

Christian College, Columbia, Missouri

Georgia State College, Atlanta, Georgia

Lansing Community College, Lansing, Michigan

Macalester College, St. Paul, Minnesota

College of Marin, San Rafael, California

University of Michigan, Ann Arbor, Michigan

Montgomery County Public Schools, Bethesda, Maryland

State University of New York, Buffalo, New York

University of Notre Dame, South Bend, Indiana

Ohio State University, Columbus, Ohio

Pennsylvania State University, State College, Pennsylvania

Principia College, Elsah, Illinois[6]

According to Peter Fenner, the Executive Director of CEGS, the aforementioned colleges are part of the approximately twenty-five schools in the United States using the A-T approach currently in varying degrees.[7] Rather than continuing the attempt to identify the remaining schools using the audio-tutorial approach, this study

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[6] Fenner and Andrews, "Preface," Audio-Tutorial Instruction, p. v.

[7] Peter Fenner, Executive Director, Council on Education in the Geological Sciences, American Geological Institute, personal telephone communication, March 17, 1970.

has been limited to those schools specifically identified in the CEGS paper.

The Selection of the Colleges and Universities to be Considered in This Study

Of the twelve schools included in the CEGS paper, two schools, Georgia State College and Montgomery County Schools, were not considered for further examination for the following reasons: Georgia State was in the initial stages of its development of an A-T program, and the Montgomery County Schools were not at the college level.

A phone call was made to each of the ten remaining institutions (see Appendix A for calling schedule). Each call was specifically addressed to the principal individual identified in the CEGS paper for the purpose of requesting the course materials--syllabi, outlines, descriptions, etc. that would include the course objectives (not including assigned textbooks unless they were especially relevant). At the time of the initial telephone call, all of the individuals contacted responded positively by indicating that they would send the materials immediately, or that they did not have the materials requested. In a few cases, materials were not received in a reasonable length of time so a follow-up phone call was made to act as a reminder. Materials from Christian College were never received, and a subsequent letter was not acknowledged, so Christian College was excluded from the remainder of the study.

Of the twelve schools described in the CEGS paper, only nine schools are considered for further study. They are:

Lansing Community College, Lansing, Michigan

Macalester College, St. Paul, Minnesota

College of Marin, San Rafael, California

University of Michigan, Ann Arbor, Michigan

State University of New York, Buffalo, New York

University of Notre Dame, South Bend, Indiana

Ohio State University, Columbus, Ohio

Pennsylvania State University, State College, Pennsylvania

Principia College, Elsah, Illinois

Comparison of the Objectives of Selected Colleges and Universities

The Determination of a Method for Evaluating Each School's Objectives

No evaluation procedure has been found in the literature for evaluating the degree of completeness of a behavioral objective, so a method had to be devised. The method used is based on the three part definition of the behavioral objective stated earlier, i.e., a behavioral objective has three parts: (1) the terminal behavior, (2) the conditions under which the behavior is to be performed, and (3) how well the performance is to be done. This is essentially the same definition as implied by Mager in Chapters IV, V, and VI of his book on Preparing Instructional Objectives.[8]

The method for evaluation depends on the assumption that the most general objective is of value, but that the specification of learner behavior makes it more valuable, and the further inclusion of conditions and criteria enable it to reach an optimum value for instruction. Based on this reasoning, the steps for the valuation of an objective now become:

1. For each objective of a given unit, one (1) point was given.
2. If the objective was stated in performance terms (as previously defined), the objective received an additional point. It is obvious that the lists of useful verbs given in the definition of performance terms was not exhaustive, so in such cases where verbs were used that were not included on the previous lists, decisions had to be made to determine whether the verbs were useful or not.
3. If the objective included the criterion, it received an additional point.

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[8] Mager, Preparing Instructional Objectives.

4. If the objective included the conditions it received an additional point.

Thus any objective might receive from 1 to 4 points, e.g., if the objective was stated in behavioral terms (including the criterion, conditions and written in performance terms) it would receive four (4) points.

The Evaluation and Comparison of the Objectives of Each School

When the course materials were received from each school, the objectives were copied and separated from the remainder of the materials for the purpose of determining objective level and each of the objectives was scored as described above.

The method for determining the overall objective level or rank value for each course of each school was as follows:

1. Each objective of a given unit was scored.
2. The objective point values or scores for a given unit were totaled. If no objectives were stated for a given unit, the objective level for that unit was scored as zero (0).
3. The average unit objective score value was determined by dividing the totaled point value by the number of objectives in the unit.
4. The average unit objective score values were totaled.

5. The average level of objective development was determined by dividing the totaled unit objective score values by the number of units.
6. The total possible accumulated objective score value for all units was determined by multiplying the number of units by 4 (the average unit score value if all objectives were stated in behavioral terms).
7. The objective level or rank value for each course of each school is expressed as a percentage and was determined by dividing the total unit score by the total possible unit score and multiplying by 100.

An Evaluation of Objective Development in the Introductory Geology Courses of Two Selected Schools

The Selection of: (1) the One School Having the Best Objectives, and (2) the One School Having the Poorest Objectives

Two institutions were selected for evaluation of their objective level development by means of comparison of the course objective level rank values. The institutions selected were those identified as having the highest and lowest objective development level. Because very similar high values were obtained for two different schools, an additional criterion was needed to make the selection. The criterion was to select the school that had used objectives in the broadest range of activities in the introductory geology course. Schools where no objectives had been developed were not considered because they did not meet the basic assumption, i.e., pre-designed instruction requires well-defined goals or objectives.

The objectives stated in The Audio-Tutorial Approach to Learning,[9] by Postlethwait et al., as typical examples of what the students receive at Purdue University in Biology 108, were scored in the same manner for the purpose of comparison.

The Analysis of Why the Two Selected Schools Differ in Their Use of Objectives

A visit was made to each of the two institutions thus identified--State University College at Buffalo, Buffalo, New York (the principal individual identified in the CEGS paper with State University of New York, Buffalo, is on the staff at State University College), and Principia College, Elsah, Illinois. State University College was visited on July 20, 1970, where an afternoon was spent with Dr. Francis T. Siemankowski discussing the initiation and development of his "Auto-Paced" Program. Principia College was visited on the afternoon of July 28, 1970, when Dr. Forbes Robertson, the initiator and developer

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[9]Postlethwait, Novak, and Murray, The Audio-Tutorial Approach to Learning, p. 26.

of the audio-tutorial program at Principia, shared his philosophy and many ideas.

The visits were made for the purpose of obtaining insight into the reasons for why the schools were particularly successful or unsuccessful in establishing behavioral objectives. The following general and specific types of questions were asked of the principal developer in each case to provide this information:

1. How long has the innovation been in operation?
2. What were the reasons for pursuing the particular curriculum development or renovation?
3. What were the originator's qualifications for pursuing this type of innovation?
4. What was (were) the source(s) of funds to carry out the innovation?
5. What were the kinds and sources of assistance that were made available for the development of software, hardware, objectives, and evaluation?
6. Why was the A-T approach chosen?
7. What is an estimate of the program's success?
8. Are there any plans to significantly change the innovation?
9. Why did you include objectives in the materials presented to the student?

10. Why were or were not the objectives you selected written or described in behavioral terms?
11. How do you think the student feels about the objectives?

The interviews were conducted using a tape recorder to record the comments of the interviewer and the interviewee to insure that the comments were accurately reported and placed in their proper context.

Summary

The procedure for obtaining the information necessary for the successful completion of this study can be summarized as follows:

1. The definition of terms.

2a. The selection of colleges and universities that were previously identified, as schools teaching introductory geology courses using the audio-tutorial approach, by Fenner and Andrews in the CEGS paper A Strategy for Teaching Introductory College Geology.

2b. Initial contact with the schools obtaining course materials that might or might not include objectives.

3. The individual course objectives were categorized by quantitatively comparing them to the three part definition of the behavioral

objective, e.g., performance, conditions, and criterion. The average objective level was then calculated for each course and for purposes of comparison was compared to the objective level of Postlethwait's objectives, categorized the same way.

4. Two schools--one with the highest level of objective development, and the other with the lowest level of objective development--were selected for an in-depth study for some of the reasons why the schools were successful or unsuccessful in their development of objectives.

CHAPTER IV

DATA

A General Look at the Introductory Geology Programs Using the Audio-Tutorial Approach and Their Use of Objectives

The geology programs using the audio-tutorial approach can be placed into either of two classes--those that state objectives for the student's use or those that do not. In this study, those that do not state objectives for the student's use will be considered first and those that do state their objectives for the student's use will be considered last.

A-T Programs in Introductory Geology That Do Not State Their Objectives for the Student's Use

Five of the nine schools being studied did not state their objectives in any materials made available to the students. They are: Macalester College, College of Marin, University of Notre Dame, Ohio State University, and Pennsylvania State University.

The schools will be considered individually and in the order in which they are given.

Macalester College.--Dr. Henry Lepp states that:

> . . . the audio-tutorial approach at the present time is used only for supplementing materials presented in a more-or-less conventional physical geology lab manual. The A-T presentation used on an experimental basis in our lab last year covered such topics as map scales, contour intervals, construction of cross sections, public land subdivision, and recognition of landforms. After completing the A-T presentation, students went to our regular lab manual to complete work on topographic maps.[1]

It is, however, planned that the entire course will be taught as a laboratory course eliminating the large lecture section of the past. The plans include putting some lab instructions and certain geologic concepts on tapes that will be coordinated with slide sets so that students can work at their own pace.[2] The students receive no special handouts for the laboratory exercises taught using the A-T approach.

College of Marin.--The College of Marin uses the audio-tutorial approach in a similar capacity to that at Macalester. It was originally planned that tapes and slides be substituted for lectures and to then use the instructor's released time for small group lectures, but because of the semester's lead time required to accomplish this, the A-T approach was decided upon as a supplementary

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[1]Henry Lepp, Geology Department, Macalester College, St. Paul, Minnesota, to the writer, June 29, 1970.

[2]Fenner and Andrews, "Audio-Tutorial Programs in Introductory College Geology," p. 10.

measure.[3] The instructors at Marin have made available to the student a large number of self-study materials. These sets generally contain either slides or cartridge movies of which some are the single concept variety or specimens, but seven self-study sets use tape recordings to explain and describe the specimens or slides. The subjects using the tape recordings include:

1. Minerals: Two tapes are used with the mineral tray. The first is a twenty-five minute recording on "Physical Properties and Identification of Minerals," and the second is a twenty-five minute recording of "Mineral Names and Uses."
2. Deformation of the Earth's Crust: A set of eighty color slides and a descriptive thirty-four minute tape recording.
3. The Ocean Basins: A set of forty-five color slides and a thirty minute taped description.
4. The Study of the Oceans: A set of forty-eight color slides with a twenty minute taped description.
5. Currents, Waves, and Tides: A set of forty-eight color slides with a forty minute taped description.

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[3] *Ibid.*, p. 11.

6. Nature of Fossils: A set of fifty-one color slides with a twenty minute taped description.
7. Fossils--Key to the Past: A set of fifty-seven color slides with a twenty-five minute taped description.[4]

Because Marin is a junior college, there are no graduate teaching assistants, so available student help was used only to open the facility, keep track of equipment, and record the use of materials. They were not expected to answer questions.[5]

The source of funds was and is one of the biggest handicaps to the expansion of the program already begun. While faculty response has been good, the source of funds to adequately staff the learning center and to develop materials has presented problems. They feel there is no source to obtain ready-made material that could be readily tailored to meet their needs.[6]

The immediate future of the use of the audio-tutorial approach at the College of Marin looks bleak because of the failure of a recent bond issue. Due to the

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[4]"Geology Self-Study Materials Available for Student Use," a guide to self-study materials prepared by the Geology Department (San Rafael, Calif.: College of Marin). (Mimeographed.)

[5]Fenner and Andrews, "Audio-Tutorial Programs in Introductory College Geology."

[6]Ibid.

lack of necessary funds and an increased enrollment, the current geology program is going to have to move into quarters only one-fourth the size of the present quarters. The unavailability of money for new equipment or maintenance of the old completes the rather drab picture.[7]

University of Notre Dame.--The A-T approach at Notre Dame is used only in some labs for mineral identification, rock and fossil identification, and map work. The student response has been quite enthusiastic,[8] but Dr. Michael J. Murphy, who developed the exercises and facilities for their use, is not quite sure. Murphy says: "While I am somewhat sold on the audio-tutorial method, I am convinced that it can in no circumstance be a complete substitute for laboratories for elementary courses in geology."[9] His reason for using the A-T approach at all is a valid one--it saves time. Murphy estimates that he can cover, for example, mineral identification in one and one-half hours, the same material that without A-T took

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[7]Ken Miller, Geology Department, College of Marin, San Rafael, California, personal telephone communication, May 4, 1970.

[8]Fenner and Andrews, "Audio-Tutorial Programs in Introductory College Geology," p. 14.

[9]Michael J. Murphy, a quotation from a personal communication recorded by Fenner and Andrews, "Audio-Tutorial Programs in Introductory College Geology."

about four hours.[10] The students do not receive any written materials for the A-T exercises, but receive all their instructions on the tapes.[11]

Ohio State University.--In many ways, Ohio State should be placed in a special category, one in which the use of objectives has played an important part, but where the objectives are not given specifically to the student. In Dr. Walter Sweet's words, "the objectives are implicit."[12]

The use of the audio-tutorial approach at Ohio State had its beginnings in 1962, when Dr. Robert L. Bates and Dr. Walter C. Sweet were called upon to develop an introductory course in college geology. In their words:

> . . . our mission was to design an educationally sound ten-week survey of an exceedingly broad field, which could be taught with a minimum of technical terms and concepts to a large number of university students with little or no previous scientific training. Because this course would also satisfy part of a 15-hour University Basic Education requirement in the physical sciences, it was to provide not only a sound grounding in geology, but also an introduction to the scientific point of view for students with widely different backgrounds and career objectives. All this was to be accomplished in a series of about

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[10]Fenner and Andrews, "Audio-Tutorial Programs in Introductory College Geology."

[11]Michael J. Murphy, Geology Department, University of Notre Dame, South Bend, Indiana, personal telephone communication, May 4, 1970.

[12]Walter C. Sweet, Geology Department, Ohio State University, Columbus, Ohio, personal telephone communication, May 1, 1970.

35 one-hour lectures, in 10 one-hour laboratory sessions, and on a three-hour field excursion.[13]

The program that they developed at that time included the publishing of a new text and a laboratory manual both specifically designed to meet the needs stated above. The students when questioned, repeatedly reacted favorably to all portions of the course _except_ the laboratory. These negative comments prompted Bates and Sweet to revise the laboratory exercises.[14]

The program they developed to make up for the deficiencies in the laboratory uses the audio-tutorial approach, or as they call it, the audio-visual-tutorial approach. The development of the AVT program included Dr. John A. Maccini, who at that time was a science education doctoral student.[15]

The AVT instruction consists of a series of nine laboratory exercises all of which are planned in the future to include a pre-lab and post-lab experience as well as the laboratory proper.

The laboratory units consist of:

Unit One   The Minerals of Granite and Gabbro

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[13]Walter C. Sweet and Robert L. Bates, _An Audio-Visual Tutorial Laboratory Program for Introductory Geology_, Final Report, National Science Foundation, Grant GY-1436, Department of Geology (Columbus: Ohio State University, 1969), p. 1.

[14]_Ibid._, p. 2.   [15]_Ibid._, p. 15.

Unit Two	Igneous Fabric and Texture and the Weathering of Igneous Rocks
Unit Three	The Formation of Sedimentary Rocks
Unit Four	The Use and Significance of Fossils
Unit Five	Metamorphic Rocks; Rocks and Earth History
Unit Six	Maps as Models
Unit Seven	The Folded Appalachians and Allegheny Plateau
Unit Eight	The Colorado Plateau
Unit Nine	A Geologic Excursion Across Colorado[16]

The facilities consist of two rooms equipped with twenty-four individual carrels, each with a slide and sound movie projector, earphones, a screen, a desk lamp, miscellaneous equipment, and a "distress flag." Students can check in and out, staying as long as they like, between 8 A.M. and 10 P.M. any weekday. A teaching assistant is available for help at all times.[17]

Maccini constructed lists of formal course objectives along with achievement-test items based upon the objectives. The evaluation of the laboratory innovation was carried out by Maccini who was able to show through the

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[16] Walter C. Sweet, Robert L. Bates, and John A. Maccini, Laboratory Manual for Introductory Geology (Dubuque, Iowa: Kendall Hunt Publishing Company, 1969).

[17] Sweet and Bates, An Audio-Visual Tutorial Laboratory Program for Introductory Geology, p. 3.

various forms of assessment used, that the new AVT laboratory program resulted in significant gains in test scores, that the use of the various media were found to be "appropriate, interesting, and informative," and the students exhibited a generally positive attitude toward the AVT program.[18]

The entire project was financed by the National Science Foundation including the production of a number of motion picture films specifically for the course.[19]

Pennsylvania State University.--The geology course at Pennsylvania State University that uses the audio-tutorial approach as part of its instruction is the elementary physical geology course for non-geology majors. The course consists of two lectures and two laboratory periods per week and lasts one term. The A-T mode is used only in laboratory for one period per week. The first laboratory period is a demonstration-lecture-recitation period and then the student comes in at any time to do the A-T portion. The audio-tutorial portion uses tapes for about forty-five minutes which have keyed to them a mimeographed laboratory manual and the other materials such as specimens of rocks, minerals, maps,

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[18]Ibid., p. 23.

[19]Ibid., p. 24.

etc.[20] The student does not have any objectives before him at all.[21]

Laurence Lattman states:

> We had originally tried an all audio-tutorial tape laboratory, but abandoned this because the students complained of lack of clarity and understanding and the laboratory instructors themselves felt they were useless. The protest of the laboratory instructors carried a great deal of weight with us. The idea of replacing the laboratory instructor with movies which would enable students to see the same demonstration was also abandoned as the students could not question the movies. It is my firm opinion that a laboratory instructor-demonstration is a necessary part of an audio-tutorial laboratory in physical geology. I do not believe from my experience that a pure audio-tutorial laboratory will be successful except with the very bright students.[22]

The topics covered in the laboratory at Pennsylvania State University follow the general scheme of topics and include:

Week One	Physical Properties of Minerals
	Introduction to the Study of Minerals
Week Two	Introduction to Rocks, Igneous Rocks
Week Three	Sedimentary Rocks, Metamorphic Rocks
Week Four	EXAM and Stream Table Demonstration

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[20] Fenner and Andrews, "Audio-Tutorial Programs in Introductory College Geology," p. 16

[21] Laurence H. Lattman, Geology Department, Pennsylvania State University, State College, Pennsylvania, personal telephone communication, May 4, 1970.

[22] Laurence H. Lattman, a quotation from a personal communication recorded by Fenner and Andrews, "Audio-Tutorial Programs in Introductory College Geology," p. 16.

Week Five	Topographic Maps
Week Six	Introduction to Structural Geology
Week Seven	Structural Geology (continued)
Week Eight	Field Trip I
Week Nine	Field Trip II
Week Ten	LAB Final Examination[23]

A-T Programs in Introductory Geology That State Their Objectives for the Student's Use

The four schools that stated their objectives and made them available to the students are: Lansing Community College, University of Michigan, State University College at Buffalo, and Principia College.

The schools will be considered individually and in the order in which they are given.

Lansing Community College.--The course that makes use of the audio-tutorial approach at Lansing Community College is not a geology course but a natural science course--the third quarter of which is earth science, e.g., astronomy and geology. The program at Lansing Community College is much more similar to Postlethwait's at Purdue University than any discussed so far, in that the A-T or

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[23]Laboratory exercises prepared by the Geology Department (State College: Pennsylvania State University). (Mimeographed.)

as it is called at Lansing Community College, the Audio-Visual-Tutorial (AVT), is not limited to just the laboratory but encompasses the entire course. Credit is based on six class hours per week. Two hours are spent in lecture and discussion-recitation, and the remaining four hours in the AVT center any time the center is open.[24]

The use of the AVT is largely the effort of Dr. David Shull, Chairman of the Science Department when Lansing Community College was in its development. The fundamentals of the approach were patterned after the work of Postlethwait with major modifications made in light of the type of the subject matter being presented, the level of the presentation, and the characteristics of the students involved.[25]

A week's work in Astronomy-Geology quarter approximately follows the pattern outlined below:

1. A Discussion-Recitation Outline.
   This takes the form of a series of questions that the student is to be prepared to respond orally to. Questions the students may have submitted on a 3-x-5 card are considered first.

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[24]Sheet on policies prepared by the Science Department (Lansing: Lansing Community College). (Mimeographed.)

[25]Yarger and Cranson, "Application of the Audio-Visual-Tutorial Approach to Earth Science Instruction," p. 43.

2. A Unit Guide.

   The unit guide includes: (a) the assignments to be completed before taking the quiz, and (b) the outline of the week's work--including a vocabulary guide.

3. Goals (objectives) for the unit.

4. Written laboratory materials to accompany the audio tape and other media.[26]

An evaluation questionnaire comparing the AVT mode to the conventional lecture-lab mode was given to approximately 900 students and the following information was obtained:

Amount of learning with AVT	
More in the same amount of time	68%
Less in the same amount of time	14%
No difference	8%
No opinion	10%
Enjoy AVT	
More	70%
Less	15%
No difference	5%
No opinion	10%
Tape versus live lecture	
Prefer tape	70%
Prefer live lecture	21%
No preference	9%
Availability of individual assistance	
More with AVT	55%
Less with AVT	5%
No difference	28%[27]
No opinion	12%

[26]Laboratory exercises prepared by the Science Department (Lansing: Lansing Community College). (Mimeographed.)

[27]Yarger and Cranson, "Application of the Audio-Visual-Tutorial Approach to Earth Science Instruction," p. 45.

The units (one per week) covered in the Astronomy-Geology term are as follows:

1. Rocks and Minerals
2. Erosion--Part 1
3. Erosion--Part 2
4. Dynamic Processes
5. Earth History
6. The Solar System
7. Historical Astronomy
8. Astronomical Methods
9. The Sun and Other Stars
10. The Milky Way and Beyond[28]

University of Michigan.--The geology department at The University of Michigan became interested in open-scheduled laboratories using the audio-tutorial approach for teaching a one semester course, Earth History--an introduction to geology, because of a desire to improve depth, coverage, and stimulation of student interest, and to lower the cost per credit hour through more efficient utilization of space, staff, and equipment. Dr. Charles I. Smith and Dr. James McClurg developed the program, which they have called an open-scheduled audio-tutorial laboratory (OSAT). The system is defended using a rationale modified slightly from Postlewait's work:

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[28] *Ibid.*

1. Students can adapt the study pace to their ability to assimilate information.
2. Exposure to difficult subjects can be repeated as often as necessary for any particular student.
3. Better students are not a "captive audience" and can use their time more effectively. Their interests are not dulled by unnecessary repetition of information already learned, but they are free to choose those activities which are more challenging and instructive.
4. The student can select a listening time adapted to his diurnal efficiency peak.
5. Tapes "demand" the attention of the students. Students are not distracted by each other.
6. Students can have more individual attention if they desire it.
7. A student's scheduling problem is simplified due to the flexibility of lab attendance.
8. More students can be accommodated in less laboratory space and with fewer staff.
9. Make-up labs and review sessions can be easily accommodated.
10. The student feels more keenly his responsibility for his own learning.

11. Each student is essentially "tutored" by a senior staff member.
12. Potentially, the system can be used to standardize instruction where desirable, e.g., between the university and the university centers.
13. Teaching fellows can adjust their worktime to fit their changing schedules.
14. A more uniform presentation of material is possible since all students receive lab instructions and related content via tape-slide presentations in the voice of the senior instructor.
15. Teaching fellows communicate with students on a one-to-one basis and are relieved of the need to lecture to a group.
16. Laboratory equipment costs are considerably reduced.
17. The audio-tutorial carrels allow lectures to be taped and used by students for make-up and review purposes.[29]

Dr. McClurg, who is now a member of the science education department at Colorado State College, made a presentation at the east-central section of the National

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[29]Introduction to laboratory exercises for An Open-Scheduled Audio-Tutorial Geology Laboratory, prepared by the Geology Department (Ann Arbor: University of Michigan). (Mimeographed.)

Association of Geology Teachers, meeting at East Lansing, Michigan, in May, 1970, where he made the following points:

1. The use of the carrels is "dry," whereas the student is asked from time to time to do work in the "wet" laboratory area.
2. Cassette recorders are used (and the students can bring in their own cassettes and make copies of what is being presented in lab) and the presentations last from fifteen to twenty minutes.
3. Tests indicate that the OSAT program results in the same comprehension being attained that required four hours previously.
4. Answers to all lab questions are posted along with sample quizzes. Students sign up to take a lab-practical at mid-semester and at the end of the semester. All material in the lab is considered "fair game" for lecture tests.[30]

The subjects covered in the laboratory consist of the following areas:

1. Earth Structure
2. Minerals
3. Igneous Rocks

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[30] Charles I. Smith, James E. McClurg, and John F. Greene, "Open-Scheduled Laboratory Teaching in Geology at the University of Michigan--An Evaluation" (paper read at the annual meeting of the east-central section of the National Association of Geology Teachers, East Lansing, Michigan, May, 1970).

4. Sedimentary Grains
5. Aerial Photographs--Structural Geology
6. Topographic Maps--Geologic Maps
7. Fossils
8. Terrestrial Environments
9. Paralic and Marine Environments
10. Stratigraphy and Correlation[31]

State University College at Buffalo.--In Chapter III of this study, it was stated that the school considered was the State University of New York at Buffalo. The reason for the change is that from the material presented in the CEGS paper Audio-Tutorial Instruction: A Strategy for Teaching Introductory College Geology a reference was made to an article, "Auto-Paced Laboratories in Physical Geology," published in the April, 1969 issue of the Journal of Geological Education. Dr. Francis Siemankowski, the senior author of the article was contacted who stated that the A-T material that he had developed was for the third quarter of a three-quarter general science course at State University College. It was not until the visit with Dr. Siemankowski in Buffalo, that it was realized that the junior author of the aforementioned article, Dr. Charles Cazeau was using the techniques used and developed

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[31]Laboratory exercises for "An Open-Scheduled Audio-Tutorial Geology Laboratory" prepared by the Geology Department (Ann Arbor: University of Michigan). (Mimeographed.)

by Siemankowski for teaching physical geology at State University of New York at Buffalo. It was decided at that time that the study would continue with the geology aspect of the general science course at State University College rather than SUNY.

The program developed and used at State University College has been termed the Auto-Paced system because of its emphasis on learning in short steps with immediate reinforcement of correct responses. The format of the program consists of a total of seventy-five minutes in a large group lecture and four hours in an independent study center.[32]

The nine units of Science 103 are:

1. Minerals
2. Rocks
3. Diastrophism
4. Geologic Time
5. Seismology
6. Weathering and Erosion
7. Topographic Maps
8. Introduction to Astronomy
9. Introduction to Meteorology[33]

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[32] Siemankowski and Cazeau, "Auto-Paced Laboratories in Physical Geology," p. 40.

[33] Laboratory exercises for Science 103, prepared by Dr. Francis T. Siemankowski (Buffalo, N.Y.: State University College at Buffalo). (Mimeographed.)

Principia College.--The audio-tutorial approach at Principia is used for both the physical and historical geology courses and in all their aspects. Dr. Forbes Robertson says:

> A-T is much like a new workshop tool that one doesn't know how to use until it has been experimented with. Student reception has been good, more than 50 per cent saying they like it as much or better than "lecture type material or explanations." Laboratories are staffed by students or faculty from 8 A.M. to 10 P.M. Monday through Friday, but the laboratory is open 24 hours per day. Students normally spend 3-5 hours in the lab each week.[34]

The subjects covered in physical geology include the following topics:

Unit I	Crystals and Crystallography
Unit II	Repeat Theory, Coordination, and Silicate Structures
Unit III	Introduction to Topographic Maps
Unit IV	Minerals in Igneous Rocks
Unit V	Igneous Rocks
Unit VI	Igneous Activity
Unit VII	Weathering
Unit VIII	Sedimentary Rocks and Sedimentation
Unit IX	The Local Stratigraphic Section
Unit X	The Work of Running Water
Unit XI	Reduction of Regions by Running Water
Unit XII	The Work of Gravity

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[34]Fenner and Andrews, "Audio-Tutorial Programs in Introductory College Geology," p. 16.

Unit XIII Miscellaneous Topics Concerning the Work of Rivers

Unit XIV Shorelines, Oceans, and Deserts

Unit XV Ground Water

Unit XVI Valley Glaciation

Unit XVII Continental Glaciation

Unit XVIII Structural Geology: Folds and Faults

Unit XIX Metamorphism and Metamorphic Rocks

Unit XX Unconformities

Unit XXI Economic Metallic and Non-metallic Resources

Unit XXII Earthquakes and the Location of Epicenter by Mercalli Scale

Unit XXIII Earthquakes and the Structure of the Earth's Interior[35]

The subjects covered in historical geology include the following topics:

Unit I Review of Sedimentary Rocks

Unit II The Role of Fossils in Establishment of the Eras of the Geologic Time-Scale

Unit III Introduction to Fossils: Trilobites, Bryozoa and Brachiopods

Unit IV Introduction to Geologic Maps and Map Patterns

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[35]Duplicated course materials for Physical Geology 111, prepared by the Geology Department, Principia College, Elsah, Illinois.

Unit V	Introduction to Fossils: Protozoans, Sponges, Coelenterates, and Echinoderms
Unit VI	Unconformities
Unit VII	Unconformity-bounded Sequences and Major Structural Features of the Midwest
Unit VIII	Introduction to Fossils: Molluscs and Graptolites
Unit IX	The Local Section
Unit X-A	Geologic History of the Midwest: Sauk and Tippecanoe
Unit X-B	Geologic History of the Central United States: Kaskaskia and Absaroka Sequences
Unit XI	Upper Paleozoic of the Local Section
Unit XII	Geologic Maps: Structure Sections, Folds, Thrust Faults
Unit XIII	Geographic and Geologic Subdivisions of the Appalachians
Unit XIV	Guide Fossils of the Lower Paleozoic, Local Section
Unit XV	Sedimentary Tectonics
Unit XVI	Geologic History of the Appalachians
Unit XVII	Introduction to Fossils: Arthropods, Chordates and Plants
Unit XVIII	Steep Faults--Igeous Rocks
Unit XIX	Provinces of the Western United States

Unit XX	Paleozoic History of the Western United States
Unit XXI	Stratigraphic Data and Synthesis
Unit XXII	Paleogeography
Unit XXIII	Cenozoic History of the Western United States
Unit XXIV	--no specific label
Unit XXV	Cenozoic History of the Gulf and Atlantic Coastal Plains
Unit XXVI	Pleistocene
Unit XXVII	Geosynclinal Theory[36]

The subjects are presented using the audio-tutorial approach very similarly to the techniques used by Postlethwait but in a more free-wheeling fashion with one or two lectures per week depending upon material and conditions, a regular Thursday help session, quizzes on Friday, and field trips as the need and situation arises.[37] An important portion of the program is the honors portion with special emphasis given to small portions of research done by each student that are later integrated to provide a larger picture. The bulk of the material is presented in the learning carrels--some of which are one-man carrels and some, usually used in historical geology, that are

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[36]Duplicated course materials for Historical Geology 112, prepared by the Geology Department, Principia College, Elsah, Illinois.

[37]*Ibid.*

two-man carrels. Objectives are used liberally for all portions of the program.

The Level and Comparison of Objective Development of and Between Schools

Determining the fit of each school's objectives to the definition of a behavioral objective proved to be somewhat more arbitrary than the procedure for determining the level would suggest. The first problem was foreseen earlier and had to do with whether the verb structure suggested many interpretations or few. It was concluded for this study that in addition to those specifically mentioned in Chapter II, the following verbs were open to many interpretations: to learn, to become familiar, to study, to develop knowledge, to develop a concept, to use, to gain skill, to introduce, to show, to discuss. The following verbs were open to fewer interpretations: to relate, to recognize, to formulate, to record, to correlate, to determine.

Conditions and criteria presented similar problems and the decisions were made upon the context and use of the objectives.

Only these objectives that dealt specifically with geology were considered for Lansing Community College and State University College at Buffalo. This was done to provide a fair comparison. It is unlikely that including all objectives would change the rank value significantly.

The data on the number of objectives, the average level of objective development, and the rank values are presented in the following table (see Appendix C for derivation).

	Number of Objectives	Average Level of Objective Development	Rank Value
Lansing Community College	51	1.18	30%
University of Michigan	33	1.35	34%
State University College	24	1.09	27%
Principia College			
phys.	358	1.34	34%
hist.	206	1.46	36%
Purdue University (Postlethwait)	15	2.94	74%

Thus it is seen that the schools with the highest rank value are the University of Michigan and Principia College. Because of the greater number of objectives and the wider scope of their use, Principia was chosen for the "in-depth" look as the school with the highest level of objective development. It should be noted, however, that the sheets containing objectives for weeks four and eight of historical geology at Principia were missing from the materials received due to an oversight.

The school with the lowest level of objective development chosen for the "in-depth" look was State University College at Buffalo.

It is interesting to note that the average level of objective development of one week's work in Postlethwait's biology course at Purdue University is slightly better than twice as high as the level of objective development at either the University of Michigan or Principia.

An In-Depth Look at the Objective Development in the Introductory Geology Course at Principia College and the General Science Course (Earth Science Quarter) at State University College at Buffalo

Principia College

Dr. Forbes Robertson came to Principia, a private, coeducational, liberal arts college with a current enrollment of about 800, ten years ago (1960) after working for industry as a geologist. When he came, he was quite dissatisfied with the materials they had, feeling they were very inadequate. The first thing that needed changing was the physical geology laboratory manual. He wanted a manual that would do the things he wanted it to. His father had taught at Principia some years earlier and had written a physical geology lab manual published by Burgess Publishing Company of Minneapolis, Minnesota. After talking to them and explaining what he wanted to do, they decided to publish a new edition--essentially a brand new manual written by Dr. Robertson.

Along with the new manual, more visuals were added to the laboratory program, but Robertson realized that the present lab situation was still not working out to his satisfaction. Perhaps twenty years ago, people were geared to coming to class at a scheduled time and accepted a lock step, but that no longer is a part of modern education. Dr. Robertson had heard about Postlethwait's course at Purdue University, but waited about six months before he did anything about it. He visited Purdue in the spring, and decided that the audio-tutorial approach was "the answer to a maiden's prayer." This was in 1964. Dr. Robertson spent the following summer preparing for physical geology and worked without compensation. By the time summer was over, he thought he had things in pretty good shape--at least up through about mid-quarter, and thought he had the audio-tutorial approach down to a "T".

When the course began--in the first week, Robertson realized that he was not doing things as well as he might have done, and many aspects should be changed. By the time the course was in the second week, he was revising drastically the materials that had been worked over so assiduously during the previous summer, and when the material for the third week on sedimentary rocks arrived, he was so pressed for time that when he got that unit redone and on tape it was about 11 P.M. on a Sunday night.

It suddenly occurred to him that he was discussing sands and that there were in their collection some sands that looked like those that he was talking about, so with the sands and some rocks that looked like cemented sands, the original lesson was discarded and by 6 A.M. Monday morning a new unit on sedimentary rocks was complete.

The more that Dr. Robertson got involved with the A-T approach--and there were some objectives included in the manual--the more and more obvious it became that he had to focus the student's attention on that which would be pertinent and to allow the student to get that. When this was done, their grades were much improved. Robertson had felt for a long time that there is no reason why every person entering the course could not get an "A" if they applied themselves, and having this as a broad objective made it necessary to spell out very carefully what an "A" was equivalent to. There is nothing difficult in a work or skill area if each step of an operation is described and illustrated. The objective is for the student to learn and to provide the information in such a way as to do it in the minimum amount of time.

Dr. Robertson stated that:

> . . . this is how the objectives evolved and became as clear-cut as they are, yet there is a lot yet to do. If a person starts with the objectives and does the work and the reading, he will have gained a "heck of a lot of information."

However, it is not just a blanket amount of material that the student has to cover, and an "A" requires an "honor's project." The students do not have a project every week, and they do have choices, but they do have to produce something that is not part of an ordinary exercise. They are projects that would never normally get into a beginning class at Principia.

Geology is outdoors and if you cannot go outdoors, the next best thing is to let the student see the outdoors through slides and work with the materials observed on the slides. Therefore a lot of slides are used and more are needed. If the students work with the materials as they look at the slides they get a lot more out of the exercise, and a large amount of materials are not needed, for instance one good fossil can be used by all the students in the A-T program. Going out in the field takes much more time for the student than using slides, rocks, and other materials in the classroom, but both are needed.

A winter field trip was washed-out so rather then have the students lose out altogether Robertson put some slides together along with some rocks and some maps for the area where they were to have gone on a field trip. The student had to turn the projector and recorder off and on, etc., it was rather complicated because of the mechanics of the thing. About one-half of the class experienced the trip vicariously and the other half of the class took the field trip the following week. At the end of the course, Robertson sprang a very detailed examination on the field trip to provide information on how much the students had retained of the trip. There was not any significant difference between the groups, but there were four people that had both experiences. The four were a whole dimension--twenty to thirty points above the rest of the class. This indicated quite clearly that a simulated field experience would do as well as the actual trip and as a preview or review of the trip would more then make up for the fantastic amount of time required for preparation.

Robertson said that:

> . . . you just don't know what you can do with this system until you've messed with it. You think you know all about it until you start to employ it--the students can do so much with it. We found out that the students can assimilate two or three times as much material in probably one-half the time that they did before. . . . We have to be more efficient in education. We've added more material, but cut down on the time requirements, and nobody is complaining.

If the students are told what they are expected to get, then they will do it. Sometimes students have decided to go off in another direction, and this is desirable.

An example of this happened in historical geology. In the quiz sessions about five students are quizzed for twenty minutes (Postlethwait has eight students for thirty minutes). In one session a group of four fellows who were not ordinarily "A" students made it evident to Robertson in about five minutes that they had just learned everything, and that they had been in the library studying all kinds of material over and above anything that had been required. When asked why, they responded that they had gotten interested. There is nothing any more complimentary to a professor than for students to say that they had gotten interested, and when asked how and why they did it, they said they had worked together, and were half-apologetic about it. Robertson assured them that if they followed that procedure every week they would be assured of "A's." Three of the fellows did continue working together and received "A's." It is quite evident that with specific objectives, avenues are opened to the students to pursue material not otherwise included in the objectives.

Dr. Robertson made a number of observations about the audio-tutorial approach and learning. He said that the first unit in physical geology uses the A-T approach extensively but after that, a large portion of the material is obtained by reading directly from the manual with a minimum of direction being given on the tape recorder. When the students were asked which technique made it more easy to learn, the class was an even split. The same response was noted several times over a period of a few years, so the students were asked if it did not make any difference, what way would they prefer, and the response was again about fifty-fifty so Robertson concluded that about 50 per cent of the students came to class knowing how to read and this is the way they learned and this is the way they liked it. The other half had not learned to read, but the A-T approach had given them a vehicle to let them compete with those that knew how to read. Dr. Robertson estimated that the average student spends a total of five hours per week on their lessons and that concept of spending two hours per week studying for every hour the class is scheduled is not realistic with all the other things that are being required of students today.

In the future Dr. Robertson would like to provide for those that are able to assimilate material very rapidly, giving the student alternative directions of study. He is also planning on going to an earth science curriculum rather than straight geology.

Dr. Forbes Robertson was not acquainted with the objective bank concept of Popham though he agreed that objectives are difficult to write. He also was not acquainted with Mager and did not know specifically what Mager calls behavioral objectives, although he had essentially made extensive use of them.

A few of Robertson's conclusions were:

> Involvement is the key, you need the student's participation.
>
> The audio-tutorial method is a better method whether there are 3 or 3,000 students.
>
> You have to have the cooperation of those that you work with. It has to be a joint effort.
>
> If you test the student on something that is not in the objectives, they let you know about it. _It_

has been the student's pressure, in a sense, that has caused objectives to have been developed.[38]

State University College at Buffalo

Dr. Francis T. Siemankowski holds the Ed.D. degree. He taught in public schools in the subject areas of physics and earth science for twenty-five years before going to State University College to teach general science and supervise student teachers.

The auto-paced program for teaching general science was started because Siemankowski recognized that to a large degree the elementary education students that take the general science course have in the past developed a poor attitude toward science, because all too often, the teaching methods by which they were taught are bad. In short, a major purpose in developing the program was to improve science teaching at the elementary level by example.

The auto-paced method was first tried in the summer of 1966, using two carrels with four students. The first trials resulted in making many revisions of the original tapes. At first the material was presented too rapidly, and later too slowly. From his experience, Dr. Siemankowski recommends that pause periods be included to permit the student to find information and assimilate it. This has

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[38]Personal interview with Forbes Robertson, Geology Department, Principia College, Elsah, Illinois, July 28, 1970.

the added benefit of permitting the instructor to make changes easily. The listening time for using audio tapes should not go beyond five minutes or so without an activity. The student must stop the recorder at a signal--usually a bell--and perform an activity. The activity requires that the student must commit himself in some way, by answering a question, stating a conclusion, etc. Siemankowski also provides immediate reinforcement in the Skinnerian fashion by some statement such as, "now let's compare notes." The directions are given in such a way that 95 times out of 100 the student will make the correct response.

When Dr. Siemankowski does the taping, it is done as if he is sitting with the student and conversing with him. The student is tested at the end of a unit in a laboratory practical exam.

The development of the auto-paced approach was done as an aside to Dr. Siemankowski's regular duties. A faculty member on campus (in the campus planning office) had some carrels he had invented and made them available for Siemankowski to use in his initial development. Most of the equipment was obtained on the campus. The department provided the materials.

Dr. Siemankowski is now using small three-inch reels, instead of the larger reels on the tape recorder to facilitate the student in the use of the auto-paced technique. This is another attempt by Dr. Siemankowski to insure the student of using a number of small steps rather than one large one. The use of the short tapes breaks a single lab period into three or four short periods. The student can make better use of his time this way. With one long exercise the student becomes tired.

Siemankowski does not approve of just using a tape recorder and slide projector. Either models or the actual subjects are usually needed. One problem is that most students have very poor three-dimensional cognition when they see a two-dimensional expression of three-dimensional objects.

Besides the lecture and independent study center aspects of the course, small discussion groups (one-half of the large group) are assigned to discussion sessions, and since attendance is not required, only six to ten attend for thirty minutes.

Dr. Siemankowski states that had he prepared the lab materials (evaluated in this study) for publication, he would have written the objectives behaviorally. He says that the students he is working with are not interested in the term objective at all, in fact he is considering using the word goal--to avoid using the word objective. Siemankowski feels that the terminology that objectives are written in scares the elementary education people. He finds that the students read everyting on the handout materials (assignments, etc.) but the objectives. The students expressed that they had been turned off by such terminology. They consider that it is some more of the "educational brainwash," and that they can save a little time by starting where it says reading assignment. Dr. Siemankowski feels that greater care should be taken in the selection of terms to avoid scaring the student.

Dr. Siemankowski defines behavioral objectives as a sort of verbal description of a task analysis that is not written in the manner of a flow chart. He sees a lot of value in using behavioral objectives but their writing takes a lot of time, and while he has had it in mind, was perhaps too lazy to do it.

He is working with Dr. Charles Cazeau for Van Nostrand and Randall and Company on a project which will involve a textbook, lab manual, and workbook along with a teacher's guide and visual aids, primarily transparency masters. Siemankowski is now working on the laboratory exercises and has been considering writing the objectives in behavioral terms, but the time is too short, so he is going back to his old habit of writing the objectives in general terms. He feels that the teacher's guide should have the objectives in more behavioral terms than that which the student receives.

Siemankowski feels that behavioral objectives are very important and suggests that a team effort, that is, a whole department should be used to develop them because of the size of the job. He is also concerned about attitudinal objectives and the problem of changing attitudes.

Because of the success with a pilot program in physical geology at State University of New York at Buffalo designed by Siemankowski and Cazeau using the audio-paced method, Cazeau is teaching all of the introductory physical geology courses at SUNY. Cazeau is covering more material in less time, the students like it better, and more students are coming in, requiring expansion. The faculty is pleased too, because they do not have to be involved in the basic course, but still are getting more students into their advanced courses.

Siemankowski is not familiar with the objective bank concept. When given Popham's idea about an objective bank, he remarked, "It sounds like a crazy idea, but it will probably work."[39]

Summary

Four of the nine schools studied that were using the A-T approach in teaching introductory geology courses made no stated use of objectives at all. They were: Macalester College, College of Marin, University of Notre Dame, and Pennsylvania State University.

Macalester College was in the early stages of development using the audio-tutorial approach and no evaluation had yet been made of its effectiveness.

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[39]Personal interview with Francis T. Siemankowski, Department of General Education, State University College at Buffalo, Buffalo, New York, July 20, 1970.

The College of Marin was having financial problems resulting from their dependence upon voter-approved bond issues. A failure of a bond issue to pass has put the entire geology program and particularly the A-T aspects in an uncertain position.

The faculty members most directly involved with the programs at Notre Dame and Pennsylvania State University both have serious doubts about the usefulness of the A-T approach at their schools and the expansion of the audio-tutorial approach is in doubt. In fact at Pennsylvania State the initial efforts using the A-T approach have been reduced by half.

The introductory geology course at Ohio State University uses objectives but they are not stated for the student. However, objectives were developed prior to evaluative instruments and hence the student is exposed to educational experiences that have been tailored to reach specific goals. The reaction of faculty and students is very favorable to the use made of the audio-tutorial approach at Ohio State.

The remaining four of the nine schools both used objectives and made them available to the students to guide the students in what they are expected to achieve. The four schools with objectives presented to the students are: Lansing Community College, University of Michigan, State University College at Buffalo, and Principia College.

It is interesting to note that two of the four schools, Lansing Community College and State University College, use objectives in the teaching of introductory geology as part of a three quarter general science course. Only one of the schools, Principia College, is using the A-T approach for teaching more than one course (both physical and historical geology).

A comparison of the rank values of the level of objective development had all the schools grouped fairly close together with State University College being the lowest with a rank value of 27 per cent and University of Michigan and Principia College (historical geology) the highest with rank values of 34 and 36 per cent. These are compared to the rank value of 74 per cent at Purdue University for a week's work in Postlethwait's biology class.

Because of the greater number of objectives--almost ten times as many--Principia was chosen as the school with the highest level of objective development to be studied more closely along with State University College at Buffalo.

Both Forbes Robertson of Principia and Francis Siemankowski of State University College stated that they felt that objectives were very important. However, Robertson concluded that objectives were absolutely essential for directing the student to reaching the

course's instructional goals and helping the student to know when he reaches them, while Siemankowski was of the opinion that objectives tended to turn the students off and that they should perhaps be phrased differently.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

There is a need for curriculum development in the discipline of geology--particularly the introductory courses--physical geology, historical geology, or their equivalent. Postlethwait's audio-tutorial approach to learning with its emphasis on the student and his needs and its resultant success provides a model that some colleges and universities have chosen to follow for their introductory geology courses.

Behavioral or instructional objectives are very necessary if not imperative for pre-planned instruction of the A-T type. The more nearly an objective fulfills the three requirements of: (1) it must be stated in performance terms, (2) the conditions under which it is to be performed must be described, and (3) the criteria must be given for how well it is to be performed, the more useful the objective becomes.

Other classifications of objectives such as Bloom's Taxonomy and Gagné's Categories of Behavior provide a useful function only after the three requirements are fulfilled.

That well-defined goals or objectives are not always given serious attention by the developer of pre-designed instruction suggests that the reasons for this omission should be identified.

The purpose of this study has been to answer the following questions about the use of objectives in curriculum development in the area of introductory geology:

1. To what extent have behavioral objectives been utilized in the development and use of the A-T approach in introductory geology?
2. What are some of the reasons that some A-T programs in introductory geology have been particularly effective while others have not?
3. Would a compilation of the objectives be useful to institutions planning curriculum improvement or renovation and if not, why not?

Six statements were made to direct attention to these questions and to assist in evaluating the development and effectiveness of the role of behavioral objectives in pre-designed instruction in geology of the audio-tutorial type. They are:

1. Institutions who have developed an A-T approach to teaching introductory courses in geology will have developed course objectives.
2. Course objectives can be categorized into levels, i.e., general through behavioral.
3. The objective level of each institution can be categorized.
4. The level of objective development at some institutions will be higher than at other institutions.
5. Institutions with either a very high or very low level of objective development can provide valuable information on the reasons for success or lack of it in the development of objectives.
6. A composite of course objectives for the introductory courses of geology will be useful to other institutions planning curriculum development in the area of introductory geology.

The strategy for testing the six statements consisted of selecting nine of approximately twenty-five schools using the A-T approach in teaching introductory courses in geology. The schools were contacted and their course materials were requested--specifically that part that would contain the course objectives if there were any available. The objectives were categorized by quantitatively comparing them to the three-part definition of the behavioral objective. The average level of objective development was calculated for each of the schools having objectives.

Two schools--one with the highest level of objective development, and the other with the lowest level of objective development--were selected for an in-depth study to attempt to determine some of the reasons why the schools were either successful or unsuccessful in their objective development.

Four of the nine schools studied made no stated use of objectives at all. The principal developers in two of these schools, the University of Notre Dame and Pennsylvania State University have serious doubts about the usefulness of the A-T approach for introductory courses in geology.

The five remaining schools used objectives, and students and faculty were unanimous in their positive reactions to the audio-tutorial approach in these schools.

The school with the highest level of objective development--Principia College and the school with the lowest level of objective development--State University College at Buffalo were visited and the developers interviewed as part of a deeper look at why they were successful or unsuccessful in their objective development.

The difference between the schools seemed to indicate a difference in attitude toward the use of objectives. Robertson at Principia states that objectives are absolutely essential for student achievement, while Siemankowski at State University College is concerned that objectives seem to turn the students off.

Conclusions

The following are the conclusions derived from this study:

1. All programs using the audio-tutorial approach were influenced by Postlethwait's pioneer work at Purdue University.
2. The reasons for using the A-T approach include:
    a. assists the student in learning,
    b. dissatisfaction with the previous system,
    c. needs of students are changing,
    d. saves the student time,
    e. covers more material,
    f. allows the student to progress at his own rate.
3. While many programs bearing the audio-tutorial title fit the definition of the A-T program in this study, they do not fit the definition of the audio-tutorial system as used by Postlethwait.

4. All institutions using the A-T approach did not use objectives.
   a. The programs that are least like Postlethwait's do not have objectives.
   b. The A-T programs that are viewed as doubtful by the developers are also without objectives.
5. None of the schools that had objectives had written them in behavioral terms as previously defined. A corollary statement is that none of the objectives were of a very high level of development.
6. Three of the five programs that made use of objectives had a professional educator actively involved in the development, namely:
   a. University of Michigan, James McClurg
   b. Ohio State University, John A. Maccini
   c. State University College at Buffalo, Francis Siemankowski
7. A strongly motivated and innovative professor may see the need and develop objectives without appreciable outside help.
8. Students tend to reflect teacher's attitudes about objectives.
9. Successful development of objectives requires the cooperation of the students and other involved faculty members.

10. Most of the developmental work was done within the individual departments involved.
11. Some financial assistance was obtained through the National Science Foundation.
12. No insights on the value of the objective bank concept to geology were obtained.

Discussion

The similarity between what Postlethwait has called the "audio-tutorial approach" and what some others have called the "audio-tutorial approach" is only in the use of the basic hardware, namely the tape recorder and slide projector. The concept of either pre-planning through the use of objectives and/or the tutorial aspect of having the instructor available for the student when the facilities are being used has been overlooked by both Dr. Murphy of Notre Dame and Dr. L. Lattman of Pennsylvania State. They have tried the audio-tutorial approach to teaching certain aspects of the introductory courses of geology, but found it less successful than anticipated. Those programs most similar to Postlethwait's at least in philosophy if not in design are those that appear to be the most viable.

All the principle initiators or developers of the programs that have made use of objectives are enthusiastic and optimistic about their programs. The students, too, have indicated in surveys such as the questionnaires used at Lansing Community College and Ohio State University that they prefer by a large majority the audio-tutorial approach over the conventional lecture-laboratory approach.

Perhaps one significant relationship to Postlethwait's model coming from this study is that the majority of the programs that appear to be the most viable have included an individual in the field of education in the development of the program. While this may not be a cause and effect relationship, some sort of correlation appears to exist. None of the programs without objectives indicated any assistance from anyone in the field of education.

Whether an objective bank for the discipline of geology would lessen the trauma of having to write objectives remains a question unanswered. Reactions to the "bank" concept were only at the lowest level of interest, perhaps only being a function of politeness.

Based upon the results of this study, a number of general rules or heuristics can be stated that might aid in preventing objectives from being omitted in the development of pre-planned instruction of the audio-tutorial type in the future in the field of geology and perhaps other fields as well. These are:

1. Seek out programs such as Postlethwait's that are successful and study the programs to determine why they are successful.

2. Obtain the cooperation of others within the same department and an interested professional educator.
3. Realizing that objectives are essential to a successful application of this approach, seek released time and financial assistance that will cover the development of these along with the rest of the innovation.
4. Design the program with specific goals in mind so that the development is logical and the completion of the goal is recognized.
5. Involve the students in the classes in the development as much as possible.
6. See to it that the students have the objectives and that the materials used are specifically designed to meet those objectives and then use them as a basis for evaluation.

Implications for Future Research

At the conclusion of the study, one of the three originally stated questions remains unanswered, that is, will the general availability of behavioral objectives facilitate curriculum development in the area of geology, or perhaps in any discipline? It is unfortunate that this study was unable to discover any objectives written in behavioral terms for courses in introductory geology. For an answer to this question is dependent upon obtaining a bank or reservoir of objectives that are stated behaviorally.

The study raises another question--What is the role of the professional educator (science educator, media specialist, or generalist) in the development of audio-tutorial programs in geology? Is the presence of the educator sufficient to significantly increase the probability of including objectives and those stated perhaps behaviorally, or is his presence another indication of the determination of the party working on curriculum development?

Perhaps answers to either or both questions could provide information that would be of value in the area of future curriculum development in the area of geology.

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Miller, Kenneth. Telephone Communication. Geology Department, College of Marin, San Rafael, California, May 4, 1970.

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APPENDICES

APPENDIX A

CALLING SCHEDULE

APPENDIX A

CALLING SCHEDULE

All telephone calls were made on a person-to-person basis to the persons indicated, except in the case of Lansing Community College, which was a local call.

Christian College, Columbia, Missouri: (314) 449-0531

Dr. Burnett E. Ellis was called first on May 1, 1970. A woman answered the telephone as Dr. Ellis and somewhat reluctantly stated that study guide material would be sent. When the business was completed the woman (unidentified) stated that she was not Dr. Ellis. When the material requested did not arrive in several weeks, Dr. Ellis was again called, but was unavailable since he was out for the summer. A letter written on June 25, 1970, again requesting the materials was not acknowledged.

Lansing Community College, Lansing, Michigan:
(517) 489-3571

Mr. K. R. Cranson was called May 1, 1970, and he suggested that the materials be picked up at the Lansing

Community College Learning Laboratory. The materials were picked up May 4, 1970, from Mr. Richard D. Yarger.

Macalester College, St. Paul, Minnesota: (612) 647-6259

Dr. Henry Lepp indicated, when called on May 12, 1970, that he had not had much to do with using audio-tutorial techniques, but indicated that he would send any material that they had. Materials were not received by the middle of June, so a letter was written June 25, 1970, and a reply was received July 1, 1970.

College of Marin, San Rafael, California: (415) 454-3962

Dr. Ken Miller was the one spoken to May 4, 1970. By June 1, 1970, no materials had been received, so Dr. Miller was called again. Materials were received June 5, 1970.

University of Michigan, Ann Arbor, Michigan: (517) 764-1458

Dr. Charles I. Smith was called on May 4, 1970. As Dr. Smith was in the field, a secretary said she would have a laboratory assistant send the materials. These were received a short time later.

State University College, Buffalo, New York: (716) 862-4914

Dr. Francis Siemankowski was called on May 1, 1970. The materials were received about one week later. A call was later made to Dr. Siemankowski on July 17, 1970, to arrange a visit with him for July 20th. The afternoon of

July 20, 1970, was spent at State University College in Buffalo with Dr. Siemankowski.

University of Notre Dame, South Bend, Indiana:
(219) 183-6011

Dr. Michael J. Murphy was called May 4, 1970. He did not have any materials to send.

Ohio State University, Columbus, Ohio: (614) 293-3148

The phone call to Dr. Walter C. Sweet was made on May 1, 1970. Dr. Sweet was most helpful and said that materials would be sent out right away and these were the first received.

Pennsylvania State University, State College, Pennsylvania:
(814) 865-5342

Dr. Laurence Lattman was called on May 4, 1970. The materials were received personally from him at the National Association of Geology Teachers East-Central Regional meeting at East Lansing, Michigan, May 8, 1970.

Principia College, Elsah, Illinois: (618) 466-2131

Dr. Forbes Robertson was not in when the first contact was made on May 1, 1970. Dr. Frederick Marshall assured that materials would be sent right out and an invitation to visit the college was made. The materials were not received and a second call was made on June 1, 1970. Dr. Marshall indicated that he had forgotten and the materials were later received. Dr. Robertson was again contacted on July 15, 1970, to arrange a visit to Principia College. On July 28, 1970, Principia College was visited and an afternoon was spent with Dr. Robertson.

APPENDIX B

LISTS OF OBJECTIVES

APPENDIX B

LISTS OF OBJECTIVES

Lansing Community College
Lansing, Michigan
Natural Science 103

Goals for Unit 1--Rocks and Minerals

Goals:

1. Discuss the common properties of minerals which are useful in their identification (hardness, color, cleavage, etc.).

2. Be able to identify, through the use of the rock and mineral keys, the samples presented.

3. Discuss the origins of rocks (sedimentation, metamorphism, vulcanism).

4. Discuss the nature and classification of igneous, sedimentary, and metamorphic rocks.

5. Discuss intrusive and extrusive volcanic landforms (dikes, cones, sills, necks, etc.).

Vocabulary Related to Above Goals

mineral
hardness
cleavage
streak
fracture (ex. conchoidal)
metallic
rock
texture (coarse, fine, glassy, massive)
igneous rock

intrusive
pluton
batholith
laccolith
sill
dike
magma

extrusive
lava

Vocabulary	Related to Above Goals
Bowen's reaction series	lava flow
ore	AA lava
sedimentary rock	pahoehoe lava
strata	fissure eruption
crossbedding	lava cone
clastic sediments	composite cone
metamorphic rock	cinder cone
regional metamorphism	parasitic cone
thermal metamorphism	volcanic neck
rock cycle	crater
	caldera
	geothermal gradient

Goals for Unit 2--Erosion: Weathering, Ground Water, and Streams

Goals:

1. Discuss the processes of physical and chemical weathering.

2. Discuss mass wastage as a means of erosion.

3. Discuss the process of ground water accumulation and describe a typical water well.

4. Discuss the processes and the results of the formation of Karst topography.

5. Discuss hot springs and geysers.

6. Discuss the mechanism for stream transportation of material and types of features created by a stream as it erodes and deposits.

7. Discuss the life history of a stream.

8. Discuss, in general terms, the Basin and Range and Plateau Province.

Vocabulary	Related to the Above Goals
physical weathering	radial drainage pattern
chemical weathering	gradient
mass wastage	youthful stream stage
soil creep	mature stream stage
landslide	old stream stage
talus (slope)	meander
bedrock	meander cutoff

Vocabulary	Related to the Above Goals
Karst topography	oxbow lake
water table	flood plain
sinkhole	natural levee
Valley sink (solution valley)	stream capture
stalactite	braided stream flow pattern
stalagmite	alluvium
interior drainage	alluvial fan
dendritic drainage pattern	delta
rectangular drainage pattern	yazoo stream
trellis drainage pattern	

Goals for Unit 3--Erosion: Glaciers, Shorelines, and Wind

Goals:

1. Discuss the difference between a valley glacier and a continental glacier.

2. Describe the process by which glaciers move and erode.

3. Describe the erosional and depositional landforms produced by glaciers.

4. Discuss the glacial history of Michigan and the Great Lakes.

5. Describe a submergent, an emergent, and a drowned shoreline and the associated landforms.

6. Discuss the wind as an agent of erosion.

7. Discuss, in general terms, the Interior Lowlands and the Coastal Plains.

Vocabulary	Related to the Above Goals
Glacial creep	Lake beds
Zone of accumulation	Erratic
Zone of wastage	Marginal drainage channel
Cirque	Submergent shoreline
Horn	Wave cut terrace
Arete	Wave cut cliff
Tarn	Wave built terrace
Pater Noster lakes	Sea cave
Valley train deposits	Sea stack
Crevasse	Tombolo

Vocabulary	Related to the Above Goals
Glacial drift	Continental shelf
Till	Emergent shoreline
Till plain	Spit
Pit (lake)	Barrier Island
Moraine	Bay barrier
Drumlin	Long shore currents
Stratified drift	Drowned shoreline
Esker	Crustal rebound
Outwash Plain	Loess
Kame	Dunes
Kettle	Sea arch

Goals for Unit 4

Goals:

1. Discuss earthquakes and their detection (seismic waves).
2. Discuss the earth's interior.
3. Discuss the concept of isostacy.
4. Discuss rock deformation (faulting and folding).
5. Describe four types of simple mountains.
6. Discuss the origin of complex mountains systems.
7. Describe the theories concerned with the force that uplifts complex mountains (convection currents, continental drift, and shrinking earth).
8. Discuss the North American Continent as a geologic unit.
9. Discuss in general terms, the Appalachian highlands, Rocky Mountains, and the Pacific Mountain System.
10. Discuss the ocean basins.

Vocabulary	Related to the Above Goals
seismograph	Orogeny
earthquake focus	volcanic mountains
P-waves	dome mountains
S-waves	erosional mountains
L-waves	block mountains
crust	folded mountains

Vocabulary Related to the Above Goals

Mohorovicic discontinuity (moho)
mantle
joint
fault
footwall
hanging wall
normal fault
thrust fault
horizontal fault
graben--horst
escarpment
anticline
syncline
monocline
hogbacks
geosyncline
isostatic equilibrium
isostatic adjustment
convection current
continental slope
continental rise
ocean trenches
mid-ocean ridges
abyssal plains
Continental Drift

Goals for Unit 5--Earth History

Goals:

1. Discuss the geologic time scale. (Memorize eras and periods in order before class).

2. Discuss the age of the earth and how it is determined.

3. Discuss the Principle of Uniformitarianism.

4. Discuss the process of establishing absolute age dates.

5. Discuss the process of establishing relative age dates.

6. Describe an unconformity and the sequence of events it indicates.

7. Discuss, in general terms, the changes which have occurred in plant and animal life through geologic time.

8. Discuss the history of the Grand Canyon region.

9. Discuss the history of the North American continent.

Vocabulary	Related to the Above Goals
Uniformitarianism	Facies relationship
Relative age	Paleontology
Stratigraphy	Brachiopod
Principle of Original Horizontality	Trilobite
Principle of Superposition	Cephalopod
Principle of Physical Continuity	Dinosaurs
Unconformity	Period
Rule of Intrusion	Era
Rule of Deformation	Absolute Age
Rule of Metamorphism	Half life
Age determination by fossils	Radioactive decay
Facies	

Note: Solutions to the interpretation of cross sections C-H are available on the instructor's desk.

University of Michigan
Ann Arbor, Michigan
Geology 117

Earth Structure

Objectives:

1. To understand the techniques used in determining the size and mass of the earth.

2. To know the basic internal structure of the earth and the techniques for determining it.

3. To construct a density model of the earth consistent with the known facts.

Minerals

Objectives:

1. To formulate a definition of a mineral.

2. To know the origin of minerals and be able to recognize their physical properties.

3. To know how to identify minerals with and without the microscope, individually and within rocks.

Igneous Rocks

Objectives:

1. To study the origin and texture of igneous rocks.

2. To learn the various igneous structure and the type of rock found in each.

3. To identify igneous rocks by texture and composition, with and without the microscope.

Sedimentary Grains

Objectives:

1. To study the origin, transportation, and deposition of sediments.

2. To learn to identify the kinds of sedimentary particles.

3. To study the transformation of sediments into rock (lithification).

4. To learn to recognize the common sedimentary rocks in hand specimen and thin-section.

Aerial Photographs, Structural Geology

Objectives:

1. To become familiar with aerial photographs and stereoscopes.

2. To know the names and be able to recognize the various types folds and faults that occur at the earth's surface.

Topographic Maps, Geologic Maps

Objectives:

1. To develop skills necessary to interpret topographic and geologic maps.

2. To learn to construct topographic and geologic maps.

3. To learn to construct a topographic profile.

Fossils

Objectives:

1. To identify the major invertebrate fossils.

2. To record environmental and morphological data for each fossil.

3. To use fossil assemlages in determining relative ages.

Terrestrial Environments

Objectives:

1. To study the processes and responses in selected arid and temperate terrestrial environments.

2. To learn to recognize the responses to arid and temperate environments in sedimentary rocks.

Paralic and Marine Environments

Objectives:

1. To study the processes and responses in selected paralic and marine environments.

2. To learn to recognize the responses to paralic and marine environments in sedimentary rocks.

Stratigraphy and Correlation

Objectives:

1. To recognize transgressive and regressive sequences as they are represented in stratigraphic sections.

2. To understand the concept of correlation.

3. To know the various methods of physical and biological correlation.

4. To correlate stratigraphic sections using lithology and sequence.

5. To correlate stratigraphic sections using fossil range zones.

Paleogeography

Objectives:

1. To determine the relative ages of rocks of an area.

2. To reconstruct the geologic history of an area.

3. To study the paleoenvironmental changes in an area through time.

Ohio State University
Columbus, Ohio
Introductory Geology

Unit 1:
The Minerals of Granite and Gabbro

1. Development of the knowledge that rocks are aggregates of minerals.
2. Rocks can be distinguished from one another on the basis of the kinds of minerals they contain.
3. Gain familiarity with granite, gabbro, and their mineral constituents.
4. Gain skill in recognizing and measuring the angles between cleavage planes and in the routine procedures of determining and expressing mineral hardness.

Unit 2:
Igneous Fabric and Texture and the Weathering of Igneous Rocks

1. Reinforced study of rocks and minerals introduced in Unit 1.
2. Recognition of several additional types of igneous rocks.
3. The use of texture and fabric as an added means of distinguishing between these rocks.
4. Be able to use all of the properties in inferring something about the mode and environment of formation of several common igneous rocks.
5. Develop a concept of what happens during decomposition of the mineral constituents of granite and helping them apply this concept to other types of rocks and their weathered products.

Unit 3:
The Formation of Sedimentary Rocks

1. To introduce students to an analysis of some everyday materials (residual regolith, hard water) and the textural or chemical components into which they are separated naturally.

2. To introduce them to the common sedimentary rocks that result from lithification of these components.

3. To provide them with a self-learned basis for understanding a genetic classification or interpretation of sedimentary rocks and structures.

Unit 4:
The Use and Significance of Fossils

1. Students should be familiar with the rudiments of biologic classification and nomenclature.

2. Be able to recognize and use the combination of morphologic and structural features that enables identification of common fossils.

3. Have some appreciation for the means by which evolutionary statements are deduced from the fossil record.

4. Have some practical experience in using fossils in correlating and interpreting stratigraphic sections.

Unit 5:
Metamorphic Rocks; Rocks and Earth History

1. Recognition of the effects of metamorphism on familiar rock types and development of the capacity to deduce from various metamorphic rocks both the original rock type and the conditions that produced the metamorphic rock from it.

2. To relate all the characters of rocks studied up to this point to historical interpretation.

Unit 6:
Maps as Models

1. To provide the student with some experience and know-how in the use of maps as models of the earth's surface.

Units 7, 8, and 9

1. To bring into play, and reinforce in different regional settings, all the skills, abilities, and concepts gained in Units 1 through 6.

2. To introduce students in a "participatory" way to the major features of three North American areas of exceptional geologic interest.

Principia College
Elsah, Illinois
Geology 111

Objectives for Units 1, 2, and 4

Unit 1: Symmetry of Crystals

- Be able to pick up a crystal model and analyze it for
  - -center
  - -axes
  - -planes
- Be able to use your chart to identify the crystal class into which a model falls
- Understand the basic distinctions between the six crystal systems in terms of
  - -number and relative lengths of the crystallographic axes
  - -angles between the axes

Unit 2: Repeat Theory, Coordination, and Silicate Structures

- Be able to analyze any of the patterns in the back of the manual for
  - -motif
  - -point group
  - -repeat operations that fill the plane
- Be able to apply analysis to yard goods, walls, ceilings, etc.
- UNDERSTAND THE SIGNIFICANCE OF REPEAT THEORY TO GEOLOGY
- Know what coordination number means
  - -know what the coordination number of the silicon atom is in the silicon-oxygen tetrahedron
  - -know what happens to coordination number when size of the central atom increases relative to size of surrounding atoms
- Know that 5 main types of silicate structures
  - -be able to recognize a model of each
  - -know, in each case, how many oxygens in any one tetrahedron are shares with adjacent tetrahedra
  - -know, the silicon-oxygen ratio in each case--be able to determine this ratio by counting the atoms on a model

Unit 4: Minerals in igneous rocks

- Know the 8 most abundant minerals in the earth's crust by weight and in order
- Show that the component SiO_2--quartz--is electrostatically balanced

Show what happens to the balance of electrostatic charges when some of the silicon is replaced by aluminum
- -show why it is necessary to add K, Ca, or Na
- -understand how the resulting formula shows that the basic quartz structure is retained

Know what a plagioclase feldspar is
Know what a ferromagnesians are
KNOW THE BOWEN REACTION SERIES
- -mineral name, composition, type of silicate structure, (si-o ratio)

Be able to identify the principle igneous minerals using the determinative tables
Be able to recognize feldspar "striations" in a microscope.

Objectives of the reading assignment--will be on test unless otherwise stated.

Chapter 2:
- Understand the nature of electrical charge
- Understand: atoms, protons, neutrons, electrons, atomic structure, ions, elements, isotopes, compounds, various forms of energy

Chapter 4:
- Know definition of mineral
- Understand the nature of mineral structure
- Identification of minerals--once over lightly
- Rock-forming minerals--enrich your understanding of:
  - silicates
    - ferromagnesians
    - feldspars
    - quartz
  - oxides
  - sulfides
  - carbonates

Chapter 1:
- Distinguish between physical and historical geology
- Know what the "doctrine of uniformitarianism" is
- Know the three basic rock families and how they are related in the rock cycle

Chapter 9:
- Distinguish between absolute and relative time
- Understand how radioactivity aids in our distinguishing time
- Know the basic principles involved in establishing relative time scale
  - -law of superposition
  - -how correlation of rocks by fossils is accomplished
- You will be expected to learn the eras and periods of the geologic time scale and the epochs of the Cenozoic--not right away though.

Objectives for Units 5 and 6

Unit 5: Igneous Rocks
- Understand basic criteria for identifying igneous rocks
  - Texture--what it means
  - Mineral composition
- Understand the various textural terms: granular, microgranular or aphanitic, porphyritic, glassy, pyroclastic
- Be able to identify the texture of igneous rock specimens
- Understand how mineral composition affects the classification of igneous rocks
  - -know the importance of the feldspars
  - -know what to look for in distinguishing feldspars from quartz; different feldspars from each other; quartz; the ferromagnesians from each other, particularly, biotite, hornblende, augite
- Be able to use the Bowen Reaction Series to deduce the identification of minerals which otherwise are not easy to identify
- Be able to use the charts, tables and descriptions in the manual to identify by name specimens of igneous rocks
- Know how vesicular basalt and amygdaloidal basalt forms
- Understand the following features: Xenolith, Aplite and Pegmatite, Pahoehoe lava flow, Volcanic bomb, Spherulites and lithophysae, Columnar basalt, compaction structures

Unit 6: Igneous Activity
- Distinguish between intrusive and extrusive
- Understand why lava flows are unlikely to issue out of tops of some of the large composite volcanoes.
- Know where, from a volcano, lava generally issues forth
- Know what the main problem is with the Columbia Plateau Basalts
- Understand the origin of welded tuffs and ignimbrites
  - -know what problem the tuffs share with the Plateau Basalts
  - -recognize compaction structures
- Understand the origin of a volcanic plug like Shiprock
- Know what magmatic differentiation is, some ways it can occur, and what results
- Know what a dike is
- Distinguish between a dike and a sill
- Distinguish between a batholith and a stock
- Know how a xenolith originates

Know what a shield volcano is
Know where, with respect to stocks, and batholiths, ore bodies are found

Chapter 6:
Understand the terms: plutons, concordant, discordant, tabular, sill, dike, massive, laccolith, batholith, stock, xenolith, stoping, granitization
Know the 7 main features of batholiths
Understand the Bowen Reaction Series
-discontinuous series
-continuous series
Know the order in which minerals crystallize as a magma cools
What happens when crystallization is interrupted
-fractionation
Understand how rate of cooling results in different textures
Understand and know the origin of pegmatite

Chapter 5:
Understand the terms: magma, lava, crater, caldera, fissure eruptions
Distinguish between: cinder cones, composite cones, shield volcanoes

Unit 7: Weathering
Know the difference between weathering and erosion
Know the difference between chemical and mechanical weathering
Understand which type of weathering would dominate under a specific set of climatic conditions
Be able to take any of the minerals in the Bowen Reaction Series and explain what happens to each of the elements under conditions of normal chemical weathering
-what minerals are formed
-what goes off in solutions
-what goes off as a colloid
Be able to do the same thing for lateritic weathering
Understand the relative rates at which the various minerals in the Bowen Reaction Series will weather chemically
Follow the fate of the weathered components to determine what kind of sedimentary rocks might be formed from them
Understand why potassium is so rare in the ocean as an ion compared to sodium

Unit 8: Sedimentary Rocks and Sedimentation

Understand the term stratification

Understand the distinction between clastic and chemical sediments

Be able to use your tables, and descriptions. Also determinative tables or ditto sheet with classification to identify any sedimentary rock

- -be sure to distinguish between the different kinds of limestones
- -distinguish between the different types of sandstones

Recognize these features: cross-bedding, ripple marks, mud cracks

Sediment Bottle

Understand the relationship of energy to sorting

- -relate energy to size of particle transported

Understand the relationship of energy to slope of stream and size of particle transported or deposited from mountains to sea

What size particle is deposited where?

Know the difference between a map and a cross-section showing the distribution of different kinds of sediment

Be able to interpret cross-sections and maps in terms of:

- -Distribution of energy
- -Probable directions of source rock
- -Direction of transport
- -Location of shoreline
- -Possible mountain-building or mountain-eroding activity in the source area

Understand the term cyclothem and some ideas on the origin of cyclothems

Understand what makes a mesa hold up

Understand the term geode

Reading objectives:

Chapter 7: Weathering and Soils

Understand the term weathering

Distinguish mechanical and chemical weathering

Understand the term exfoliation and spheroidal weathering

Understand how particle size, temperature, moisture, and type of mineral affects the rate of chemical weathering

Understand the chemical weathering of quartz, feldspars, and the ferromagnesians minerals

Know and be able to characterize the A, B, and C soil horizons

Understand and be able to distinguish between the terms pedocal, pedalfer, and laterite

Chapter 8: Sedimentary Rocks

- Distinguish between detrital (clastic) and chemical sediments
- Understand the term sedimentation
- Understand what is meant by: source of material, methods of transportation, processes of sedimentation
- Know what the principal sedimentary minerals are
- Distinguish between clastic and nonclastic texture
- Understand the term lithification
- Understand the processes of lithification
  - -cementation
  - -compaction and dessication
  - -crystallization
- Classification--once over lightly
- Understand the nature of bedding
  - -What is responsible for inclined bedding (cross-bedding)?
    - dunes
    - deltas
    - scour and fill
- Understand the origin of ripple marks and mud cracks
- Understand the terms: nodule, concretion, geode, fossil
- Understand the term sedimentary facies
- Understand the origin of the color in sedimentary rocks

Unit 3: Introduction to Topographic Maps

- Understand the following:
  - -symbols
  - -scales--be able to use the bar scale
  - -location
    - range and township
    - latitude and longitude
  - -magnetic declination
  - -how maps are oriented
- Understand why quadrangle maps are not square
  - -why quadrangles in northern latitudes are narrower than quadrangles nearer the equator
- Know what a contour line is
- Know what is meant by contour interval
- Be able to distinguish, on the basis of contour lines
  - -steep slopes from gentle slopes
  - -valleys, rivers, streams, creeks, gulches and gullies, using the shape of contour lines
  - -hills and ridges
  - -going uphill from going downhill
- Understand what happens to a contour line when it crosses a stream valley of some sort and how one can distinguish upstream from downstream using the shape of the contour line

Be able to locate yourself in the field by means of a topographic map
Be able to draw an accurate topographic profile (using a sharp, hard pencil)
Be able to prepare a simple contour map from elevation data

Unit 12: Work of Gravity--see reading objective sheet.

Unit 10: Work of Running Water
Be able to recognize rivers and creeks on topographic maps, even when there are no symbols indicating such --using the shape of contour lines.
Understand the concepts of ultimate and temporary baselevel
Understand why rivers don't flow into the ocean at exorbitant rates
Understand the typical shape of the long profile of a stream, know what a long profile is
Understand the terms: degradational, graded--know particularly the meaning of this term!, aggradational
Be able to recognize in the field and on a map
- -a river which is degrading
- -a graded stream
- -river which is aggrading
- -braided stream

Understand the 3 kinds of load that a river carries
Understand what can happen when the entire bed load of a river is in motion
Be able to construct an accurate long profile
Be able to recognize on a map
- -meanders
- -flood plain
- -terraces--particularly as evidence for change in base level
- -levees
- -deltas
- -alluvial fan
- -oxbow lakes
- -meander scars or scrolls
- -sandbars
- -entrenched meanders
- -rejuvenated streams

Be able to use the pocket stereoscope to recognize different types of stream valleys in the photos in your manual
BE ABLE TO DISCUSS <u>ANY</u> OF THE EXERCISES WHICH YOU HAVE BEEN ASSIGNED TO <u>DO</u>

Reading Objectives:
Chapter 10: Mass Movement of Surface Material
Understand the following concepts
- -mass movement

-clastic, plastic, fluid behavior of material
Understand the factors which influence mass movement
Understand the various types of rapid and slow mass movements

Chapter 11: Running Water
Know the runoff equation
Be able to distinguish between
-lanimar flow
-turbulent flow
-jet or shooting flow
Understand the terms
-velocity
-gradient
-discharge
Understand the nature of base level
-Be able to explain the adjustments a stream makes when base level is raised or lowered
Know the jobs that a river does
Understand the terms
-load
-capacity
-competency
-solution
-suspension
-bed load
Understand the various mechanisms by which erosion takes place
Understand the conditions under which deposition takes place
Understand the general features of valleys
-channel
-divide
-flood plain
-valley wall
Understand the role of streams and mass movement in the enlargement of valleys
Distinguish between narrow and broad valleys on the basis of features that characterize each
Distinguish between delta and alluvial fan
Understand the nature and origin of terraces
Compare the cycle of stream valley given in text and the development presented in the manual and on tape
Understand the nature and origin of entrenched meanders and rejuvenated streams

Unit 11: Reduction of Regions
Understand the following concepts as applied to regions
-new or initial
-youth
-maturity
-old age
-peneplain

Know the characteristics of each stage and be able to recognize them on a map
Be able to analyze any map in terms of its stage of regional development
Know what kind of evidence leads to the interpretation of an ancient peneplain, or surface of erosion
-Be able to recognize this on a map
Understand the concept of rejuvenation--know how rejuvenation can be recognized on a map
Understand how the relative rates of headward erosion can affect the position of a divide
Be able to analyze streams and regions from kodachrome slides
Be able to analyze streams and regions from aerial stereo photos
Be able to distinguish between the arid and humid cycles of erosion
Understand the concepts of pediment and inselberg
Know what a debris dam is

Unit 13: Miscellaneous topic on Running Water
Know what a drainage basin is and be able to outline one accurately on a map
Understand the terms--dendritic, trellis, rectangular, radial, and be able to recognize them on a map
Understand the origin of various patterns, including the combination of concentric and radial streams around Hicks Dome
Distinguish between antecedent and superposed streams in theory (origin)
-Be able to recognize the antecedent or superposed stream on a map
-You will not be asked to distinguish one from the other solely from the topography on a map in most cases--you will usually be given some other pertinent information
Know how to recognize stream capture on a map

Unit 15: Ground Water
Know the ground water equation
Know the sources of ground water
Distinguish between porosity and permeability
-Understand the kinds of spaces which are expressed as porosity
Know the terms: Zone of Aeration, Zone of Saturation, Water Table Capillary Fringe
Be able to sketch a diagram showing these features--such a diagram is usually called the ground water profile
Understand what is meant by cone of depression
Distinguish between seep and spring

Know the principles behind artisian wells and flowing wells
- -Be able to sketch a diagram showing the necessary conditions for artisian wells

Understand the concepts of confined and unconfined aquifers

Distinguish between theoretical and actual pressure surface

Understand the solution effects of ground water: caves, caverns, sinks, stalagmites, stalactites

On a map, be able to recognize: sinks, karst topography

Understand the origin of hot springs and geysers, travertine and geyserite

Know the common cementing materials carried by ground water

Understand the origin of petrified wood

BE ABLE TO DISCUSS ORALLY ANY OF THE ASSIGNED EXERCISES

Chapter 11

Understand the following concepts: relief, youth maturity, old age, peneplain, monadnock

Understand the 3 principal criticisms of erosional cycles

Understand the terms: radial, trellis, dendritic, rectangular

Understand what sorts of geologic conditions are expressed by each pattern

Understand the following concepts: consequent streams, subsequent streams, anticedent streams, superposed streams, stream capture, water, gap, wind gap

Chapter 14: Deserts

Understand the nature of pediments and what is thought concerning their origin

Be able to distinguish between humid and arid cycles of erosion

Chapter 12: Underground Water

Understand: Zone of Aeration, Zone of Saturation, Water Table

Understand the shape of the water table

Understand: Cone of Depression

Understand the nature of porosity and how it may be expressed in different materials

Understand the following concepts:
- -spring
- -aquifer--and what kind of material makes a good aquifer
- -perched water table

Understand the principles governing artesian water
- -know the relations between aquifer and capping layers--what kind of rock makes a good capping layer
- -understand: pressure surface

Understand the principles governing thermal springs and geysers

Understand the principles governing the recharge of ground water

Understand the nature and effects of groundwater solution, caves, dripstone, stalactite, stalagmite, columns, sinks, karst topography

Understand the principles governing cementation
- -What are the common cementing materials

Know the principal sources of ground water--meteoric juvenile, connate

Unit 14: Shorelines, Oceans, Deserts

Understand the nature and origin of the drift of material along the shore (long-shore currents or drifts)

Understand the following features: wave-cut terrace, sea cliff, backshore, foreshore, offshore, bars, spits

Understand the relationship between particle size and type of coast (rocky or sandy)

Understand the effect of a groin on the longshore transport of sediment

Be able to recognize on a map--uplifted wave-cut terrace

Be able to recognize on a map some kind of evidence indicating rise or lowering of sea level

Know what a guyot is

On the oceanic maps--be able to recognize: oceanic ridges, transverse fractures, trench down middle of ridge, deep trenches

Understand why some trenches are full of sediment and some are not

Understand pediment and inselberg

Distinguish between humid and arid erosion cycle

Unit 16: Valley glaciation

Understand why, on maps showing mountain glaciation, erosional features dominate over depositional, while on maps of continental glaciation, depositional features are dominant

Be able to recognize, on a map: arete, horn, col, glacial staircase, hanging valley, paternoster lakes, cirque lake, cirqui, typical glaciated valley, terminal moraine, moraine-damned lake

Understand the accumulation and movement of ice, snow to firn to ice to moving ice, snow line, nature of movement
Understand how ice erodes
Terms: crevass, bergschrund, lateral moraine, medial moraine
Know how you can determine how far down a valley a glacier has extended.
Be able to take a map on which no glaciers are either present or close by and determine whether the area has been glaciated
-Be able to recognize as many features as possible

Unit 17: Continental Glaciation
Be able to recognize on a map: ground moraine, terminal or recessional moraine, outwash plain, esker drumlin
-Understand the nature of the evidence for the glacial theory
-Know what till is

Chapter 15: Oceans and Shorelines
Know the 2 most abundant salts and most abundant gasses dissolved in the ocean
Distinguish between eustatic and tectonic changes in sea level
Know what a density current is and the 3 types, particularly the turbidity current
-graded bedding--turbidites
Understand the terms: continental shelf, continental slope, submarine canyon, seamount, guyots, ridges, rises, fracture zones, trenches
Understand how surf and long-shore drift are created
Understand the shoreline profile--offshore, shore or beach, backshore, foreshore, berm wave-dut terrace, wave-built terrace
Understand erosional and depositional features: wave cut cliff; sea caves, sea arches, stacks, spits, bay barrier, barrier island, tombolo

Chapter 14: Deserts
Distinguish, in terms of origin, between tropical and topographic deserts
Understand the deposition of loess
Understand the arid cycle of erosion and how it differs from humid cycle--pediment

Chapter 13: Glaciation
Understand the terms: glacier, snowfield, snow line, firn, glacier ice
Distinguish between valley glacier and continental glacier

Be able to sketch a diagram of a valley glacier and label--zones of accumulation, wastage, fracture and flow
Understand the terms: cirque, bergschrund, rock flour, striation, grooves
Erosional effects: Tarn, arete, col
Features of glaciated valleys: U-shape, truncated spur, rockbasins and paternoster lakes, hanging valleys, fiords
Depositional features
  Drift, stratified versus unstratified--BE ABLE TO DISTINGUISH
  Unstratified Drift--till, moraines (terminal, recessional, ground, lateral, medial), drumlins (clue to direction of ice advance)
  Stratified--outwash (kettle), eskers, kames, varves
Glacial theory: know the principal contributions of Venetz, Agassiz
What is basic proof of the glacial theory
Understand the effect of ice age on sea level and origin of pluvial lakes
Understand some of the data which a theory should explain
Know some proposed reasons for climatic change
KNOW THE GEOLOGIC TIME SCALE AS FOLLOWS

ERA	PERIOD	EPOCH
Cenozoic	Quaternary	Recent
		Pleistocene
	Tertiary	Pliocene
		Miocene
		Oligocene
		Eocene
		Paleocene
Mesozoic	Cretaceous	
	Jurassic	
	Triassic	
Paleozoic	Permian	
	Pennsylvanian	
	Mississippian	
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	

Unit 18: Folds, Faults

Understand the terms: strike, dip, anticline, syncline, monocline, plunge, axis, axial plane

Know the symbols for strike and dip of folded beds, horizontal beds, vertical beds

On a hypothetical geologic map, be able to:

-draw dip and strike symbols if ages of beds are known

-state the age relationship of beds of dip and strike are given

-draw a logical structure section at top, bottom or anywhere else on map

-draw in the axial plane and indicate direction of plunge of any fold

Understand how plunging folds produce a wrap-around pattern in terms of patterns of formations and in terms of topography

Understand why, on a map, the core of an anticline contains the oldest rocks and the core of a syncline contains the youngest rocks

Know how to use the law of superposition to construct a logical structure section

Understand the terms: fault, normal, reverse, thrust hanging wall, footwall, strike-slip fault, right lateral, left lateral

Unit 19: Metamorphism and Metamorphic Rocks

Know the agents of metamorphism

Be able to identify, using the manual, the common metamorphic rocks and minerals presented to you

Be able to take a shale--explain in detail what happens as it is metamorphosed step-by-step into--slate, then phyllite, then schist, then gneiss

Understand the distinction between the origin of a granite gneiss and the origin of a garnetiferous gneiss, shist, or phyllite

Understand the term--granitization

Understand the changes that take place in the metamorphism of

-impure limestone

-sandstone

-basalt

Chapter 16: Deformation of the Earth's Crust

Understand the terms: fold, monocline, anticline, syncline, plunge, axis, axial plane, fault, fault-block mountains, strike-slip fault, hanging wall, footwall, normal fault, joint

Understand the terms: unconformity, angular, disconformity, nonconformity

Chapter 17: Mountains and Mountain Building
- Understand the terms: orogeny, fold mountains, fault-block mountains, volcanic mountains
- Understand the term geosyncline
- Understand the nature of the rocks of a geosyncline
- Understand the nature of the deformation of a geosyncline
- Understand the kind of movement responsible for plateaus, fault-blocks mountains, and upwarped mountains
- Know what the term "isostacy" means
- Understand the essential ideas behind the three theories of mountain-building

Chapter 18: Metamorphism and Metamorphic Rocks
- Know the 3 agents of metamorphism
- Distinguish between contact and regional metamorphism
- Understand the terms referring to the textures and names of metamorphic rocks
  - For gneiss--be sure you stay with the definition given on the tape in terms of characteristic minerals
- Understand what types of metamorphic rocks are produced from the different igneous and sedimentary rocks
- Know what is meant by the term "metamorphic facies"
- Understand what is meant by the term "granitization"

Unit 20: Unconformities
- Understand what an unconformity is
- Be able to distinguish between the 3 kinds of unconformities
- Be able to recognize each kind on a cross-section diagram
- Be able to explain the history involved in the formation of any of the types of unconformities
- Know what the four rules are for interpreting unconformities and be able to apply them in interpreting any cross-section diagram
  - -Practice on the ones in manuals and worksheets
- Understand the principle of cross-cutting relationships and how to apply it to any problem where cross-cutting is involved (dikes, batholiths, faults, etc.)

Unit 21: Economic Metallic and Non-metallic Resources
- Be able to identify the minerals you have had presented which serve as metallic or non-metallic ore minerals
- Know what is in them, and what they are used for
- Understand the principles behind the occurrence of oil

Know something about the geographic distribution of some of the most important minerals and fuels

Chapter 16
- Know the definition of unconformity
- Distinguish between the three major types of unconformities

Chapter 22: Our Earth's Resources
- Understand the terms: metals, nonmetals, ore deposits, flotation
- Concentration by igneous activity--understand
  - -concentration by early or late crystallization of a magma
  - -concentration by hydrothermal solutions
  - -concentration by metasomatism
  - -concentration by weathering
  - -understand the three important processes
- Concentration by sedimentary processes
  - -understand placer deposit
- Cencentration by rock formation
- Be able to cite one example of an important metal or nonmetal concentrated by each of the above methods
- Know what is meant by fossil fuel
- Understand the nature and origin of coal
- Understand the nature of oil
- Understand what is meant by source bed
- Know the three conditions necessary for the formation of an oil deposit
- Understand the "gravitational theory" of oil movement
  - -understand under what conditions oil might accumulate in a syncline
- Know what is meant by--stratigraphic trap
- Be able to show the distribution of gas, oil and water in the following types of traps: anticline, fault, unconformity, stratigraphic (reef, others)

Unit 22: Earthquakes and the Location of Epicenter by Mercalli Scale
- Understand the terms: elastic rebound, focus, epicenter
- Be able to plot epicenter using Mercalli Scale
- Understand the relationship between earthquakes and faults

Unit 23: Earthquakes and the Structure of the Earth's Interior
- Understand the distinction between primary, secondary, and longitudinal (surface) waves
- Understand what materials will or will not transmit the various types of waves

Understand the models of the Earth's interior
Distinguish between sial and sima
Distinguish between the mantle and the core in terms of their effects on earthquake waves
Be able to, on a model of the earth, trace the paths of various kinds of earthquake waves from the focus to various parts of the earth's surface

Chapter 19
Understand the terms: seismic sea wave, tsunami
Understand the immediate cause of earthquakes
Understand the terms: elastic rebound, focus, epicenter, magnitude
Understand in general the geographic distribution of earthquakes

Chapter 20
Understand the term seismograph
Distinguish between body waves and surface waves
Distinguish between shake waves and push-pull waves
Distinguish between the behavior of the various waves at less than, and more than, 7,000 miles
Understand the terms: crust, mantle, core, discontinuity, Mohorovicic discontinuity--Moho, sialic, simatic, intermediate crust, andesite line
Understand the nature and behavior of the mantle and core

Chapter 21
Understand the terms: magnetic poles, magnetic dip
Understand the term remanent magnetism
-how igneous and sedimentary rocks acquire remanent magnetism
Understand the essence of Wegener idea
Be aware of some of the evidence
Fit of continents
paleomagnetism
ancient climates--glaciation
distribution of terrestrial plants and animals
Understand some alternative explanations of some of the evidence

Principia College
Elsah, Illinois
Geology 112

Objectives for Units 1, 2, 3, 4, and 6

Unit 1: Review of Sedimentary Rocks
Be able to identify any sedimentary rock

Unit 2: The Role of Fossils in the Establishment of the Eras
Understand the rationale of Sedgewick and Phillips and their use of fossile in arriving at the names
Know the Wernerian Subdivisions, the principle they were based upon and the rocks included in each

Unit 3: Introduction to fossils--Trilobites, Brachiopods, and Bryozoans
Be able to recognize a typical representative of each of these on sight
Be able to use your manual to identify specimens

Unit 4: Introduction to Geologic Maps
Understand the following:
- -what a map is and what it shows
- -how and why maps are made--academic and economic reasons
- -how formations are represented
- -how contacts are shown--different types of contacts
- -how faults are shown
- -what structure sections are supposed to show

Be able to interpret map patterns and recognize them
- -dendritic
- -banded--be able to use the rule of V's
- -concentric circular or elliptical
- -distinguish anticlines and synclines

Understand the relationship of folding and erosion to patterns

Unit 6: Unconformities
Know the two main elements in the concept of an unconformity
Be able to recognize the three main types of unconformities
- -know that criteria for recognizing each type on a map

Be able to interpret any unconformity for the sequence of events that produced it.
- -know the 4 rules for interpretation
- -be able to locate unconformities
- -apply the rules to each type of unconformity

Unit 5

Protozoans

- Be able to recognize a small foram, and a fusulinid

Sponges

- Be able to recognize spicule network
- Be able to recognize Receptaculites

Coelenterates

- Be able to identify: tabulae, septa
- Be able to recognize a Tetracoral (you don't have to worry about hexacorals)
- Be able to recognize: honeycomb coral chain, "spaghetti coral"

Distinguish colonial from solitary corals

Echinoderms

- Be able to distinguish cystoids, crinoids, blastoids
- Understand the terms: calyx, stalk, columnals
- Recognize crinoids stems
- Distinguish between regular and irregular echinoids
- Be able to recognize: echinoids spines, echinoid plates with tubercles
- Understand the terms petaloids, food grooves
- Recognize sand dollars and heart urchins

Unit 7

Know names and locations of major structural features of the Midwest--eight of them

Be able to point out on a map of Missouri, Illionis and of the Cincinnati Arch area--the major unconformities common to the three areas

Understand what a "subcrop" map is and how it may be interpreted (same as paleogeologic map)

Know what an unconformity-bounded sequence is

Know the four major unconformity-bounded sequences in the Paleozoic strata of the central U.S. and age range of each. Know where (in the Paleozoic) the major unconformities are

Unit 9

Acquaint you with a means for representing data from a stratigraphic section

Give you information on the local section which you will be asked to KNOW!

Acquaint you with some of the broad features of the Geologic History of the Midwest (Audiscan cartridge)

Historical Geology

Reading Objectives for Units 5, 7, and 9

Know what Achaeocyathids are

Know what carpoids are

- Understand the terms: craton, epeiric, epicontinental
- Know the Principle Tectonic Divisions of the Carton
  - Canadian Shield
- Arches and Basins
  - Understand the three types of arches
  - Know what an Isopach map is--how it may be interpreted
  - Know how distribution of rock types may be interpreted
- Early Paleozoic Basins and Arches
  - Transcontinental Arch
- Stratigraphic Divisions of Cratonic Rocks
  - Understand the basis for U.B. sequences
    - Theoretical
    - Physical
  - Understand the fate of the transgressive and regressive parts of the sequences
  - Understand why time span of a sequence may be different in different areas

Unit 8: Molluscs and Graptolites

- Be able to recognize a representative of
  - pelecypods
  - grastropods
  - cephalopods
    - nautioloids
    - goniatite ammonite
    - ceratite ammonite
    - ammonite ammonite
    - belemnite
- Understand the following terms
  - Pelecypods
    - hingeline, tooth and socket, pallial line and pallial sinus, mantle, siphon, ribs and growth line
  - Gastropods
    - whorl, siphonal canal, umbilicus
  - Cephalopods
    - septa, living chamber, siphon and siphuncle, suture, lobes, saddles, various suture patterns, orthoconic, cyrtonconic, gyroconic evolute, convolute, involute
  - Graptolites-stipes, thecae

Unit 10-A: Geologic History of the Midwest: Sauk and Tippecanoe

- Understand the term craton
- Know what the outstanding feature of the sauk and Tippecanoe sequences are.
- Understand the conditions leading up to the deposition of the basal sandstones of the sauk sequence
  - Be able to tie this in with the kind of sandstone deposited

Understand how the term facies is used
Be able to interpret a facies diagram in terms of
- -direction of source area
- -direction of marine transgression or regression

Understand how cross-bedding can be used to interpret prevailing current direction
Understand the different factors that identify maturity
- Know what some of the ideas are for the origin of a mature sandstone

Understand the environmental factors which produce a dark shale
Concerning patch reefs:
- Understand the interrelationships between these aspects of reefs:
  1. Distribution of the various reef parts
  2. Distribution of the various types of rocks and fossils in an ancient reef
  3. Distribution of various combinations of environmental factors

Be able to analyze one of these aspects for which information is given (as on a map) and deduce the nature of the other two
Understand the conditions necessary for the formation of evaporites and the mechanism involved
- Be able to diagram these conditions

Know the order in which salts evaporate
Understand the interrelationships between
1. The distribution of sills and entrances to a basin
2. The distribution of salinities
3. The distribution of various types of salts

Unit 11: Upper Paleozoic of the Local Section
Be able to identify ON SIGHT
- -guide fossils for each formation of the Upper Paleozoic where they are present
- -kind of rock typical of that formation

Be able to identify the formation from which a diagnostic combination of rocks and/or fossils occur
When a particular group is not diagnostic, be able to give the names of several formations which could have that particular rock type or fossil
Understand which major groups of fossils seem to characterize Upper Paleozoic strata as a whole

Reading Objectives

Understand some of the problems involved with recognizing the base of the Cambrian
Understand the ways in which source for sand may be interpreted

Understand the nature of the evidence by which a marine transgression is interpreted
Understand the terms multicycle, immature, mature, supermature
What different explanations have been offered for the uniformity of lithology and fauna of late Ordivician deposits
Understand the term Paraconformity
Understand the term framebuilder
-know what types of organisms make good frame-builders
Understand why reefs are economically significant
Understand the mechanism suggested in the formation of evaporite deposits
Understand the facies relationships involved with evaporite basins
Get an idea of the kinds of organisms plant and animal, present during the Upper Paleozoic

Unit 17: Arthropods, Chordates, Plants
Distinguish shell crushing teeth from flesh shearing teeth
Recognize a fossil fish
Be able to recognize: lycopsid, sphenopsid, fern, gymnosperm (conifers), and angiosperm

Unit 15: Sedimentary Tectonics
Distinguish between the factors influencing sedimentation in the central United States and the factors influencing sedimentation in the Appalachians
Understand the term tectonics
Understand the use of the term surf zone
Understand the two tectonic factors which influence the nature of sedimentation: sediment supply, basin subsidence
Be able to relate type of sediment to various combinations of the different factors and the depositional site (shoreline, offshore, etc.)
Understand the terms: turbidity, graded bedding, graded greywacke
Be able to interpret facies relationships under conditions of mountain building in terms of
-environment of deposition
-types of sediment
-tectonic factors
-migration of facies

Unit 16: Geologic History of the Appalachians

- Understand, by way of review, the distinction between the rocks of the New England, Blue Ridge and Piedmont Provinces on the one hand and the Appalachian Plateau, Central and Southern Appalachian provinces on the other hand
- Relate these types of rocks to the tectonic factors involved in their sedimentation
- Understand the term geosyncline
  - What Hall and Dana applied it to
  - What is meant by eugeosyncline and miogeosyncline
  - What the terms craton, marginal basin and geosyncline will be applied to in this course
- Know the names and dates of the major orogenies
- Know what characterizes the history between the major orogenies
- Know the main depositional and structural effects of the
  - -taconic orogeny
  - -Acadian orogeny
  - -Appalachian orogeny
- Know the effect of each orogeny on the
  - -geosyncline
  - -marginal basins
- Know the two major ideas on when the thrusting and folding took place in the central and southern Appalachians
- BE ABLE TO DISCUSS ANY OF THE ASSIGNED EXERCISES

Unit 21: Stratigraphic Data and Synthesis

- Acquire some skill in making and interpreting facies diagrams
- Draw logical facies boundaries
- Bring together some of the principles previously presented on sedimentation and sedimentary tectonics

Unit 18: Steep Faults; Igneous Rocks

- Distinguish on a map steep faults from thrust faults
- Be able to use formation contacts and contour lines to determine amount of displacement
- Be able to distinguish upthrown and downthrown sides of a fault using
  - -symbols
  - -age of formation on either side
- Be able to distinguish, using map pattern, discordant and concordant bodies
- Be able to distinguish dikes, stocks, sills, batholiths and lava flows, using map pattern age

Unit 19: Provinces of the Western United States

- Be able to locate provinces and subprovinces
- Be able to distinguish, geologically, between any pair of provinces of subprovinces

Unit 20: Paleozoic History of the Western United States

- Know the distribution of tectonic elements, and the kind of sediments present in each
- Understand the structural and stratigraphic effects of the Antler orogeny
- Be able to compare the effects of the Antler Orogeny with the effects of the Taconic and Acadian Orogenies
- Understand the effect of the Transcontinental Arch on sedimentation during the Paleozoic
- On an outline map be able to locate the principal tectonic elements in the four-corners area during the Pennsylvania and Permian
- Understand the nature of the sedimentation in the basins during the Pennsylvanian and what changes took place in the Permian
- Understand the conditions resulting in the economic accumulation of petroleum
- Understand the relationship of the Permian History to the monuments of Monument Valley and the Garden of the Gods and the Rockies
- Understand the paleogeographic picture at the end of the Paleozoic
- Understand the effects of the Sonoma Orogeny

Unit 22

- Be able to recognize maps on which the paleogeography of the following features is shown: Moenkopi alluvial plains and Thaynes seaway, Chinle Alluvial Plains
- Understand the noteworthy features of the Chinle formation and their significance.
- Understand the basic nature and significance of the Navajo-Nugget sandstone.
- Understand the changes which took place in the paleogeographic and lectonic elements from the Absaroka to the Zuni sequences.
- Know the names of the Zuni elements, where they are located relative to each other and how Zuni sedimentation is affected
- Be able to recognize maps showing the paleogeography of the Sundance seaway, Morrison alluvial plains, Cretaceous seaway, Latest Cretaceous and earliest Tertiary alluvial plains
- Understand the noteworthy features of the Morrison formation and their significance

Be able to distinguish between the location and extent of the Thaynes seaway, Sundance seaway, Cretaceous seaway
Understand the paleogeographic picture at the end of the Mesozoic

Unit 26: Plistocene
Understand the lines of evidence leading to interpretation of climate fluctuation during the Cenozoic and during the Pleistocene
Understand the relationship between snowline and the initiation of an ice cap
Understand the 2 factors involved in perpetuating an ice cap
Distinguish between the eastern and western ice caps in terms of mode of growth
Understand the distribution and nature of the pluvial lakes
- -Understand the two hypotheses relating to their origin

Distinguish between "stratified" and "unstratified" drift in terms of their nature and depositional agent
Understand the different types of inter-glacial deposits--peat, varved clay, loess
Understand the profile of a weathered till
Understand 2 lines of evidence for multiple glaciation
Understand the following features associated with deglaciation
- -proglacial lakes--Agassiz, great lakes (understand evolution)
- -underfit streams
- -origin of the channeled scablands-coulees, Glacial Lake Missoula
- -effect of fluctuating sea level on topography--land bridges, animal migrations, sea cliff, terraces
- -isostatic rebound--raising and tilting of shorelines
  be able to illustrate "hingeline"

Understand some of the postulated cases for
- -decrease in temperature
- -increase in precipitation

Be able to discuss our present status

Unit 27: Geosynclinal Theory
Understand and be able to discuss the series of diagrams presented

Understand what is meant by
- -geosynclinal phase
- -consolidation phase
- -post orogenic phase

Be able to list the types of activity characteristic of each phase

Understand some of the hypothesized causes for the initial downbuckling

Understand the sedimentational history of the geosynclinal phase and the term "geosynclinal cannibalism"

Understand the evidence behind the description whether vertical or horizontal movements were primary

Be able to distinguish between the two types of batholiths in terms of their origin and characteristics

Understand the concepts "isostacy" and "isostatic adjustments"

Understand the various ways in which isostatic adjustment expresses itself during the post orogenic phase of the geosynclinal cycle

Know something about the tectonic make-up of North America

Distinguish between the history of the platform and the history of the Canadian Shield

Distinguish between the history of the platform and history of the marginal basins

Be able to take any of the events which you have encountered in past units as having taken place in the Appalachian Geosyncline or the Cordilleran Geosyncline, and place them in some phase of the geosynclinal cycle (be sure you review the worksheets from previous units)

Unit 28: Polar Wandering and Continental Drift

Know the two opposing hypotheses concerning the relationship of the continents and ocean basins

Be able to list, and briefly explain, each of the various lines of evidence in favoring continental drift--8 of them

Understand the convection current hypothesis as it is related to: mountain building, seafloor spreading, continental drift

Understand the evidence for seafloor spreading
1. age of volcanics
2. reversal of earth's magnetic field

Understand the nature of the "expanding earth" hypothesis and some of the evidence supporting it

State University College
Buffalo, New York
Science 103

Unit 1--Minerals

Objectives:

1. To recognize the basic differences between rocks and minerals
2. To develop an understanding of the physical and chemical properties of minerals
3. To learn how to use mineral identification keys or tables.

Unit 2--Rocks

Objectives:

1. To become acquainted with Petrology, the scientific study of rocks.
2. To become familiar with the characteristics of the three main groups--igneous, sedimentary, and metamorphic rocks.
3. To establish a relationship among the three groups through the Rock Cycle.
4. To learn how rock identification keys are used in the identification of unknown rocks.

Unit 3--Diastrophism

Objectives:

1. To understand the nature, causes, and evidences related to diastrophism.
2. To learn the origins of the various types of mountains.

Unit 4--Geologic Time

Objectives:

1. To understand the differences between "relative" time and "absolute" time and the importance of each.
2. To understand the laws of: superposition, faunal succession, and cross-cutting.
3. To note the importance of index fossils.

Unit 5--Seismology

Objectives:

1. To understand the causes and effects of earthquakes.
2. To learn how earthquakes are recorded and why this scientific study has reduced casualties in recent earthquakes.
3. To understand how the knowledge of wave motion as recorded in seismograph stations reveal information about the nature of the interior of the earth.

Unit 6--Weathering and Erosion

Objectives:

1. To understand the causes and effects of weathering and erosion.
2. To note the relationship with climate.
3. To understand the significance of the erosion and hydrologic cycles.

Unit 7--Topographic Maps

Objectives:

1. To become acquainted with the terms, maps, charts, and projections.
2. To learn the elements of a topographic map.
3. To understand how contour lines on topographic maps show ground relief.
4. To learn how cross-sections are made and how they help in the study of topography.
5. To become acquainted with the standard land division system used in the United States.
6. To interpret geologic processes from topographic maps.

APPENDIX C

STATISTICAL DATA

TABLE 1.--Derivation of score value--Lansing Community College.

1	2	3	4	5	6	7	8	9
		Number of Objectives of Value					Points/ Unit	Score Value
Unit No.	Number of Objectives	4 Points	3 Points	2 Points	1 Point	0 Points	(Sum Cols. 3-7)	(Col. 8/ Col. 2)
I	6	0	0	1	5	0	7	1.2
II	9	0	0	0	9	0	9	1.0
III	8	0	0	3	5	0	11	1.4
IV	11	0	0	2	9	0	13	1.2
V	10	0	0	1	9	0	11	1.1
5	Total number of units Lansing Community College					Total accumulated score value		5.9

TABLE 2.--Calculations--Lansing Community College.

Total possible unit score value = total number of units x total possible points per objective

$$= 5 \times 4 = 20$$

$$\text{Average level of objective development} = \frac{\text{total accumulated score value}}{\text{number of units}}$$

$$= \frac{5.9}{5} = 1.18$$

$$\text{Rank Value} = \frac{\text{total accumulated score value}}{\text{total possible unit score value}} \times 100$$

$$= \frac{5.9}{20} \times 100 = 30\%$$

TABLE 3.--Derivation of score value--University of Michigan.

1	2	3	4	5	6	7	8	9
Unit No.	Number of Objectives	Number of Objectives of Value					Points/ Unit	Score Value
		4 Points	3 Points	2 Points	1 Point	0 Points	(Sum Cols. 3-7)	(Col. 8/ Col. 2)
1	3	0	0	1	2	0	4	1.3
2	3	0	0	1	2	0	4	1.3
3	3	0	1	0	2	0	5	1.7
4	4	0	0	0	4	0	4	1.0
5	2	0	0	0	3	0	2	1.0
6	3	0	0	0	3	0	3	1.0
7	3	0	1	1	1	0	6	2.0
8	2	0	0	0	2	0	2	1.0
9	2	0	0	0	2	0	2	1.0
10	5	0	1	3	3	0	9	1.8
11	3	0	0	2	1	0	5	1.7
11	Total number of units University of Michigan						Total accumulated score value	14.8

TABLE 4.--Calculations--University of Michigan.

Total possible unit score value = total number of units x total possible points per objective

$$= 11 \times 4 = 44$$

$$\text{Average level of objective development} = \frac{\text{total accumulated score value}}{\text{number of units}}$$

$$= \frac{14.8}{11} = 1.35$$

$$\text{Rank Value} = \frac{\text{total accumulated score value}}{\text{total possible unit score value}} \times 100$$

$$= \frac{14.8}{44} \times 100 = 34\%$$

TABLE 5.--Derivation of score value--Ohio State University.

1	2	3	4	5	6	7	8	9
Unit No.	Number of Objectives	Number of Objectives of Value					Points/ Unit	Score Value
		4 Points	3 Points	2 Points	1 Point	0 Points	(Sum Cols. 3-7)	(Col.8/ Col. 2)
1	4	0	0	1	3	0	5	1.3
2	5	0	0	3	2	0	8	1.6
3	3	0	0	0	3	0	3	1.0
4	4	0	0	1	3	0	5	1.6
5	2	0	0	2	0	0	4	2.0
6	1	0	0	0	1	0	1	1.0
7	2	0	0	0	2	0	2	1.0
8	2	0	0	0	2	0	2	1.0
9	2	0	0	0	2	0	2	1.0
9	Total number of units Ohio State University						Total accumulated score value	11.5

TABLE 6.--Calculations--Ohio State University.

Total possible unit score value = total number of units x total possible points per objective

$$= 9 \times 4 = 36$$

$$\text{Average level of objective development} = \frac{\text{total accumulated score value}}{\text{number of units}}$$

$$= \frac{11.5}{9} = 1.28$$

$$\text{Rank Value} = \frac{\text{total accumulated score value}}{\text{total possible unit score value}} \times 100$$

$$= \frac{11.5}{36} \times 100 = 32\%$$

TABLE 7.--Derivation of score value--Principia College, Physical Geology.

1	2	3	4	5	6	7	8	9
Unit No.	Number of Objectives	Number of Objectives of Value					Points/ Unit	Score Value
		4 Points	3 Points	2 Points	1 Point	0 Points	(Sum Cols. 3-7)	(Col. 8/ Col. 2)
1	38	0	0	10	28	0	48	1.3
2	36	0	0	11	25	0	47	1.3
3	44	0	3	9	32	0	59	1.3
4	41	0	6	9	26	0	66	1.6
5	57	0	1	11	45	0	70	1.2
6	43	0	7	5	31	0	62	1.4
7	32	0	4	3	25	0	43	1.3
8	39	0	1	13	25	0	54	1.4
9	27	0	0	7	20	0	34	1.3
9	Total number of units Principia College--Physical Geology						Total accumulated score value	12.1

TABLE 8.--Calculations--Principia College, Physical Geology.

$$\text{Total possible unit score value} = \text{total number of units} \times \text{total possible points per objective}$$

$$= 9 \times 4 = 36$$

$$\text{Average level of objective development} = \frac{\text{total accumulated score value}}{\text{number of units}}$$

$$= \frac{12.1}{9} = 1.34$$

$$\text{Rank Value} = \frac{\text{total accumulated score value}}{\text{total possible unit score value}} \times 100$$

$$= \frac{12.1}{36} \times 100 = 34\%$$

TABLE 9.--Derivation of score value--Principia College, Historical Geology.

1	2	3	4	5	6	7	8	9
Unit No.	Number of Objectives	Number of Objectives of Value					Points/ Unit	Score Value
		4 Points	3 Points	2 Points	1 Point	0 Points	(Sum Cols. 3-7)	(Col. 8/ Col. 2)
1	20	0	0	8	21	0	28	1.4
2	38	0	0	15	23	0	53	1.4
3	48	0	2	14	32	0	66	1.4
4	Did not receive objectives for this week							
5	31	0	0	11	20	0	43	1.4
6	11	0	0	10	1	0	21	1.9
7	24	0	0	9	15	0	33	1.4
8	Did not receive objectives for this week							
9	34	0	1	7	26	0	43	1.3
7	Total number of units Principia College--Historical Geology						Total accumulated score value	10.2

TABLE 10.--Calculations--Principia College, Historical Geology.

Total possible unit score value = total number of units x total possible points per objective

$$= 7 \times 4 = 28$$

$$\text{Average level of objective development} = \frac{\text{total accumulated score value}}{\text{number of units}}$$

$$= \frac{10.2}{7} = 1.46$$

$$\text{Rank Value} = \frac{\text{total accumulated score value}}{\text{total possible unit score value}} \times 100$$

$$= \frac{10.2}{28} \times 100 = 36\%$$

TABLE 11.--Derivation of score value--State University College at Buffalo.

1	2	3	4	5	6	7	8	9
Unit No.	Number of Objectives	Number of Objectives of Value					Points/ Unit	Score Value
		4 Points	3 Points	2 Points	1 Point	0 Points	(Sum Cols. 3-7)	(Col. 8/ Col. 2)
I	3	0	0	1	3	0	4	1.3
II	4	0	0	1	3	0	5	1.3
III	2	0	0	0	2	0	2	1.0
IV	3	0	0	0	3	0	3	1.0
V	3	0	0	0	3	0	3	1.0
VI	3	0	0	0	3	0	3	1.0
VII	6	0	0	0	6	0	6	1.0
7	Total number of units State University College at Buffalo					Total accumulated score value		7.6

TABLE 12.--Calculations--State University College at Buffalo.

Total possible unit score value = total number of units x total possible points per objective

$$= 7 \times 4 = 28$$

$$\text{Average level of objective development} = \frac{\text{total accumulated score value}}{\text{number of units}}$$

$$= \frac{7.6}{7} = 1.09$$

$$\text{Rank Value} = \frac{\text{total accumulated score value}}{\text{total possible unit score value}} \times 100$$

$$= \frac{7.6}{28} \times 100 = 27\%$$

TABLE 13.--Derivation of score value--Purdue University (one week of Postlethwait's course).

1	2	3	4	5	6	7	8	9
Unit No.	Number of Objectives	Number of Objectives of Value					Points/ Unit	Score Value
		4 Points	3 Points	2 Points	1 Point	0 Points	(Sum Cols. 3-7)	(Col. 8/ Col. 2)
1	15	1	12	2	0	0	44	2.94
1	Total number of units Purdue University (Objectives for one week)						Total accumulated score value	2.94

TABLE 14.--Calculations--Purdue University (one week of Postlethwait's course).

$$\text{Total possible unit score value} = \text{total number of units} \times \text{total possible points per objective}$$

$$= 1 \times 4 = 4$$

$$\text{Average level of objective development} = \frac{\text{total accumulated score value}}{\text{number of units}}$$

$$= \frac{2.94}{1} = 2.94$$

$$\text{Rank Value} = \frac{\text{total accumulated score value}}{\text{total possible unit score value}} \times 100$$

$$= \frac{2.94}{4} \times 100 = 74\%$$