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EVALUATION OF AN AUDIO-VISUAL TUTORIAL
LABORATORY SERVING COLLEGE-LEVEL
INTRODUCTORY GEOLOGY

DISSERTATION

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

By

John Andrew Maccini, B.A., M.A.

* * * * * * * * * *

The Ohio State University
1969

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CHAPTER I

INTRODUCTION

Problems Associated with Introductory Geology

Since the rise of various national curriculum groups in the past decade, there have been many reforms and innovations in mathematics and science presented at elementary, junior-high and senior-high levels. At the same time, geology departments began to contemplate the successes of these programs and the possible effects they might have on students destined to enter college, especially in terms of elementary geology courses. In some cases, experience gained by college personnel at writers' conferences provided the necessary spark for concern toward introductory courses as well as insight suggesting possible improvements.

For instance, introductory geology courses have a long history of being classification-type, fact-oriented and descriptive. It is a disturbing fact that even in this day of enlightenment one finds students being forced many times to resort to a variety of mnemonic devices in order to be able to deal successfully with physical and/or historical geology courses. Even if facts are mastered, little concern is usually


given to the context in which they might be useful. Yet there is sufficient evidence that many geology departments are concerned enough to direct attention to the problem. The age-old questions of curriculum-planning (Who? What? How? Why?) may not yet be answerable in detail; however, the literature concerned with geologic education over the past few years clearly indicates a movement to deal with such questions.

With regard to who is being taught, geology departments have long been concerned with serving the needs of two groups: 1) future professional geologists, and 2) non-geology majors composed mainly of such students as those in liberal arts, future engineers, teachers, and economists. Obviously, one type of course serving as an introduction to geology can hardly serve both groups effectively. However, courses are often tried this way and usually fail.

In the case of training future geologists, most departments are able to meet the challenge well. After all, one can expect a certain amount of agreement among successful geologists as to what constitutes a good grounding in essentials for the discipline, and the introductory course simply initiates the total program. For example, 200 geologists were polled as to such essentials for a total undergraduate program and they unanimously agreed on the following:³

Table 1
Suggested Courses and Credit Hours in Preparation
For Geology Majors*

<table>
<thead>
<tr>
<th>Geology Course</th>
<th>Qtr. Hrs.</th>
<th>Related Subject</th>
<th>Qtr. Hrs.</th>
</tr>
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<tr>
<td>Physical Geology</td>
<td>5</td>
<td>General Chemistry</td>
<td>13</td>
</tr>
<tr>
<td>Historical Geology</td>
<td>5</td>
<td>General Physics</td>
<td>16</td>
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<tr>
<td>Mineralogy</td>
<td>5</td>
<td>College Mathematics</td>
<td>15</td>
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<td>Field Geology</td>
<td>9</td>
<td>English Composition</td>
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<tr>
<td>Structural Geology</td>
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<td></td>
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*adapted from McMannis

All that remains, therefore, is to design an introductory course that is well-grounded in fundamentals derived from the courses next in sequence and to be certain that it is rigorous, well-staffed, and replete with materials and equipment.

On the other hand, many of these same departments are forced to deal with an overwhelmingly large number of students who have no intentions of becoming geologists or scientists of any sort. And to complicate matters further, their numbers are increasing steadily. A summary of seven years of enrollment data supplied by 300 colleges in the United States and Canada concerning the number of students who are studying geology for non-career reasons illustrates this point. The figures cited herein represent students registered in the United States alone and do not include what must be a substantial number enrolled in junior-college programs.

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Table 2

Growth in Enrollment in Elementary Geology - 1960-67

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Students</th>
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<tbody>
<tr>
<td>1960</td>
<td>52,683</td>
</tr>
<tr>
<td>1964</td>
<td>77,445</td>
</tr>
<tr>
<td>1967</td>
<td>108,816</td>
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These figures clearly show that the number of students enrolled in introductory geology has more than doubled in the period 1960 to 1967. Although this increase is at least partly attributable to the growth of college enrollments in general, it is quite possible that marked interest and enrollment in high-school earth science programs during the past few years has been a factor.

As pointed out earlier, it is evident that rigorous courses designed for future geology majors can hardly satisfy large numbers of liberal arts students having varied interests and backgrounds. Yet, in many cases the "Procrustean Bed" approach sought conformity at any cost. As a result, some institutions chose to offer watered-down versions of rigorous courses initially developed for geology majors, with difficult concepts being replaced or simplified to emphasize the cultural aspects of geology. The course cannot be so difficult as to completely discourage enrollment. Further, departments are acutely aware of their responsibility to educate the layman and future teachers. The results have been predictable.
Students often elect introductory geology under the misconception that the course is a "lesser evil" necessary to fulfill science requirements. Some students have indicated to the investigator that higher grades may be gained by the few majors in the course; however, with a respectable amount of application one need not fear failure as much as in other sciences.

To raise the level of the course, the faculty may respond by increasing the tempo without changing the tune - obtain a more dynamic lecturer; show plenty of slides; set up longer "arm-waving" trips; spend a little more time showing students how to key-out rocks, minerals and fossils. Small matter that students would never experience the joy of unfolding events in earth history themselves; introductory geology simply had to fill their minds with facts and ideas gained by the profession. In some magic way it was believed that students would come to realize and appreciate the worth of geology. Many students did not come to such a realization and during the early 1960's questions were raised to this effect.

In 1962, Gatewood asked geology departments to reconsider their old notions as to what it takes to create a good geologist; further, he warned that better-educated students supplied from high schools would eventually constitute a bored majority faced with duplication of information presented in college.  

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Another writer of that period insisted that most traditionally-oriented introductory geology courses were inadequate due to heavy emphasis on classificatory aspects of paleontology, rocks, and minerals and too much concern for details of events; introductory courses should be problem-oriented and concerned with the processes of science within the context of geology. Further, it is indicated that subject matter should be treated in depth rather than covering the field.\footnote{William Hambleton, "The Status of Undergraduate Geological Education, Part B," \textit{Geotimes}, VIII (January - February, 1964), pp. 1-13.}

In summary, criticism of introductory geology deals with the following points:

1. Too few departments have clearly defined for themselves just what the goals for introductory geology are and by what means these may be attained.
2. The descriptive approach has long been over-emphasized. Geology has been presented as a purely taxonomic science rather than as an application of principles, concepts, and techniques to geologic problems.
3. Obsolete traditional approaches have become ingrained, giving rise to substantial redundancy in content.
4. Stimulating, thought-provoking, relevant exercises for field and innovative laboratory programs have not been developed for most courses.

In answer to the above charges, many institutions have been producing courses designed to meet challenges imposed by new developments in
learning and curriculum theory. Several innovations are in effect today.  

For example, Natural Sciences 10 (Harvard University) utilizes a "topical approach" emphasizing application of biological, chemical and physical concepts to study of the earth; these topics do not attempt to review the field but are dealt with in considerable depth. The course objective is "to expose each student to currently significant problems and ideas in earth science and give him an overall view of the inter-relationships that exist in the earth's structure." The traditional laboratory program has been replaced by a series of field trips. Ninety-eight per cent of the students are not interested in becoming geology majors; 80% are fulfilling a science requirement.

Somewhat similar is the core-course given at Williams College. There it is postulated that the student gains a better knowledge of the earth through studying its major environments and how they were formed. The record of stratigraphy is used as evidence showing how present-day processes are useful in interpreting environments of the past. For example, the field of chemistry contributes to the student's knowledge of formation of evaporites; biology aids in understanding self-development; and physics is vital to studying wave action or turbidity currents. All such concepts are closely related to marine or non-marine environments, which are recorded in the rock record during the Paleozoic Era. Almost all of the students are enrolled in Liberal Arts.

\[^{7}Thomas\ \text{E.}\ \text{Hendrix}\ \text{and}\ \text{William}\ \text{T.}\ \text{Fox},\ "\text{Experimental\ Approaches\ to\ the\ Introductory\ Geology\ Course},"\ \text{Journal\ of\ Geology\ Education,}\ XIII\ (\text{December,}\ 1965),\ \text{pp.}\ 137-142.\]

\[^{8}\text{Ibid.},\ p.\ 140.\]
At Indiana University, 65% of the introductory geology students are also from Liberal Arts; fully 20% are education majors. The structure of the course is based on the rock cycle and cycles of orogenesis. Major themes are: Uniformitarianism, Geologic Time, Dynamic Equilibrium of Physical-Biological Systems, and Energy and Evaluation of Biological-Physical Things.

The University of Michigan has adopted a "case-histories" approach with a major objective to "show how a geologist goes about solving a scientific problem." To reinforce this objective, the student is required to submit a field or lab-based research paper at the conclusion of the course. Ninety percent of the students are in Liberal Arts; 5% are in education.

Prior to 1966, Kent State University offered a historical geology course that consisted of "a potpourri of facts, concepts and techniques." As a result, students did not seem to be able to grasp relationships and felt they were buried in unrelated and non-relevant minutiae. Presently the program has students working on a set of integrated exercises based on interpretation of two geological models installed in the laboratory. These models permit the student himself to determine ages of beds using fossils, interpret depositional history, decipher structural history and ultimately produce his own topographic-geologic map from raw data.

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9 Ibid., p. 140.

During academic year 1967-68, the 400 students taking the course "overwhelmingly favor it," indicating satisfaction with the problem-solving approach. From a teaching point of view, the authors of the laboratory claim that students gained a greater understanding of geologic reasoning and laboratory instruction was much more uniform than in the past.

Perhaps one of the more unusual approaches to introductory geology is now being worked out by O.T. Hayward at Baylor University. No course outline is necessary, the problem involves independent study. On the premise that in order to learn geology one must DO geology, students are engaged in research of their own choosing. Majors and non-majors alike are presented with three questions that must be answered in six weeks:

1. Having selected a rock specimen, tell all you can about it. What is it? What does it mean? What are implications and ramifications attendant upon its existence?

2. Having selected a topographic map (from a collection of 8000!) describe the natural environment.

3. How have human history and economic development of the quadrangle selected depended on the material environment?

Future plans are to augment this program utilizing self-instructional media.

11Ibid., p. 44.

12O.T. Hayward, personal communication, June, 1966.
What conclusions and implications might be derived from a review of the literature concerning development of introductory geology courses during the past few years? Obviously, geology departments have failed for many years to capture the interest of the laymen or non-science majors, notwithstanding the great numbers of students passing through introductory courses. Present college-level courses are today reaching almost twice as many persons as the 9th grade ESCP program; they are also entirely responsible for training earth-science teachers who will be influencing high-school students. The implication is clear: These courses not only serve as general education for the non-professional, but indirectly influence a large segment of the populace not intent upon going to college.

Yet geology for everyone suggests that students with varied backgrounds or interests should find the program interesting, challenging, relevant, and to their liking. According to one author, a solution to the problem is simply the abandonment of introductory geology altogether.\(^ {13} \)

This article points out that one goal of introductory geology is "to furnish a foundation for more advanced courses"; however, the author feels that these courses offer only general concepts and usually everything has to be repeated in advanced courses. A second goal is "to give students who take no further courses in geology and understanding and appreciation of his earthly environment," but the author says this goal

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is unnecessary since this is now apparently achieved in the high schools and lower grades as evidenced by content analyses of texts. This type of thinking represents a rather radical solution to the problem. The assumption that geology, as presented in most commercial elementary or secondary textbooks, in any way contributes to a worthwhile understanding of what geologists do and how they solve problems has not been supported by research. Further the suggestion that introductory geology can never amount to more than juggling a few geologic facts, and can be relegated to grade-school activities indicates a rather limited perception of what the course can accomplish for college students.

How do we know what liberal arts students are capable of assimilating as long as we insist upon burying them with minutae? Is the only justification for the learning of a fact or concept to be found in the rationale that it will appear on the forthcoming quiz? How can we adjust introductory geology so that it becomes a challenge for the gifted student? How can we make it more palatable for students who must struggle to understand science? How do we compensate for the increasing numbers of students enrolling in introductory geology? What is the nature of a scientifically literate society with respect to geology?

In order to answer these and many other questions, geology departments must be willing to subject courses to innovation and evaluate results. The trend of the past few years is encouraging; however, unless introductory courses are given the very best attention by top talent in the ranks of the profession, this movement may lose ground.
Audio-Tutorial Instruction and Introductory Geology

In an effort to remedy the above situation, the Geology Department at The Ohio State University has designed a new program to replace the conventional Introductory Geology 100 laboratory. It is described as an audio-visual tutorial program that uses a format of integrated experiences in geology. Twenty-four carrels have been installed in a large laboratory; each carrel is equipped with a Technicolor Super-8 film-loop projector and earphones, a Sawyer slide projector and all of the necessary specimens, maps and instructions pertaining to each laboratory session. Students attend laboratories on a voluntary basis, and each of the nine laboratories has been designed to last approximately two hours. In addition to the laboratory program, the students are responsible for attending three lectures per week and reading in the text, Geology: An Introduction by Bates and Sweet. The design of the audio-visual tutorial laboratory is grounded on assumptions that (1) certain media are most effective in presenting some information, (2) differences in students can be accounted for by the self-instructional nature of the program and through better interaction with teaching assistants, and (3) the "open-laboratory" schedule permits better use of student's time and more efficient use of laboratory space.

The audio-tutorial approach to learning can be largely credited to the work of S. N. Postlethwait of Purdue University, who began to

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experiment with and modify his botany program as early as 1962.  

Recently, this mode of instruction has increased in use especially at the college level. The investigator corresponded this year with a major publishing firm representing the most knowledgeable source of information on the status of A-T instruction. According to this source, there are 95 institutions reporting use of A-T instruction; 54 are in biology-botany, 10 in agronomy-agriculture, 4 in chemistry, 3 in nursing, 1 in physical science, and 1 in geology.

Yet, despite this recent proliferation, very few research data are available concerning evaluation of these programs. In a personal interview, Dr. Postlethwait indicated the need for such information and pointed out that the success of his program for a number of years has been due primarily to periodic revisions coupled with student-expressed satisfaction with self-learning in an "open-laboratory" situation.

In a position paper issued by Novak, the importance of involving students in construction of audio-tutorial courses is dramatized by the following remarks:

... more important (than pretesting of materials) is the design of sequential experience involving perhaps some audio-guided study of specimens, observation of an experiment or exhibit in a central location, discussion with laboratory instructor or colleagues - all these in some optimal order. Students are a valuable source of instruction for improving sequences of instruction when their

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17 Samuel N. Postlethwait, private interview held during meeting of the American Institute of Biological Sciences, The Ohio State University, Columbus, Ohio, November, 1968.
counsel on this is sought or obtained in some systematic way. (Italics the writer's)\textsuperscript{18}

In 1967, staff members of Golden West College, following the Postlethwait format, ended the first quarter of instruction with a critique as follows:\textsuperscript{19}

1. Students preferred A-T instruction to the conventional laboratory approach.

2. Students liked the opportunity to work at their own pace, and freedom to use lab at their own convenience.

3. Students liked graduate students as instructors.

4. Course content increased by over one-third.

5. Grade distributions were as follows: A - 19\%, B - 23\%, C - 40\%, D - 12\%, and F - 6\%.

In the same year, Dr. Forbes Robertson reported success using 12 A-T stations serving 112 students of physical geology:

We shouldn't have been, but we were nevertheless amazed at how quickly students related ideas by this method and we were able to work well beyond what has been the norm for our conventional laboratories.\textsuperscript{20}

Response to this program was reported as "favorable"; however, Dr. Robertson notes that some students "did not have the maturity to do the job."\textsuperscript{21}


\textsuperscript{21}\textit{Ibid.}
At Syracuse University, during the academic year 1967-68, Meleca applied multi-variate analysis to determine factors contributing to achievement level. Forty-eight students were in the experimental audio-instructional group; 43 students participated in the conventional biology program as a control group. Such research indicated that students using audio-tutorial materials can demonstrate satisfactory achievement in college biology, and aptitude in mathematics and biology are effective predictors of achievement in the experimental group; however, data do not support this finding for the control group. As a conclusion, it is stated that "auto-instructional approach lecture and laboratory is as good or better than the conventional approach; and perhaps the same number of teachers could handle a greater number of students without loss of individualized attention." 

From the foregoing paragraphs, it is evident that audio-tutorial programs have been in existence for a short time and very little has been accomplished in evaluating this approach to learning. The investigator has been closely associated with development of the geology program reported herein and recognizes need for basic data that will serve as feedback for revision, and as a catalyst for future investigations.

The Problem

The basic problem of the present study was to provide a method for evaluating how effectively the laboratory program provided for the

22 Ben Meleca, private interview, The Ohio State University, Columbus, Ohio, March, 1969.

23 Ibid.
general education of students enrolled in introductory geology at The Ohio State University. More specifically, the study investigated the attitudes, interest, achievement, and behavior of these students during the laboratory sessions in an attempt to formulate an analysis with curriculum improvement in mind. Also, the self-instructional aspect of the program implied recognition of individual differences as an important part of the study; therefore, certain data dealing with student characteristics, achievement and time-use of carrels lend themselves to multivariate analysis for the purpose of predicting success in the laboratory program.

Hypotheses

The rationale used in determining achievement in this program lies within the concept of content validity; therefore, achievement items have been prepared from specific objectives associated with each laboratory session. Ideally, each student should be able to answer every question successfully, assuming he has the time, motivation and ability to pursue the AVT program to its fullest. Further, it was assumed that some students were better prepared than others because of prior interest and education. In order to test such assumptions and check on the results of the pre-post test design the following hypotheses were considered.

1. There will be no significant difference in the means of subgroup scores on each unit post-test, when students are grouped according to those administered the post-test only and those taking the pre- and -posts only.

2. There will be no significant difference in the means of student's scores on each unit pre-test and the means of unit post-tests taken by these same students.

In order to ascertain the relationship between achievement in the A-V tutorial laboratory and specific background variables, the following hypotheses were tested:

3. A student's sex will not be related to attitude toward the A-V tutorial laboratory.

4. Success in the university undergraduate program will not be related to success in the A-V tutorial laboratory.

5. Time spent in use of AVT carrels will not be related to success in the A-V tutorial laboratory.

6. Student general attitude towards the A-V tutorial laboratory program will not be related to success in the A-V tutorial laboratory.

7. No combination of two, three or all of the above factors will be related to success in the A-V tutorial program.

**Definition of Terms**

**Success in the A-V tutorial laboratory** - will be determined by comparing final grade scores of the lowest 27 percent and the highest 27 percent. The upper group will be considered as successful in the A-V tutorial laboratory; the lowest group will be considered as comparatively unsuccessful.

**The Audio-Visual Tutorial Laboratory** - was based on materials developed by Dr. W. C. Sweet, Dr. R. L. Bates and the investigator during 1967-68 with the joint support of the National Science Foundation.
and The Ohio State University. It included a laboratory manual, single-concept films, slides, a programmed pre-lab and special geology materials, all contained within individual carrels fitted with necessary audio-visual equipment.

*Introductory Geology 100* - was the course served by the A-V tutorial laboratory. It was a 5-credit hour course serving as the introductory sequence to a 15-hour general science requirement elected by students having either non-professional or preprofessional interest in geology.

*Population of the study* - was confined to one lecture section (approximately 270 students) under Dr. V. M. Mayer.

**Assumptions**

1. Students would respond honestly to tests and questionnaires.
2. Students would respond to the specific or general nature of assessment questionnaire, as directed.
3. Students would not be prejudiced by external sources in any specific direction before responding to tests and questionnaires.
4. Disruption of laboratory performance due to equipment malfunction would not be of a serious nature.
5. Students would cooperate with the evaluative process by scheduling sufficient time (5-10 minutes) to effect responses when asked to do so.
6. Objectives and test items constructed for each laboratory unit adequately reflected instructional content of the program.
7. The General Attitude Scale (Form D) validly indicates relative student attitudes towards the AVT laboratory program.

**Delimitations of the Study**

1. The population in this study concerned one lecture section (approximately 270 students). Random samples were drawn from this population over a period of 9 weeks. (An additional lecture section participated in the program; however, it was not considered in this report.)

2. Personnel associated with the lecture section included the authors of the text, a lecturer and several graduate and undergraduate aides; the staff remained stable over the period of testing.

**Limitations of the Study**

1. Assignment of students to the laboratory hour was made initially by the scheduling office of the University; however, selection of subjects from this group to be studied remained with the investigator.

2. The nature of the population changed as the study progressed. Students were able to transfer into or out of the population with some degree of freedom during the first week; however, some stability appeared after this period.
Procedure

The investigation has been conducted in a series of phases during the academic year 1968-69.

In Phase I during the Spring and Summer Quarters, 1968, the investigator began constructing course objectives and test items for each unit of instruction. Some 120 achievement test items were available; these were based upon objectives for each unit. These items were administered during the Autumn Quarter, 1968, to the first group of 250 students ever assigned to the AVT program. Also, at the end of the quarter, these students were asked to express, in essay form, their likes and dislikes concerning the program. As a result of Phase I, the following information and items were realized:

1. A collection of 120 multiple-choice items was screened for levels of discrimination and difficulty by testing 30 students each week; 20 of the items were rejected and the remainder were reworked into better form.

2. Students were favorably disposed toward testing before and after laboratory sessions; however, the ideal unit quiz should not contain more than 10 items since these could be completed in less than 10 minutes.

3. Students were reluctant to seek aid; many indicated strong disapproval of the type of assistance given in the laboratory.

4. Many students insisted upon better reinforcement via answers supplied during the laboratory session.
5. Movies, a programmed pre-lab and Unit 4 were favorably received by many students.

During the Winter Quarter, 1969, approximately 500 students were involved in the AV-tutorial program; slightly over half this number were assigned to the study group. Phase Two then consisted of a period of data collection in which information was yielded by forms such as (1) item analysis of each unit-achievement test (Form A & B), (2) ratings of specific areas of the course (Form C), (3) general attitude of students toward the program (Form D), (4) taped interviews of the students and staff, (5) time-utilization of carrels (carrel-cards), and (6) an Achievement final examination (Form E) based upon items selected from unit quizzes.

At times, collection of data could be accomplished with the entire population; however, in some cases sampling at random was required. For example, Forms A, B, and C could not be given to all students entering and leaving the laboratory. Prior to testing for any particular week, a group of 135 students was isolated from the population, using a table of random numbers. The first 45 students were assigned to the unit post-test; the next 45 were given a pre-test and post-test; the final 45 were assigned to the unit media-assessment questionnaire. Diagrammatically, the scheme for administration of Forms A, B, C, D, and E was as follows:

Fig. 1: Schedule for administration of tests and questionnaires.

Also, during phase Two, careful records of student use of carrels were kept. During the Autumn Quarter, carrel-cards were used and found to have been maintained fairly accurately by the students themselves. The design of the card was only slightly changed for Winter Quarter.

Finally, after the forms and questionnaires were administered, student records were checked for additional data concerning student background.

The collection and processing of all the data used in this study were greatly facilitated by the use of data-processing techniques.
CHAPTER II

THE AUDIO-VISUAL TUTORIAL LABORATORY PROGRAM
FOR INTRODUCTORY GEOLOGY 100

AVT Introductory Geology - Goals and Scope

Since the A-V tutorial laboratory serves Introductory Geology 100 (a five-quarter-hour course given at The Ohio State University) it was necessary to consider the goals of this program. The course attracts several hundred students each quarter, most of whom are from various colleges throughout the university (see analysis, Chapter 3). The goals of the course are treated in the preface of the textbook as follows:

We have made no effort to write the longest and heaviest possible book on the subject. Rather, we have steered a course considerably this side of the encyclopedic, keeping in mind that most students who use the book will be taking geology for cultural reasons. On the other hand, we have tried to be sufficiently accurate and inclusive that a student who elects to continue in geology will have a good background for so doing. (Italics mine)26

Course content has traditionally followed the format of the textbook via the following topics: Introduction to Science; Sequence and Time; Rocks and Minerals; Igneous Processes and Products; Weathering; Downslope Movement; Erosion; Sediment Transport; Deposition;

Lithification; Fossils and Fossilization; Identification and Correlation; Glaciers; Ground water; Folding and Faulting; Metamorphism; Origin of Mountains; Historical Geology of North America; History of the Biosphere.

The goals of the laboratory program serving this course were considered in more detail after the inception of the A-V tutorial mode of instruction. In the proposal submitted to N.S.F. several areas of concern were expressed by the authors of the A-V tutorial laboratory, the solutions to which were attempted by this program. These were:

1. Maximum use of physical space.
2. Increasing university enrollments and our obligation to serve more and more of the students admitted.
5. Means of increasing the scope and coverage of laboratory instruction without significantly increasing student laboratory time commitments.
6. Means of making more efficient and meaningful use of the graduate teaching staff without sufficiently increasing its size.
7. Means of providing laboratory instruction that was flexible enough that it would be tutorial for the slow learner, but challenging and stimulating for the more gifted student.*

From the above it can be said that the original conception of AVT instruction centered on a more efficient means for presenting information.

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While this was of prime import during the development of materials, the authors were also conscious of program goals in terms of the audience intended and the nature of curriculum materials that would benefit both slow and gifted students by being challenging and stimulating. As a result of these additional goals, the nature of the laboratory program changed considerably from conventional offerings.

First, the new laboratory program is heavily oriented toward having the student solve geologic problems rather than commit geologic information to memory. The number of rocks, minerals and fossils usually dealt with was cut severely; however, the number of geologic concepts treated in problem-solving situations was enlarged. Because of this, it was decided that lectures could be reduced to three per week, rather than four.

In attempting to develop a more stimulating program for students, the authors scrapped the "time-honored" approaches to laboratory work. Innovative ways of presenting content were sought during the writing period. Integration of media designed to best capture the imagination of students and more effectively present content, was attempted in each laboratory unit. This resulted in the development of models, movies and other materials that were unique in the field of geologic education.

The remainder of this chapter is devoted to a description of the audio-visual Tutorial Laboratory. The description will present the program in terms of the physical setting, objectives and materials produced to meet the requirements of the original proposal, and focus upon the intent of the writers to produce an unique and stimulating laboratory program.
The AVT Environment

A large laboratory, formerly used for introductory geology, has been outfitted for the new program. Figure 2 shows the general appearance of the room which contains 24 carrels and a small area for storage of materials at the north end of the room.

Fig. 2: Room 100E, Mendenhall Laboratory

Each of the carrels is equipped with a Technicolor Super-8 film-loop projector with headphones, a Sawyer slide projector, a desk lamp
and all of the necessary specimens, maps and instructions needed to carry out the program without having to leave the carrel (see Fig. 3).

Fig. 3: A view of equipment in carrels. The Sawyer slide projector is positioned above the Technicolor Super-8 film-sound projector.

Upon entering the laboratory, the student fills in his own "carrel use card" obtained from a small box reserved for his lecture section (see Fig. 4). Placing the card in a slot on the master display board, he then obtains a box of materials needed for that week's laboratory and proceeds to the booth. Students may come whenever they wish during the hours the laboratory is open, as often as they like, and stay as long
as they feel impelled to stay. Upon completion of work, students return the materials to the aide and sign out, returning carrel-cards to the lecture-section box.

Fig. 4: A student signs up for a carrel. Each lecture section has a carrel-card file.

Objectives, Content and Materials for Each Unit

Overview - Unit One

The major theme of this unit centers on the concept that rocks are composed of minerals, and that type of rocks vary according to the kinds and amounts of minerals composing them. In this unit students are provided with fundamental knowledge about rocks and minerals that
will be useful in solving geologic problems in later units.

For instance, Part One entitled "The Minerals of Granite and Gabbro" acquaints students with granite and gabbro by way of observation. First, the introductory film sets the stage by emphasizing the distribution and significance of these two rock types. Specimens are then examined in a logical manner - from complex to simple - by observing entire rock specimens first, and then by studying crushed material from the very same specimens. In this way, the student recognizes both variety in composition and amounts of the "constituents" in each rock. He is led to the conclusion that rocks are composed of minerals and classification of rocks is based upon such analyses.

Part Two of the unit concentrates on closer examination of the mineral "constituents"; these are restricted to common rock-forming minerals throughout the entire program. The mineral property of cleavage is introduced by examination of biotite, and this is followed by a filmed sequence that develops skills in recognition and measurement of cleavage using a goniometer. Observations and measurements are then performed on a number of minerals. In the same manner, the concept of hardness is developed.

Objectives - Unit One

Objectives for this, and each of the following units have been developed in some detail for the purpose of creating test-items for this study; therefore, numbering will be done consecutively throughout this chapter so that proper identification of each objective will be facilitated.
They were stated in terms of expected student behavior in the following manner: Upon completion of this laboratory unit, the student should be able to:

1. Pick out the maximum number of different "constituents" in gabbro and granite; describe each using own terms.

2. Distinguish between granite and gabbro on the basis of types and proportions of minerals present in each.

3. Recall the names of minerals studied in this unit.

4. Distinguish between rocks and minerals.

5. Describe the general distribution of granitic and gabbroic rocks in the earth's crust.

6. Demonstrate the presence (or absence) of cleavage in certain minerals.

7. Identify the total number of cleavage planes and estimate angles between planes using a goniometer in minerals such as augite, plagioclase feldspar and orthoclase feldspar.

8. Using hardness materials, distinguish between minerals by applying scratch tests and placing each in Mohs' Scale of Hardness.

9. Distinguish between each mineral studied in the unit on the basis of outstanding properties of each.  

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28Professor Henry H. Walbesser provides a definitive list of "action-verbs" useful in constructing specific objectives in his forthcoming book *Constructing Behavioral Objectives* (College Park, Maryland: Bureau of Educational Research and Field Services, 1968).
In preparing materials for the laboratory units, it was decided that each carrel would be outfitted completely as a self-contained unit. Also, effort was placed upon obtaining materials from localities discussed in the manual, developing special models, slides, films and maintaining a high level of credibility between manual and materials.

Since evaluation of student response to media and materials appears in this study (see pp. 110-119), a complete listing of the items is presented for each unit as follows:

- Biotite Granite: coarse-grained, 3" x 4" (Sp. 1-1)
- Biotite Granite: coarse-grained, crushed (Tray 1-1)
- Gabbro: coarse-grained, 3" x 4" (Sp. 1-2)
- Gabbro: coarse-grained, crushed (Tray 1-2)
- Microcline: pink, cleavages, 1" x 1" (Tray A: sp. 1-3)
- Quartz: milky, 1" x 1" (Tray A: sp. 1-4)
- Biotite: cleavage, 1" x 1" (Tray A: sp. 1-5)
- Oligoclase: gray, cleavable, striations, 1" x 1" (Tray A: sp. 1-6)
- Augite: dark green, cleavage, 1" x 1" (Tray A: sp. 1-7)
- Slide showing granite and gabbro with associated minerals (Slide 1-1)

Goniometer

Hardness kit

Dissecting needles
Graph paper
Tripod magnifiers
Movies: "Introduction," "Cleavage," "Hardness"

Overview - Unit Two

The purpose of the unit is to have the student continue an examination of granite and gabbro in a manner that will demonstrate how the geologist infers mode of rock origin. Thin sections of each rock type are projected in order to study examples of interlocking fabric and textural characteristics. Comparison of these qualities found in gabbro, granite and basalt are entered into a table in the manual.

Having observed the above characteristics, a single-concept film develops the idea that fabric and texture relate to mode of origin of each rock type, and the student then applies this principle by examination of felsite and porphyritic basalt. Another film sequence emphasizes conditions of heat and pressure in the rock-forming environment as rock is experimentally produced in the laboratory.

In Part II of this unit, a new environment in which changes in rocks are produced is introduced in consideration of weathering of igneous rocks. Investigation of weathering in a granite quarry is carried out using film sequences of the quarry, actual specimens in various states of decomposition, vials containing mineral constituents of fresh and weathered samples and slides showing locations from which samples were collected. Using all of these media and materials, the student is led to examine alteration of feldspar to clay, biotite changing to limonite, and the
relatively unalterable quality of quartz. The unit concludes by having the student discover the relationship between products of decomposition and the nature of "parent" rocks.

Objectives - Unit Two

Upon completion of laboratory unit two, the student should be able to:

10. Recognize and name igneous rocks - obsidian, basalt, porphyritic basalt, granite, gabbro, pumice and felsite.

11. Differentiate between rocks listed in previous objective on basis of fabric and texture.

12. Name and describe the various categories used in identification of rock texture and fabric.

13. Relate characteristics of fabric, texture and composition to environment of rock formation for several types of igneous rocks.

14. Describe effects of chemical weathering of granite in terms of alteration of minerals present.

15. Identify the mineral limonite on the basis of outstanding physical properties.

16. Apply the technique of inferring nature of parent material from study of decomposition products of igneous rocks, when provided with analysis of both materials.
Materials and Equipment - Unit Two

Obsidian: black, 3" x 4"  
Basalt: dense, 3" x 4"  
Felsite: 3" x 4"  
Basalt: porphyritic, 3" x 4"  
Granite: porphyritic, 3" x 4"  
Granite: unweathered, Mt. Airy Quarry  
Granite: partly weathered, Mt. Airy Quarry  
Granite: regolith, Mt. Airy Quarry  
Limonite: 1" x 1"  
Quartz, Biotite and Albite, 1" x 1"  
Quartz, Biotite and Feldspar in vials representing fresh granite  
Quartz, Biotite, Feldspar and Clay in vials representing weathered granite  
Slide of thin-section of granite  
Slide of thin-section of gabbro  
Slide diagram of face of granite quarry showing locations of samples 2-6, 7 and 8  
Streak Plates  
Dissecting Needles  
Movies: "Formation of Lava," "Lab Formation of Igneous Rocks," "Weathering"
A large flow-chart displayed in each carrel lends continuity to this unit as the student follows the processes of weathering, erosion and deposition involved in formation of sedimentary rocks.

The unit begins with a short filmed sequence explaining the process of weathering and the production of residual regolith and materials in aqueous solution. A short movie sequence permits the student to watch a demonstration and collect data on settling velocities of different sizes of particles; data gained from the movie are utilized in the manual as problems involving distribution of fractions along a stream bed. Further, actual samples of residual regolith and stream gravels illustrate what happens to these materials in transport. This is followed up by another film sequence dealing with abrasion of rocks.

Having become familiar with gravel, sand, silt and clay as land-derived clastics, the student moves on to examine solid specimens in the same textural classification proposed for loose materials. The flow chart then moves into a consideration of cementing agents found in these rocks.

Turning from terrigenous clastics, the flow chart concentrates on rocks derived from materials in aqueous solution. One branch involves biogenic clastics—coquina, calcirudite, calcarenite and calcilutite; another branch of the chart covers chemical precipitates—rock gypsum, rock salt, limestone and chert. Slides accompanying this unit are designed for "self-check" in order to prevent the student from becoming hopelessly lost.
In Part Two of this unit mudcracked, ripple-marked and cross-stratified specimens are studied in much the same way the field geologist does to determine top and bottom of beds, direction of current or conditions during deposition. Figure 5 illustrates use of these specimens.

Fig. 5: A student orients marked specimen on basis of observed sedimentary feature.

Further, a filmed laboratory demonstration of the formation of cross-stratification patterns aids in the understanding of this feature.

At this point in the laboratory program, the emphasis has been shifted from "learning about" earth materials; students are continually being asked to engage in the kind of thinking involving processes of science, rather than products.
Objectives - Unit Three

Upon completion of this laboratory unit, the student should be able to:

17. Name size fractions of unconsolidated material used in this unit; state a principle governing the relationship between size, settling-velocity and order of deposition.

18. Relate changes in particle size and degree of roundness to distance of transport.

19. Name and identify, on the basis of composition, texture and fabric, sedimentary rocks that formed from land-derived clastics.

20. Name and identify hematite, calcite, gypsum and halite on the basis of outstanding physical and chemical properties (action of dilute HCl).

21. Name and identify biogenic clastic rocks—coquina, calcirudite, calcarenite and calcilutite—using textural characteristics and appearances.

22. Name and identify rocks formed as chemical precipitates—rock salt, rock gypsum, limestone and chert.

23. Describe the mode of origin and environmental conditions during formation associated with each sedimentary rock discussed in this unit.

24. Distinguish between sedimentary and igneous rocks on the basis of mineral composition and texture or fabric of the rock.

25. Name and identify sedimentary-rock structures—ripple-marks, cross-stratification, mudcracks; relate each structure to environment during formation of such features.
Materials and Equipment - Unit Three

Gravel: stream-rounded
Regolith: residual, gravel-sized
Conglomerate, Sandstone, Siltstone: limonite cement
Conglomerate, Sandstone, Siltstone: calcite cement
Hematite: 1" x 1"
Calcite: 1" x 1"
Coquina, Calcirudite, Calcarenite, Calcinulutite
Gypsum: cleavages, 1" x 1"
Halite: 1" x 1"
Gypsum, Halite, Calcite, Quartz
Rock Gypsum, Rock Salt, Limestone
Sandstone: ripple-marked
Sandstone: cross-stratified
Dolostone: mudcracked
Slide: flow-chart showing clastic rocks
Slide: flow-chart showing biogenic clastics
Slide: flow chart showing chemically precipitated rocks
Slide: ripple-mark sketch, symmetrical, asymmetrical
Slide: cross-stratification, view of movie model
Movies: "Introduction to Sedimentary Rocks,"
"Settling Velocities," "Cross-Stratification"
Complete flow-chart
The unit concerns the use and significance of fossils and contains a problem in fossil correlation. Since students must have some knowledge of biologic classification, a programmed section on Linnean classification is assigned prior to the actual laboratory session. The programmed section also illustrates use of a "Working Key" for identification of fossils in the unit.

An introductory film sequence explains how fossils are useful in describing animals and plants of the past, how they changed with time, and how fossils indicate past environments. Examples are given by specimens associated with the model used in a fossil correlation problem. Bryozoa are found to develop increasingly complex surface patterns. The ornamentation of brachiopods varies systematically with time. Suture lines on nautiloid specimens vary in the same manner. In this way, the student builds up a complete picture of the rock and fossil record within a hypothetical region shown by a block-diagram, and he is led to identify rock formations and zones which meet at angles to one another.

Interpretation of the results of the completed block diagram is reserved as a "take-home" activity, wherein several questions related to interpretation of past history are presented. Students are asked to sketch in the boundaries of sedimentary environments within the block diagram during selected intervals of time.
Objectives - Unit Four

Upon completion of this laboratory unit, the student should be able to:

26. Name, in proper order, the divisions used in the Linnaean classification system.

27. Interpret Linnaean divisions in terms of synthesis and analysis: demonstrate familiarity with conventional nomenclature.

28. Distinguish between a variety of fossil forms on the basis of symmetry, number of skeletal parts and mode of existence.

29. Apply the "Working Key" found in the unit for proper fossil identification.

30. Identify and name features found on bryozoa, brachiopods and mollusks; relate changes in such features to the concept of evolution.

31. Solve problems concerning correlation, when provided with data concerning rock types, structure and fossil assemblages.

32. Distinguish between rock zones and formations.

33. Describe environment during deposition of sediments and events taking place within the time a given rock zone was deposited.

Materials and Equipment - Unit Four

Bryozoa: 4 smooth, 1 faintly nodose  Tray BR-1
Bryozoa: 1 smooth, 3 faintly nodose, 1 nodose  Tray BR-2
Bryozoa: 1 faintly nodose, 3 nodose, 1 with ridges  Tray BR-3
Bryozoa: 1 nodose, 3 with ridges, 1 with joined ridges
Bryozoa: 1 with some nodes joined, 4 with all nodes joined to form ridges
Hom Coral; Colonial Coral
Trilobite
Ammonite: straight
Brachiopods: 4, *Platystrophia*
Brachiopods: 4; Bryozoa: 5 as in BR-4
Brachiopods: 4; Bryozoa: 5 as in BR-5
Brachiopods: 4; Nautiloid: 1, coiled
Goniatite: 1
Coral, colonial; Horn Coral
Trilobite: 1
Ammonite: 1, coiled
Trilobite: 1
Brachiopods: 4, as in GR-4
Brachiopods: 4; Nautiloid: 1, straight
Trilobite: 1
Ammonoid: 1, coiled; 1, straight
Sandstone: 2 varieties, 1" x 1"
Shale: 2 varieties, 1" x 1"
Limestone: 1" x 1"
Conglomerate: 1" x 1"
Movie: "Introduction to Fossils"
Slide: Drawing of *Platystrophia*, plications
Slide: Drawing of Cephalopod, sutures
Overview - Unit Five

Metamorphic rocks, the remaining class of rocks to be studied, are presented in Part One of this chapter. The first rock encountered is a sedimentary rock (limestone) containing small bits of calcite. A second variety of limestone (Holston limestone) is examined and shown to consist of a higher percentage of larger calcite crystals, therefore having a greater capacity for "polish" as a dimension or decorative stone. Finally, the student encounters a variety of marble that has been highly recrystallized. In this manner, the concept of varying degrees of metamorphic effects on similar rocks is introduced. The terms fabric and texture are also used in this section of the manual. To dramatize the relationship between folding and heat energy to degree of metamorphism, the student places the preceding rock types in appropriate boxes placed in a block diagram in the manual.

In somewhat the same manner, the student investigates the effect of increased metamorphism in sandstone-quartzite and shale-slate; however, the point is made that these sequences represent relatively "pure" rock types and metamorphism of "mixed" rocks results in differently appearing rocks. This point is developed by having marble available for study containing bands of muscovite, mica-schist, talc-schist, garnet-schist and a specimen of gneiss.

Having completed a study of the major classes of rocks, Part Two of this chapter attempts to develop the idea that knowledge of rocks (texture, fabric and composition) is useful for understanding earth history;
however, when field relations of rock bodies can be combined with this information, the resulting information is far superior.

In order to aid the student in visualizing field relations in all dimensions, a 3-dimensional model using clear plastic "fences" and colored rock units was constructed (see Fig. 6). The student is oriented to the model by a film entitled "Geologic Models" describing direct and indirect methods used for obtaining data presented in geologic cross-sections. This film sequence is designed specifically for the model and provides certain useful clues in interpreting the model. By utilizing rock specimens with the model, students are asked to arrange a series of "geologic-event cards" in proper sequence of formation (see Fig. 7). These cards are checked by laboratory assistants.

Fig. 6: Plastic fence model used in interpreting earth history, Lab. Unit Five.
Fig. 7: Interpreting earth history using "geologic-event cards."

Objectives - Unit Five

Upon completion of this unit, the student should be able to:

34. Differentiate between limestone and marble on the basis of texture, fabric and degree of fossil preservation.

35. Identify and name metamorphic equivalents of sedimentary rocks studied thus far.

36. Differentiate between sandstone and quartzite on the basis of texture, fabric and fracture pattern.

37. Differentiate between slate and shale on the basis of foliation: relate this type of rock cleavage to conditions at time of origin.
38. Name and identify minerals present in metamorphic rocks, and infer the general type of parent rock or sediment.

39. Distinguish between direct and indirect methods employed for gathering data in constructing geologic cross-sections.

40. Interpret earth history utilizing concepts of rock texture, composition and fabric, in conjunction with three-dimensional geological models.

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**Materials and Equipment - Unit Five**

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<th>Item Description</th>
<th>Code</th>
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</tr>
<tr>
<td>Limestone, polished, variety Holston limestone 3&quot; x 4&quot;</td>
<td>5-2</td>
</tr>
<tr>
<td>Marble, polished, 3&quot; x 4&quot;</td>
<td>5-3</td>
</tr>
<tr>
<td>Sandstone, 3&quot; x 4&quot;</td>
<td>5-4</td>
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<tr>
<td>Quartzite, 3&quot; x 4&quot;</td>
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<tr>
<td>Shale, 3&quot; x 4&quot;</td>
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<tr>
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</tr>
<tr>
<td>G-2 Slate</td>
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<td>G-3 Limestone</td>
<td></td>
</tr>
<tr>
<td>G-4 Quartzite</td>
<td></td>
</tr>
<tr>
<td>G-5 Granite</td>
<td></td>
</tr>
<tr>
<td>G-6 Quartzite</td>
<td></td>
</tr>
<tr>
<td>G-7 Marble</td>
<td></td>
</tr>
<tr>
<td>G-8 Slate</td>
<td></td>
</tr>
<tr>
<td>G-9 Quartzite</td>
<td></td>
</tr>
<tr>
<td>G-10 Shale</td>
<td></td>
</tr>
<tr>
<td>G-11 Quartzite, conglomeritic</td>
<td></td>
</tr>
<tr>
<td>Tray G</td>
<td></td>
</tr>
</tbody>
</table>
Overview - Unit Six

The purpose of the unit is to have the student obtain skill in interpreting maps as models of the earth’s surface, in anticipation of using maps to interpret earth history in succeeding units.

First, the relationship of maps to planet earth is shown on a small model globe. On this globe, students identify reference lines used in the latitude-longitude coordinate system. They then determine the scale of the model globe using string and ruler for measuring and calculation of fractional and linear scales. Finally, using latitude and longitude, areas represented by different portions of the globe are calculated.

In Part Two, the manual turns from the three-dimensional globe to the two-dimensional topographic map. Again, the student works with coordinates and problems involving distance, direction, gradient and scale. In order to achieve skill in interpreting topographic relief via contour lines, a single-concept film presents a study of a large relief model with animated lines superimposed on different surfaces of the model.

The remainder of the unit provides a series of exercises in topographic map reading that employ the Frankstown, Pennsylvania, 7.5-minute quadrangle.
Objectives - Unit Six

Upon completion of the laboratory unit, the student should be able to:

41. Identify the equator, International Date Line and Prime Meridian on a world map or globe.

42. Identify approximately a place on the earth's surface, when provided with coordinates of latitude and longitude.

43. Calculate actual distances on the earth's surface, when provided with model distances and appropriate conversion scales.

44. Name sub-units dividing each degree of latitude or longitude: relate these sub-units to actual distances.

45. Distinguish between 7.5-minute and 30-minute topographic maps: determine actual land areas represented by each.

46. Compute slope gradients of valley walls, rivers, and surfaces, when provided with necessary contour and scale information.

47. Describe terrain of a region, and comment upon maximum relief, stream direction, valley profiles, ridge shape, and elevations of selected points, when provided with topographic maps of certain areas.

Materials and Equipment - Unit Six

Plastic Globes (purchased from Hubbard Scientific Co., Boston, Mass.)

New Orleans East Quadrangle: 7.5-minute

Frankstown, Pennsylvania Quadrangle: 7.5-minute

Rulers

String: 26"
Overview - Unit Seven

In the unit, and the remaining units, emphasis is placed on putting together knowledge of rock type, geologic models and topographic maps to solve problems dealing with interpretation of earth history. Students also gain knowledge of the basis for division of North America into physiographic provinces. The manual guides the student to an examination of geomorphic features of the Allegheny Plateau and the Ridge and Valley Province. By way of a "trip" up Lock Mountain in Pennsylvania, the student notes the relationship between actual rock specimens and topography. This information is then extended to larger structures by using maps depicting larger regions. A summary exercise provides consideration of the geologic events transpiring in both Allegheny Plateau and Ridge and Valley provinces and a table for the purpose of contrasting geomorphology and culture found in both provinces.

Objectives - Unit Seven

Upon completion of the laboratory unit, the student should be able to:

48. Describe shapes of ridges and relate sedimentary rocks to geomorphic features, given appropriate topographic and geologic information concerning the Ridge and Valley Province.

49. Identify and name dendritic, radial and trellised drainage patterns, using topographic maps.

50. Describe anticlines or synclines, when provided with topographic maps and/or geologic profiles.
51. Describe the geographic extent of the Ridge and Valley Province and the Allegheny Plateau, and trace the interface between these two provinces.

52. Identify and describe major structural events in the two provinces; relate these events in terms of geologic time.

53. Compare and contrast geological and cultural features portrayed on topographic maps of the Ridge and Valley and Allegheny Plateau provinces.

Materials and Equipment - Unit Seven

Frankstown, Pennsylvania: 7.5-minute quadrangle
Pittsburgh, Pennsylvania: 7.5-minute quadrangle
Altoona, Pennsylvania: 7.5-minute quadrangle

Reedsville shale: 3" x 4"  Sp. 7-1
Juniata sandstone: 3" x 4" Sp. 7-2
Tuscarora sandstone: 3" x 4" Sp. 7-3
Slide: aerial view of Appalachians Slide 7-1
Slide: Chestnut Ridge, Pa. Slide 7-2

Overview - Unit Eight

Emphasis on the unit continues to be examination of a physiographic province - the Colorado Plateaus. The province is examined in a general way first, and then in detail by focusing on the Bright Angel region of the Grand Canyon.
For instance, in Part One, a sectional aeronautical chart is used to survey the plateau. Using this map for reference, the student examines several regions by way of slides and topographic maps. Brief geological interpretations are made at each location.

In Part Two of the unit a more detailed study of one region—the Grand Canyon—is presented. Students study features produced as the Colorado River erodes horizontal rock layers. A problem involving correlation using "trilobite cards" from lower Paleozoic formations, is employed. For this, students are provided with rock samples, data on ranges of trilobite families and geologic maps and cross-sections, and from these they are asked to write a detailed account of earth history in this region.

Of particular interest in this unit is the experimental use of a "branching" technique as a format for the laboratory manual. At critical places in the manual, students are asked to choose a response and turn to another section of the manual for verification of the choice. This section may direct students to consider the error in detail or tell them to continue, adding supplementary information. Methods for adequate reinforcement are a major concern of the authors of this program.

Objectives - Unit Eight

Upon completion of the laboratory unit, the student should be able to:

54. Describe extent and attitude of rock formations of the Grand Canyon, Arizona.
55. Identify the main agent of erosion affecting the Colorado Plateaus province.

56. Name and describe terms used in categorizing environments and mode of life for certain aquatic fossil forms of the region.

57. Identify entrenched meander systems and relate their significance in interpreting earth history.

58. State requirements for an "index" fossil.

59. Identify ages of Grand Canyon formations and apply the Law of Sequence to these formations.

60. Demonstrate ability to limit ages of fossil assemblages when provided with data on fossil types and family ranges.

61. Describe that portion of geologic time represented in the rock record of the Grand Canyon and major events occurring there within that period of time.

Materials and Equipment - Unit Eight

Sectional Aeronautical chart: Grand Canyon
Mexican Hat, Utah: 15-minute quadrangle
Goulding, Utah: 15-minute quadrangle
Shiprock, New Mexico: 15-minute quadrangle
Soda Canyon, Utah: 15-minute quadrangle
Bright Angel, Arizona: 15-minute quadrangle
Bright Angel, Arizona: special geologic map
Tapeats Sandstone (or substitute)  
Bright Angel shale (or substitute)  
Sp. 8-1  
Sp. 8-2
Overview - Unit Nine

This, the final laboratory unit, may be termed a vicarious trip across Colorado into the heart of the Rocky Mountains. Each carrel contains: 1) a geologic map with the route and stops clearly marked, 2) a state highway map of Colorado, 3) two dozen slides taken along the trip route, and 4) several rock specimens obtained from actual outcrops represented by the various media.

It is the major purpose of the unit to have students apply knowledge and skills gained throughout the entire program. Questions posed along the route are designed to serve as a check on how well the student employs processes of science in his thinking. Also, the student becomes familiar with two more physiographic provinces - the Great Plains and the Rocky Mountains.
Objectives - Unit Nine

Upon completion of the laboratory unit, students should be able to:

62. Describe and differentiate between characteristics of river systems of the Great Plains and Rocky Mountains.

63. Construct a definition of physiographic regions based upon observable landscape patterns.

64. Demonstrate knowledge of major geological events associated with regions along the trip route and place such events within the framework of geologic time.

65. Relate certain geomorphic features along the Front Ranges - Great Plains interface to underlying structure and forces producing said features.

66. Infer the geologic history of the Rocky Mountains region on the basis of rock type, geometry of rock bodies and fossil evidence.

Materials and Equipment - Unit Nine

Colorado Highway Maps, 1968 ed.

Slides: Bird City, Kansas
       Hwy 36, near Bird City
       Great Plains in Kansas
       Joes, Colorado
       Last Chance, Colorado
       Oil rig
Front Range, Strasburg, Colorado  
Front Range, aerial view looking N.  
Front Range, aerial view looking S.  
Red Rocks amphitheater  
View of Great Plains from Idaho Springs  
Idaho Springs Formation  
Idaho Springs Formation  
Central City, Colorado  
Highway near Silver Plume, Colorado  
Silver Plume granite  
Silver Plume granite  
Loveland Pass  
Loveland Pass  
Loveland Pass, winter  
Gore Pass, Colorado  
Lake Creek, Colorado  
Mt. Elbert, Colorado  
Maroon Peaks, Colorado  
Book Cliffs, Utah  
Fountain Formation  
Dakota Sandstone  
Niobrara limestone  
Idaho Springs Formation  
Silver Plume Granite
SUMMARY

Objectives stated for the first three laboratory units emphasize study of earth materials with some mention of possible use of specimens in interpretation of earth history. In the following units, the emphasis decidedly favors problem-solving as students are expected to put to work concepts learned earlier in the program. Every effort has been made to allow the student to handle a variety of materials and to lead him to conclude for himself what kinds of relationships exist between earth materials, models and earth history. Each laboratory builds on knowledge acquired in previous units so that a high degree of integration of information occurs throughout the entire program. Students are not expected to acquire sporadic bits of information and forget a particular unit as they move on to the next hurdle. Many objectives are repeated in one form or another, throughout the entire program.

Materials have been selected to hold the student's interest. Rocks have been collected from Pennsylvania, Ohio and Colorado. Movies and slides were taken at the sites discussed in the manual. Special models have been created for the program. Examination of the materials in this chapter testifies as to the uniqueness and diversity of the specimens, maps and models obtained for this program.

29 Slides for this unit and earlier ones were obtained from a variety of sources. Some were made on the premises by the authors of the program or were available in their private collections. The Earth Science Curriculum Project, Boulder, Colorado supplied several slides used in Unit Nine. Several were purchased from John H. Shelton, Claremont, California.
Since the goals, objectives and materials have been specifically designed for this program, it is suggested that the reader may find it useful to return to unit descriptions provided in this chapter when following the analyses given in Chapter 4. For example, the forthcoming discussion on achievement will be directly tied to objectives and goals. Understanding the section on media assessment will be facilitated by referring back to the list of materials provided herein.
CHAPTER III

THE POPULATION, MATERIALS, AND PROCEDURES

The Population Under Study

Three lecture sections (approximately 750 students) of Introductory Geology 100 were scheduled by the University Scheduling Office for Winter Quarter, 1969. The 10:00 A.M. lecture section was chosen for the study by the investigator primarily because the lecturer, Dr. Victor Meyer, expressed interest in the evaluation. Dr. Meyer shared an office with the investigator and encouraged contact with students for purposes of orientation toward the test program and administration of questionnaires. Also, the director of the laboratory program, Dr. Walter C. Sweet, provided assistance via student aides who were responsible for issuance of forms to students and maintenance of records.

The population consisted of approximately 280 undergraduate students enrolled in the 10:00 A.M. lecture section of Introductory Geology 100, at The Ohio State University during Winter Quarter, 1969. Due to limitations beyond the investigator's control, the population changed somewhat during the quarter. For example, an initial class list completed from registrations accepted prior to the start of classes indicated an enrollment of 280. During the first two weeks of the quarter, a revised list based upon requests for dropping the course or changes in
lecture hour indicated 24 students had left the section and 27 entered, leaving a total of 283 students. By the end of the quarter this number was reduced to 266. This figure can be considered a normal attrition value as students dropped out of the course (see p. 122). Changes in the population were noted as accurately as possible by matching lecture attendance with both mid quarter examination lists in order to gain more accurate information on the composition of the population. From these revised lists, random selections were made for the weekly testing program.

Students in the population represented several colleges within the university. An analysis of colleges represented is as follows:

Table 3

<table>
<thead>
<tr>
<th>College</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arts and Sciences</td>
<td>39</td>
</tr>
<tr>
<td>Education</td>
<td>36</td>
</tr>
<tr>
<td>University College</td>
<td>17</td>
</tr>
<tr>
<td>Administrative Sciences</td>
<td>6</td>
</tr>
<tr>
<td>Agriculture &amp; Home Economics</td>
<td>2</td>
</tr>
</tbody>
</table>

Development of Achievement Tests

Three achievement-test forms were constructed for the testing program:
1. Form A - a series of nine post-tests, each consisting of approximately ten multiple-choice items (see items, pages 71 to 109).

2. Form B - a series of nine pre-tests, and a series of nine post-tests, identical to form A.

3. Form E - 30 items selected from Form A and administered as part of the final examination for the quarter. These items represent a measure of achievement for the total AVT program (see Appendix I).

All students in the sample groups were administered pre-tests and post-tests according to a color-code affixed to carrel cards each week. Although all students were oriented to the testing schedule, none had advance knowledge as to the nature of the items given each week, or of the actual selection of individuals for testing. Weekly tests were administered and supervised by the laboratory aides or by the investigator, and all forms were kept in the preparation room during the quarter.

Achievement - Form A

Items for this series of post-tests were constructed during Phase I in Autumn Quarter, 1968. Each week, 10 to 15 items were constructed and administered to 30 students involved in AVT instruction. A rough item analysis was performed on each test, which resulted in an array of 100 items deemed acceptable for use the following quarter, after certain items were rewritten and others rejected. Construction of items was based on the objectives for the program, which were developed during curriculum construction before and during Phase I.

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In Phase II, the corrected test items were administered to samples of the population. Each week, students were selected, using a table of random numbers, and complete item analysis was performed by the 1620 computer. Criteria for inclusion of items in Form E that concern the qualities of reliability and validity are discussed later in this chapter (see Achievement - Form E).

Form A was intended to serve as a normative examination for each unit as well as a supplier of items for Form E. For this reason, it was hoped that the reliability of each unit exam would be as high as possible. Also, this form would be compared to pre-tests to measure significance of gains in each unit.

Achievement - Form B

Development of this form was the same as Form A in all respects. Test items were identical. Form B, however, was administered to a different sample of students each week as both a pre-test and a post-test of the same students in a given unit.

The purpose of Form B was to serve as a measure of the knowledge possessed by the students before entering the carrels. Not only did the information contribute to gain study, but it served as a check on the possible effects of pre-testing on students. The design of this research format is described as a "quasi-experimental design" by Gage.31

Achievement - Form E

Since Form E was intended to serve as a measure of achievement for the AVT program, the best items developed during weekly testing were selected to make up 30 items for this measure. The criteria for selection were applied to the results of item analysis to arrive at a high-quality test. Of the two qualities (reliability and validity) generally attributed to good tests, validity is generally regarded as the most important. Measuring instruments are valid for evaluation if they truthfully report aspects of student's performance. In this study validity depends upon the competent judgment of the investigator and his interpretation of course objectives accumulated during creation of the manual.

Discrimination indices range from +1 to -1. An item answered correctly by all of the students in the upper 27 percent of the sample tested, and incorrectly by all of the lower 27 percent, would have an index of +1. In selecting items for Phase II and Form E, items with high positive discrimination indices were favored; those items having indices less than .25 were rejected.

Item difficulty concerns the percentage of students unable to respond to each item correctly. The latest view of test-makers is that this is a difficulty level so that a value of .10 means ten percent of the sample incorrectly answered the item, and value of .92 signifies a difficult item since ninety-two percent got the item wrong. This scheme is adhered to in the report. During Phase I, items within the range .2 to .9 were considered acceptable for Phase II; however, selection of items for Form E was more stringent with limits set between .4 and .6 levels
of difficulty in order to produce a mean difficulty value close to .5 for this test (Form E).

Both level of difficulty and power of discrimination affect the reliability of a test. (Consistency and stability are good synonyms for reliability.) Reliability for all test forms was determined as part of the item analysis program, and utilized the Kuder-Richardson-20 formula. Most teacher-made tests tend to have a reliability of about .60, whereas test-makers of standardized tests should get .90 or better.\textsuperscript{32} For this study, it was intended that reliability would be as high as possible - .90 or better.

Form E served as a criterion variable for an analysis of the contributions made by such variables as attitude, average time in carrels and accumulated grade-point average toward achievement.

\textbf{Development of Questionnaires}

Two types of questionnaires were chosen for the study:

1. Form C - a Media Assessment Questionnaire utilizing a semantic differential scale evoking affective student responses to various media (see Appendix II).

2. Form D - a General Attitude Questionnaire consisting of 32 valued statements about the AVT program. The statements were selected by students as representing their own attitudes toward the program (see Appendix III).

Form C - The Media Assessment Questionnaire

The Media Assessment Questionnaire was based on a form nearly identical to that developed by Smith, Walberg, Poorman and Schagrin. Apart from a recent trial with this form in (Harvard) Project Physics, there is no record of its use elsewhere. In fact, the possibility that this particular form will be useful for the specific purpose of assessing audio-tutorial programs needs itself to be investigated.

The format of the questionnaire was similar to the one developed by Smith (et al.). It deals with criteria of interest, difficulty, liking and appropriateness as applied to movies, slides, earth materials, earth models and the laboratory manual. Rating of the nature of assistance is also included.

Form C was intended to rate all of the media, according to the above criteria, in all of the laboratory units. The scales presented in the report were analyzed in a general way, with the purpose of analysis directed toward suggestions for curriculum improvement and reporting of any significant trends in assessment of media.

Form D - The General Attitude Questionnaire

The General Attitude Questionnaire was adapted from Remmers' and Silance's questionnaire used to measure attitudes toward school

subjects. Remmers employed 150 sortings of statements from college themes written by students concerning subjects liked or disliked. Two separate instruments were constructed, and applications of these forms in many college situations yielded correlations ranging from .81 to .90.

In this form, AVT students were asked to check statements that expressed their feelings toward the program. Thirty-three such statements were selected from both forms, with but minor modifications. For example, the original words this subject were replaced by the audio-visual tutorial laboratory program, or some other variation of these words. Each of the statements was assigned a value by Remmers, on the basis of numerous sortings accomplished by students. These values range from 10.3 as the most positive statement, down to .6 as the most negative attitude statement (see Appendix III). In 1934, the questionnaire was employed in a study of relationships between attitudes toward school subjects. In 1934 the scale was used in a study of relationships between attitudes toward school subjects and variables of sex, age and year in school. Popham and Sadnovich used this form in a study to determine effectiveness of filmed science courses used in public secondary schools.


35 Ibid.


Christantiello used Remmers' scale to measure attitudes of college sophomores toward the subject of mathematics, looking for significant relationships linking attitudes and mathematics achievement.\textsuperscript{38} Thus, the scale has been used over a considerable period of time in studies dealing with different levels of instruction and a variety of subjects.

\textbf{Administration of Tests, Questionnaires and Interviews}

All testing and interviewing was conducted during the Winter Quarter, 1969. Three programs were followed during the testing period:

1. Achievement tests (Form A and B) and the Media Assessment Questionnaire (Form C) were given each week for the duration of the program.

2. The General Attitude Questionnaire (Form D) and the Achievement Final Exam (Form E) were administered during quarter final examinations.

3. Interviews were conducted only during the week of laboratory unit nine.

4. Carrel-records were maintained constantly during the quarter.

\textbf{Achievement Tests and Media Assessment}

Each week 135 students were selected from the population using a table of random numbers. Forty-five of these students were assigned to

take Form A as an achievement post-test upon leaving the carrel; 45 were assigned to take both a pre-test and a post-test of achievement (Form B). The remaining 45 were assigned to the Media Assessment Questionnaire upon leaving the carrel.

Students were asked to make every effort to allow from 5 to 10 minutes to take these tests and questionnaires. Those not completing the laboratory in one visit were tested upon return to the laboratory whenever possible. Each week a new random sample was selected, with adjustments made in the population as it changed.

The General Attitude Questionnaire

The General Attitude Questionnaire was administered to the entire population at the conclusion of the course; however, a random sample of 44 students was selected for Regression Analysis.

Interviews

Taped interviews were conducted during the last week of the laboratory program. A tape recorder was placed on a movable cart and all taping was conducted by the investigator. Although topics for discussion were suggested by the investigator, the students were asked to comment either positively or negatively on any facet they wished. The interviewer left the scene during actual taping and returned only when the student concluded his remarks. Comments by the graduate assistants were also recorded.
Student Records

Careful records of student use of carrels were maintained during the entire quarter. Students entered time-in and time-out as well as duration of visit. The university testing office supplied data on grade-point accumulated averages.

Collection and Tabulation of Data

In order to widen the scope of this study, the investigator planned for the use of data processing in collection and tabulation of information. Without the use of the data processing the amount of information presented in this report would have been restricted severely.

Achievement - Forms A, B and E

Responses to pre-tests and post-tests were put directly on the quiz sheets by the students. At the end of each week, the investigator transferred those responses to standard forms used by optical scanning for punching data cards.\(^{39}\)

Early in the week following achievement testing, the punched cards were brought to the College of Administrative Science Data Center for processing.\(^{40}\) Data were presented on large print-out sheets, and condensed into table form for this report.

\(^{39}\) Form number 115 was provided by the Orientation and Testing Center, The Ohio State University.

\(^{40}\) Program entitled "Item Analysis," library reference number C6.01.016, on the IBM 1620 computer was used on analysis of these items.
Some calculations were performed by hand. This was necessary to test for significance of difference between mean scores on pre-tests and post-tests, and also in the case of calculating reliability when number of test items are increased (Spearman-Brown formula).

In Form E data collection, the first 30 items of the final examination for the course were analyzed. These items were selected from each unit. When item analysis was performed for the entire test, the data center provided print-out sheets for the first thirty items only, treating them as an individual examination. The same computer program was used for this analysis as in the item analysis for weekly units.

Media Assessment - Form C

Responses to the media assessment forms were made directly on the forms designed by the investigator (see Appendix II). This information was then transferred by hand to general coding forms supplied by the Data Center. It is the opinion of the writer that semantic differential choices do not appear easy to differentiate when responses are to be made on rather crowded general coding forms used in optical scanning. Punched cards were brought to the Data Center for analysis by the IBM 1620 computer. 41

Although over 300 means, standard deviations and distributions were obtained concerning responses to various media, hand calculations for testing significant differences of various selected means were required.

The General Attitude Questionnaire - Form C

There were 263 responses to the questionnaire. This information was not put on data cards. Hand calculations determined the mean score for each student; however, 44 students were drawn at random from the total number of respondents and information from their questionnaires was processed at the Data Center.42

Interviews and Carrel-Records

Taped interviews were transcribed and examined for categories into which the information could be presented effectively. It was decided that two or three of the more interesting interviews would be preserved as they were transcribed.

Carrel-record information was converted to a graphic display for analysis. Plots of the duration of each student's visit to the carrel were made in such a manner that vital information was available for determining daily patterns of utilization as well as total numbers of students involved daily, weekly, or the entire quarter.

In the following chapter the data obtained will be tabulated and analyzed. The investigator will interpret the results of interviews, questionnaires and tests insofar as space permits. The reader may find many interpretations within the next few pages, not treated in the report. Not all questions can be treated in this report; however, an attempt is made to treat broadly the areas of achievement, assessment and attitude, with some discussion of specifics.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Introduction

Data considered pertinent to the evaluation of the audio-visual tutorial laboratory concern achievement, assessment of media, student attitudes, time-use of carrels, and interviews. In this chapter such data are presented in their most concise and pertinent form.

Forms A and B, All Units - Item Analysis

The study of achievement was based upon student response to test items presented in weekly examinations and on the final examination. These items were based upon unit objectives developed in Chapter Two, and the results of item analysis are presented first. Following this, group data for each unit test are presented along with hypotheses dealing with possible factors influencing pretesting of subjects. Ability of the students to score high on pre-tests prior to entering carrels is analyzed in detail. Finally, group data on the achievement exam are then presented and analyzed.
Achievement Test - Unit I

Percent Responding to Each Item

<table>
<thead>
<tr>
<th>Form B</th>
<th>Form B</th>
<th>Form A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>Post</td>
<td>Post</td>
</tr>
</tbody>
</table>

1. Which of these is classed as a rock?
   a. Quartz 33 10 10
   * b. Gabbro 43 74 83
   c. Augite 2 2 0
d. None of the above 21 12 7

Objectives: Difficulty: .571 .262 .167
(3,4) Discrimination: .454 .469 .406

2. The mineral that is very soft, and is composed of thin, elastic plates that easily separate is called
   a. Quartz 7 0 0
   * b. Mica 64 64 76
c. Feldspar 24 26 24
d. Granite 5 7 0

Objectives: Difficulty: .357 .357 .238
(9) Discrimination: .339 .387 .362

3. A rock may most generally be defined as a
   a. substance of very definite chemical composition 21 0 0
   b. homogeneous mixture of two or more elements 19 12 12
   c. material with definite cleavage and streak 7 2 2
   * d. mixture of minerals 52 83 86

Objectives: Difficulty: .476 .167 .143
(4) Discrimination: .188 .359 .336

* Denotes correct answers.
4. Mineral "Y" is scratched by both "W" and "X"; however, mineral "X" is scratched by "Z". From these three tests, we can conclude that

  a. "W" is softer than "X".  
  b. "X" is softer than "W".  
  c. "W" is as hard as "X".  
  * d. none of the above relationships can be determined.

<table>
<thead>
<tr>
<th></th>
<th>Form B Pre</th>
<th>Form B Post</th>
<th>Form A Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>7</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>b</td>
<td>21</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>c</td>
<td>7</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>d</td>
<td>64</td>
<td>64</td>
<td>71</td>
</tr>
</tbody>
</table>

Objective: Difficulty: .357 .357 .286
(8) Discrimination: .339 .359 .119

5. An analysis of minerals present in gabbro would be closest to

  a. 30% quartz, 20% biotite and 50% feldspar.  
  b. 5% feldspar and 95% augite.  
  c. 40% feldspar, 30% augite and 20% biotite.  
  * d. 80% feldspar and 20% augite.

<table>
<thead>
<tr>
<th></th>
<th>Form B 1</th>
<th>Form B 2</th>
<th>Form B 3</th>
</tr>
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<tbody>
<tr>
<td>a</td>
<td>38</td>
<td>14</td>
<td>26</td>
</tr>
<tr>
<td>b</td>
<td>14</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>c</td>
<td>29</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>d</td>
<td>19</td>
<td>57</td>
<td>57</td>
</tr>
</tbody>
</table>

Objective: Difficulty: .810 .429 .286
(1,2,3) Discrimination: .180 .147 .572

6. Two rock specimens from different parts of the world are found to contain quartz, mica and feldspar. To classify them properly, the next step is to determine the

  a. density and specific gravity of each rock.  
  * b. proportions of each mineral present.  
  c. cleavage angles of minerals in each rock.  
  d. hardness of each rock specimen.

<table>
<thead>
<tr>
<th></th>
<th>Form B 1</th>
<th>Form B 2</th>
<th>Form B 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>10</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>b</td>
<td>62</td>
<td>48</td>
<td>50</td>
</tr>
<tr>
<td>c</td>
<td>21</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>d</td>
<td>7</td>
<td>21</td>
<td>26</td>
</tr>
</tbody>
</table>

Objective: Difficulty: .381 .524 .500
(4) Discrimination: .321 .532 .265
7. A mineral with three cleavage angles has a minimum of how many cleavage directions?

- a. 2
- *b. 3
- c. 4
- d. 6

Objectives: Difficulty: (7)

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<tr>
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<th>Form B Pre</th>
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<td>43</td>
<td>36</td>
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</tr>
<tr>
<td>Discrimination</td>
<td>.036</td>
<td>.272</td>
<td>.452</td>
</tr>
</tbody>
</table>

8. How many sets of cleavage directions are shown above?

- a. 3
- *b. 4
- c. 6
- d. 8

Objectives: Difficulty: (7)

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<tr>
<td></td>
<td>12</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Discrimination</td>
<td>.762</td>
<td>.714</td>
<td>.571</td>
</tr>
</tbody>
</table>

9. What is the smallest angle (estimated) between the cleavage directions or planes shown in question 8?

- a. 10 degrees
- *b. 75 degrees
- c. 90 degrees
- d. 135 degrees

Objectives: Difficulty: (7)

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<td>45</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Discrimination</td>
<td>.690</td>
<td>.571</td>
<td>.667</td>
</tr>
</tbody>
</table>
10. Which of the physical properties listed below is least reliable for the purpose of mineral classification?

- a. Hardness
- b. Cleavage
- c. Fracture
- d. Color

Objectives: Difficulty: 0.405 0.381 0.429
(9) Discrimination 0.410 0.323 0.121

11. According to Mohs' Scale of Hardness

- a. absolute values are not assigned to minerals.
- b. diamonds are about nine times harder than talc.
- c. minerals not having cleavage appear as higher values.
- d. the force applied to each mineral must be equal.

Objectives: Difficulty: 0.881 0.905 0.762
(6) Discrimination 0.059 0.117 0.392

Analysis of Presentation

The above item analysis indicates that students came into the laboratory moderately familiar with items 2, 4, 6 and 10 dealing with means for classification of rocks, Mohs' Scale and recognition of the properties of biotite. They were least familiar with items 5, 8 and 11 dealing with information on cleavage, composition of gabbro, and Mohs' Scale as an indicator of relative values.
However, greatest gains were made on 1, 3, 5 and 7, which deal mainly with recall of names of minerals and distinguishing between rocks and minerals. Also, the post-test items showing least difficulty were 1 and 3, which concern recognition of a rock name among a list of mineral names and identifying a proper definition of a rock as a mixture of minerals.

Items 5 and 10 were judged to be of average level of difficulty, high enough in point-biserial discrimination, and suitable to represent Unit One as items included in Form E. Item 11, though too difficult, was included to check the student's concept of a relative scale of hardness.

Achievement Test - Unit II

<table>
<thead>
<tr>
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<th>Form B Pre</th>
<th>Form B Post</th>
<th>Form A Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Felsite may be described as a (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* a. igneous rock similar in composition to granite which cooled at a relatively shallow depth.</td>
<td>15</td>
<td>52</td>
<td>44</td>
</tr>
<tr>
<td>b. igneous rock containing microscopic-sized crystals of feldspar and augite.</td>
<td>27</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>c. common mineral found in vicinity of volcanoes.</td>
<td>15</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>d. rock forming from molten material at great depth, containing crystals of quartz and feldspar.</td>
<td>38</td>
<td>20</td>
<td>41</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .850 .475 .564
(10,11,13) Discrimination .133 .521 .533
2. Rocks weather because they are
   a. exposed to carbon dioxide.  
   b. not stable in the presence of water.  
   c. oxidized by oxygen dissolved in water.  
   * d. not at equilibrium with the environment.

   Objectives: Difficulty  
   (14) Discrimination

3. Select the rock that cooled most rapidly from the molten state.
   a. Granite
   b. Felsite
   * c. Obsidian
   d. Gabbro

   Objectives: Difficulty:  
   (10,11) Discrimination

4. Evidence that the rock selected as the answer to the above question did cool most rapidly is that
   a. the groundmass consists of feldspar.  
   b. crystals of augite settled to the bottom.  
   c. the rock is composed of quartz and feldspar.  
   * d. no crystals developed.

   Objectives: Difficulty:  
   (13) Discrimination

5. Basalt may be described as a (n)
   a. igneous rock that cooled slowly and contains much quartz.
   * b. fine-grained igneous rock containing little quartz.

   Objectives: Difficulty:  
   (10,11) Discrimination
c. quartz-deficient igneous rock that formed at relatively great depth.

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<th>Form B Pre</th>
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<th>Form A Post</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17</td>
<td>22</td>
<td>31</td>
</tr>
</tbody>
</table>

d. common rock forming mineral found near the surface of the earth.

<table>
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<tr>
<th></th>
<th>Form B Pre</th>
<th>Form B Post</th>
<th>Form A Post</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>38</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .725 .475 .615
(10,11,13) Discrimination .124 .410 .263

6. When granite is weathered, products of decomposition are usually found to be

a. completely different elements. 5 13 10

b. the same minerals as in the original rock, only broken-up. 47 13 5

c. the same minerals as were found in the original rock; however, these are in different proportions. 27 27 23

* d. none of the above. 20 47 62

Objectives: Difficulty: .800 .525 .385
(14,16) Discrimination .506 .366 .098

Questions 7-11 concern the following observations of a rock:

1. The rock is light colored.
2. It is composed of large crystals which are easily visible to the unaided eye.
3. It contains appreciable amounts of quartz and feldspar.

Check each of the statements below (7-11) to see if it is contradictory to the observations given above.

If observation 1 contradicts the statement, circle "a."

If observation 2 contradicts the statement, circle "b."
If observation 3 contradicts the statement, circle "c."

If NONE of the observations contradict the statement, circle "d."

7. The rock may be granite.

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<tr>
<th></th>
<th>Form B Pre</th>
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</thead>
<tbody>
<tr>
<td>a.</td>
<td>20</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>b.</td>
<td>17</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>c.</td>
<td>7</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>*</td>
<td>55</td>
<td>72</td>
<td>56</td>
</tr>
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</table>

Objectives: Difficulty:
(10,11) Discrimination

8. The rock may have a granular fabric.

<table>
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<th>Form A</th>
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</thead>
<tbody>
<tr>
<td>a.</td>
<td>15</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>*</td>
<td>40</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td>b.</td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>c.</td>
<td>32</td>
<td>40</td>
<td>46</td>
</tr>
</tbody>
</table>

Objectives: Difficulty:
(13) Discrimination

9. The rock may be felsite.

<table>
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<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>a.</td>
<td>22</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>*</td>
<td>30</td>
<td>32</td>
<td>41</td>
</tr>
<tr>
<td>b.</td>
<td>15</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>c.</td>
<td>20</td>
<td>15</td>
<td>13</td>
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</table>

Objectives: Difficulty:
(10,11) Discrimination

10. The rock may have formed near the surface.

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</thead>
<tbody>
<tr>
<td>a.</td>
<td>15</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>*</td>
<td>22</td>
<td>42</td>
<td>46</td>
</tr>
<tr>
<td>b.</td>
<td>7</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>c.</td>
<td>52</td>
<td>27</td>
<td>31</td>
</tr>
</tbody>
</table>

Objectives: Difficulty:
(13) Discrimination
11. The rock may have cooled very slowly while forming.

   a.  10  7  10
   b.  27  25  13
   c.  10  0  8
   * d.  52  67  67

Objectives: Difficulty:
(13) Discrimination
   .472  .550  .489

Analysis of Presentation

On pretests, students were moderately familiar with items 3 and 7. That is, they recognized that obsidian cooled very rapidly and they understood the environment of formation of granite. They were initially least familiar with items 1 and 6 which deal with description of felsite, and the addition of clay minerals as decomposition products of granite.

Most outstanding gains after instruction concerned items 1 and 3, which related to placement of obsidian and felsite in proper environment of formation. On the other hand, items 7 and 8 did not show much gain; however, there is a possibility that the stem for these items may have been confusing to some students. Generally, gains were made on all of the objectives related to these items and it is apparent that readings or lectures contributed to student responses on questions dealing with some igneous rock types and their environment of formation.

Questions 2, 8, 9 and 10 were selected for use in Form E.
Achievement Test - Unit III

Percent Responding to Each Item

<table>
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<tr>
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</table>

1. Deposition of sediments in a stream increases as

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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>a. stream velocity increases.</td>
<td>34</td>
<td>32</td>
</tr>
<tr>
<td>* b. stream velocity decreases.</td>
<td>52</td>
<td>55</td>
</tr>
<tr>
<td>c. particle size decreases.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>d. volume of water increases.</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .477 .455 .368
(17) Discrimination: .413 .414 .498

2. Rock salt deposits in the earth were formed

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</thead>
<tbody>
<tr>
<td>a. from calcite.</td>
<td>27</td>
<td>16</td>
</tr>
<tr>
<td>b. by neutralization of NaOH in rocks, with HCL.</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>c. as molten halite cooled.</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>* d. by the evaporation of sea water.</td>
<td>34</td>
<td>30</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .659 .705 .474
(22,23) Discrimination: .041 .301 .584

3. The Mississippi Delta was formed

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<tbody>
<tr>
<td>a. as flood plains pushed their way into the Gulf of Mexico.</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>b. by deposition caused chiefly by a velocity increase due to an increase in the amount of water at the Gulf.</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>c. by deposition caused by an increase in stream friction as it floods its banks.</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>d. by deposition due to a decrease in velocity as the stream entered the quiet waters of the Gulf.</td>
<td>57</td>
<td>59</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .432 .409 .211
(17,23) Discrimination: .303 .452 .431
4. A distinction can be made between quartz and feldspar by observing:

- a. color.
- b. streak.
- *c. hardness.
- d. texture.

Objectives: Difficulty:

(20) Discrimination

5.

Information from many cores taken from a sediment-filled lake appears in the above diagram. It is apparent from this diagram that:

- a. each layer took an equal amount of time to accumulate.
- b. the lake basin sank as sediment was deposited.
- c. entering streams cut through a variety of source rocks.
- *d. sand was the oldest of the sediments.

Objectives: Difficulty:

(23) Discrimination
Study of sedimentary structures, such as those listed below in questions 6, 7 and 8, yields information on rock environments during formation. Such information may include:

1. Current direction  
2. Top and bottom of beds  
3. Nature of site

If it yields information on 1 and 2 only, select "a."

If it yields information on 2 and 3 only, select "b."

If it yields information on 1 and 3 only, select "c."

If it yields information on 1, 2 and 3, select "d."

6. Mudcracks

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<tr>
<td>b.</td>
<td>39</td>
<td>43</td>
</tr>
<tr>
<td>c.</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>d.</td>
<td>16</td>
<td>23</td>
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Objectives: Difficulty: Discrimination:  
(25) .614 .568 .342  
.511 .216 .544

7. Cross-bedding

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<tr>
<td>b.</td>
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<td>7</td>
</tr>
<tr>
<td>c.</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>d.</td>
<td>34</td>
<td>43</td>
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Objectives: Difficulty: Discrimination:  
(125) .659 .568 .447  
.475 .163 .524
8. Ripple marks

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<td>a.</td>
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<td>11</td>
</tr>
<tr>
<td>b.</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>c.</td>
<td>43</td>
<td>48</td>
</tr>
<tr>
<td>* d.</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: (25) 
Discrimination: 0.750 0.705 0.579

For items 9, 10 and 11, select from the key given below the essential mineral associated with the rock type given in each item.

Key

9. Shale

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<tr>
<td>a.</td>
<td>39</td>
<td>43</td>
</tr>
<tr>
<td>* b.</td>
<td>25</td>
<td>32</td>
</tr>
<tr>
<td>c.</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>d.</td>
<td>18</td>
<td>7</td>
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</table>

Objectives: Difficulty: (20,22) 
Discrimination: 0.750 0.682 0.605

10. Limestone

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<tbody>
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<td>a.</td>
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<td>7</td>
</tr>
<tr>
<td>b.</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>* c.</td>
<td>57</td>
<td>84</td>
</tr>
<tr>
<td>d.</td>
<td>20</td>
<td>7</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: (20,22) 
Discrimination: 0.432 0.159 0.263

11. Rock Salt

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<tbody>
<tr>
<td>a.</td>
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<td>2</td>
</tr>
<tr>
<td>b.</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>c.</td>
<td>48</td>
<td>7</td>
</tr>
<tr>
<td>* d.</td>
<td>39</td>
<td>91</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: (20,22) 
Discrimination: 0.614 0.091 0.342
Analysis of Presentation

Items 10 and 11 dealing with minerals found in sedimentary rocks were best mastered by students according to these figures. Low results for minerals found in shale was due to use of term kaolin, which did not appear in the laboratory manual.

Items 1, 2, 6 and 7 were selected for incorporation into the final examination.

Achievement Test - Unit IV

<table>
<thead>
<tr>
<th>Percent Responding To Each Item</th>
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<tbody>
<tr>
<td>Form B</td>
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<tr>
<td>Pre</td>
</tr>
</tbody>
</table>

Questions 1-4 relate to the following illustrations.

1. Which of the above is described as having bilateral symmetry, solitary
form and a many-piece skeleton?

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
<th>Form A</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>* b. II</td>
<td>81</td>
<td>75</td>
<td>86</td>
</tr>
<tr>
<td>c. III</td>
<td>14</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>d. IV</td>
<td>0</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: (.194, .250, .143)
(28, 29) Discrimination: (.586, .697, .628)

2. Which of the above is solitary, asymmetrical, and has a one-piece skeleton?

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
<th>Form A</th>
</tr>
</thead>
<tbody>
<tr>
<td>* a. I</td>
<td>61</td>
<td>69</td>
<td>83</td>
</tr>
<tr>
<td>b. II</td>
<td>3</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>c. III</td>
<td>11</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>d. IV</td>
<td>25</td>
<td>19</td>
<td>7</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: (.389, .306, .167)
(28, 29) Discrimination: (.431, .611, .393)

3. Which form shown above is least likely to be able to exist in shallow water zones where wave currents are substantial?

<table>
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<tr>
<td>a. I</td>
<td>25</td>
<td>31</td>
<td>21</td>
</tr>
<tr>
<td>b. II</td>
<td>31</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>c. III</td>
<td>8</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>* d. IV</td>
<td>33</td>
<td>39</td>
<td>45</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: (.556, .611, .548)
(33) Discrimination: (.578, .506, .045)

4. An indication of evolutionary development can be noted in "ridges" and "nodes" found on

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<tbody>
<tr>
<td>a. I</td>
<td>25</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>b. II</td>
<td>31</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>c. III</td>
<td>8</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>* d. IV</td>
<td>33</td>
<td>67</td>
<td>74</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: (.667, .333, .262)
(30) Discrimination: (.180, .288, .243)
5. The correct order of Linnean division is

a. kingdom, phylum, class, family, order, genus, species.  
   post: 6 3 5

* b. kingdom, phylum, class, order, family, genus, species.  
   post: 81 89 95

c. kingdom, phylum, order, class, family, species, genus.  
   post: 14 6 0

d. kingdom, class, order, phylum, genus, species, family  
   post: 0 3 0

Objectives: Difficulty: .194 .111 .048
(26, 27) Discrimination: .209 .304 .266

6. How many GENERA are represented in the following list?

- PANTHERA LEOPARDI
- FELIS PARDAULIS
- PANTHERA ONCA
- LYNX RUFIN

a. One  
   post: 6 0 5

b. Two  
   post: 8 6 14

* c. Three  
   post: 47 64 67

d. Four  
   post: 39 31 14

Objectives: Difficulty: .528 .361 .333
(26) Discrimination: .415 .387 .227

7. On what basis do scientists conclude that fossil corals required a warm shallow water environment?

a. The composition of rocks in which fossils are found determines this.  
   post: 25 22 17

b. The geographic distribution of fossil corals furnishes proof of this.  
   post: 39 36 38

* c. Most present day corals live in this type of environment.  
   post: 28 36 33

d. Corals are composed of calcium carbonate.  
   post: 8 3 12

Objectives: Difficulty: .722 .639 .667
(31) Discrimination: .280 .147 .288
8. A group of interbreeding plants or animals that are closely related in many ways and are known to be reproductively isolated from other such groups is called a

- a. phylum.
- b. species [83 83 79]
- c. genus
- d. family

Objectives: Difficulty:
(27) Discrimination: 0.167 0.167 0.214

9. Use of fossils as a means for correlating rock layers is based on the idea that forms of life

- a. achieved different states of evolutionary development at about the same time everywhere they occurred. 19 14 12
- b. have been found to be associated with certain rock types. 25 11 7
- c. remained unchanged in form throughout geologic time. 3 0 2
- d. attained approximately the same stage of evolutionary development at the same time everywhere they existed. 53 75 79

Objectives: Difficulty:
(31) Discrimination: 0.472 0.250 0.214

10. A unit of rock distinguished by its fossil content is called a

- a. zone.
- b. layer.
- c. facies.
- d. formation

Objectives: Difficulty:
(32) Discrimination: 0.750 0.639 0.738 0.199 0.241 0.372
Analysis of Presentation

Students scored well on pretests on items dealing with objectives 26, 27, 28 and 29 which were given in the programmed pre-lab exercise for this unit. Upon completion of the unit, these same test items were successfully answered. In addition, gains were shown on items related to objective 30 concerning features found on bryozoas.

Very little improvement was shown for objectives 31, 32, and 33 dealing with interpretation of correlated data and environments of the past, and on the discussion of rock zones since these concepts were treated in the post laboratory section of the manual. However, on the final examination item 7 difficulty dropped to .399 and item 9 difficulty fell to .392. These data suggest that the post-laboratory exercise was completed by many students.

Achievement items 6, 7 and 10 were chosen for inclusion in the final examination, Form E.

Achievement Test - Unit V

Percent Responding To Each Item

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</table>

1. The three fundamental categories into which rocks are classified are based on

   a. chemical composition 35 22 28
   b. origin * 59 68 54
   c. hardness 0 0 10
   d. age 3 8 5

Objectives: Difficulty:
(4, 40) Discrimination:
   .405 .324 .462
   .474 .522 .493
2. Which of these is UNRELATED to the others?

   a. Slate     14 Pre  8 Post  18 Post
   * b. Basalt  46 Pre  81 Post  62 Post
   c. Gneiss   27 Pre  11 Post  10 Post
   d. Quartzite 14 Pre  0 Post  10 Post

   Objectives: Difficulty:  .541 Pre .189 Post .385 Post
   (35) Discrimination: .543 Pre .336 Post .309 Post

3. Seismic prospecting for petroleum is possible because

   a. dynamite shatters rocks without pulverizing them.  8 Pre  5 Post  0 Post
   * b. certain rock layers reflect sound waves differently than others.  84 Pre  86 Post  90 Post
   c. all rocks react in the same manner to sound waves.  3 Pre  5 Post  0 Post
   d. explosion of dynamite directly reveals presence of or absence of oil.  5 Pre  3 Post  8 Post

   Objectives: Difficulty:  .162 Pre .135 Post .103 Post
   (39) Discrimination: .244 Pre .175 Post .261 Post

4. The best way to distinguish quartzite from sandstone is

   a. to apply dilute HCL to each.  38 Pre  27 Post  21 Post
   b. in observing and measuring cleavage faces.  11 Pre  8 Post  33 Post
   * c. by observing surface of fracture using a hand lens.  24 Pre  65 Post  38 Post
   d. by recording color differences between the two rocks.  27 Pre  0 Post  8 Post

   Objectives: Difficulty:  .757 Pre .351 Post .615 Post
   (35,36) Discrimination: .393 Pre .448 Post .387 Post

5. All samples of granite gneiss and marble are alike in that they are
Objectives: Difficulty:
(34, 35) Discrimination:

6. Metamorphic rocks yield clues as to direction of pressure exerted on rocks during their formation. This may be seen in

- bedding. 19 35 36
- foliation. 43 51 38
- structure. 11 5 13
d. cross-bedding 27 5 13

Objectives: Difficulty:
(37) Discrimination:

Questions 7-11 refer to the diagram appearing below.
7. The oldest rock unit in the diagram is

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<tbody>
<tr>
<td>a</td>
<td>57</td>
<td>81</td>
<td>72</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>c</td>
<td>35</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>d</td>
<td>8</td>
<td>0</td>
<td>10</td>
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Objectives: Difficulty: .432 .189 .282
Discrimination: .604 .404 .216

8. Unit 1, adjacent to "D" is most likely

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<tr>
<td>a</td>
<td>limestone</td>
<td>65</td>
<td>19</td>
</tr>
<tr>
<td>b</td>
<td>gneiss</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>c</td>
<td>marble</td>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>d</td>
<td>slate</td>
<td>16</td>
<td>35</td>
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Objectives: Difficulty: .919 .649 .744
Discrimination: .029 .052 .129

9. Surface "Z" is most nearly like the surface

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<tbody>
<tr>
<td>a</td>
<td>11</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>b</td>
<td>16</td>
<td>16</td>
<td>26</td>
</tr>
<tr>
<td>c</td>
<td>59</td>
<td>57</td>
<td>51</td>
</tr>
<tr>
<td>d</td>
<td>16</td>
<td>16</td>
<td>26</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .405 .432 .487
Discrimination: .353 .461 .485

10. Which of the geologic events below is oldest?

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<tr>
<td>a</td>
<td>19</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>b</td>
<td>30</td>
<td>27</td>
<td>38</td>
</tr>
<tr>
<td>c</td>
<td>46</td>
<td>57</td>
<td>49</td>
</tr>
<tr>
<td>d</td>
<td>5</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .541 .432 .513
Discrimination: .335 .461 .349

11. Unit "F" was probably converted to solid rock (lithified) by
Items dealing with interpretation of the block diagram were moderately difficult for most students before entering the carrels. Gains were substantial in this area as well as objectives dealing with metamorphic equivalents of sedimentary rock types. The item dealing with rock foliation showed very little gain.

Items 5, 9, and 10 were included in the final examination, Form E.

Achievement Test - Unit VI

Percent Responding To Each Item

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</thead>
<tbody>
<tr>
<td>1. Which of the following is true?</td>
<td>* a. Latitude is measured from the equator; values range from 0° to 90°. 61 80 79</td>
<td>b. Latitude is measured from the Prime Meridian; values range from 0° to 90°. 5 2 0</td>
<td>c. Latitude is measured from the Prime Meridian; values range from 0° to 180°. 12 7 5</td>
</tr>
</tbody>
</table>
Objectives: Difficulty:  Form B Pre  Form B Post  Form A Post  
(41) Discrimination:  .390  .200  .211  
(42)                   .391  .456  .535  

2. A region of the earth at 5° North  
   Latitude and 175° West Longitude is  
   most likely  
   * a. near a tropical island.  51  72  76  
   b. surrounded by sea, ice and  
      glaciers.  12  10  3  
   c. somewhere between Australia  
      and the equator.  20  7  5  
   d. to be experiencing Monday when  
      it is Sunday in Ohio.  15  10  13  

Objectives: Difficulty:  Form B Post  Form B Post  Form A Post  
(42) Discrimination:  .488  .275  .237  
(47)                   .379  .650  .477  

3. An important factor in choosing a  
   proper contour interval for a topo­  
   graphical map is  
   a. spacing of points actually  
      surveyed.  27  13  11  
   b. surface elevation .  29  25  24  
   * c. surface relief .  39  60  66  
   d. degree of error in surveying  
      techniques.  5  2  0  

Objectives: Difficulty:  Form B Post  Form B Post  Form A Post  
(47) Discrimination:  .610  .400  .342  
(43)                   .310  .506  .362  

4. Which of the following places are  
   nearest to each other?  

Place 1 at lat. 20° N, long. 50° E  
Place 2 at lat. 30° N, long. 50° E  
Place 3 at lat. 30° N, long. 60° E  
Place 4 at lat. 20° N, long. 60° E  

   a. Place 1 and place 2.  12  15  5  
   * b. Place 2 and place 3.  41  40  29  
   c. Place 1 and place 3.  5  2  11  
   d. All are the same distance from  
      each other.  37  42  55  

Objectives: Difficulty:  Form B Post  Form B Post  Form A Post  
(43) Discrimination:  .585  .600  .711  
(43)                   .580  .401  .465
5. A fractional scale appearing on a map as $\frac{1}{6000}$ is interpreted as

a. 1 inch on the map equals 6000 feet on earth. 51 47 42

* b. 1 foot on the map equals 6000 feet on earth. 10 15 13

c. 1 degree of latitude on the map equals 6000 feet on the earth. 22 25 34

d. none of the above.

Objectives: Difficulty: .902 .850 .868
(43) Discrimination: .059 .477 .137

6. When comparing two 30-minute topographical maps from different parts of the United States (Alaska vs. Ohio), it may be said that

a. both maps represent the same number of square miles. 44 20 18

b. the Alaskan map contains a greater number of square miles. 15 15 8

* c. the Ohio map contains greater number of square miles. 10 32 50

d. the fact that they are called 30-minute sheets has nothing to do with areas involved. 32 32 21

Objectives: Difficulty: .902 .675 .500
(45) Discrimination: .388 .500 .605

7. Given a planet with circumference 10,000 miles, our system of latitude-longitude superimposed on this hypothetical planet would result in which of the following?

a. Each degree of latitude and longitude equals 28 miles. 17 25 24

b. Each degree of latitude equals 56 miles. 20 10 11

c. Each degree of longitude equals 28 miles. 12 13 11

d. Each degree of longitude at the equator equals 28 miles. 44 50 47
The drawing below contains information normally found on topographic maps. The map and related legend contain enough information to answer items 8 through 10 successfully.

8. The gradient of the slope from point A to point D is closest to
   a. 40 feet per mile 20 10 16
   b. 80 feet per mile 22 13 13
   * c. 100 feet per mile 44 65 61
   d. 125 feet per mile 10 13 11

   Objectives:
   Difficulty: .561 .350 .395
   Discrimination: .388 .369 .350

9. If water flows from point C (on the surface represented at the right), it will flow in the direction CX toward X. Two and only two of the four statements presented below are consistent with facts shown by the contour sketch.
   a. The sketch represents a stream valley.
b. The steepest slope occurs at A.
c. Water would naturally flow from F to E.
d. A, B, and D lie on a highland ridge.

The correct statements are:

| a. 1 and 2  | 22 | 20 | 26 |
| b. 2 and 3  | 22 | 17 | 11 |
| * c. 3 and 4| 49 | 38 | 39 |
| d. 1 and 3  | 2  | 25 | 24 |

| Objectives: Difficulty: | 0.512 | 0.625 | 0.605 |
| Discrimination:           | 0.044 | 0.118 | 0.374 |

10. If the stream flowing from C to X began to carve a channel great enough to affect the appearance of the contours

| a. the contours now shown crossing the stream would appear to bend as "vees" pointing to the east. | 24 | 55 | 37 |
| b. the contours now shown crossing the stream would appear to bend as "vees" pointing to the west. | 46 | 27 | 50 |
| c. the new contours would be interrupted by a gap. | 7 | 10 | 8 |
| d. the new contours would not appear in any different arrangement when compared to the original ones. | 15 | 7 | 5 |

| Objectives: Difficulty: | 0.756 | 0.450 | 0.632 |
| Discrimination:           | 0.253 | 0.690 | 0.378 |

Analysis of Presentation

Students appeared to have little advance knowledge on items concerning most of the objectives in this unit, especially conversion of distances and use of scales. Most of the objectives were met and
improved with the exception of item 5 which may have been too hastily read by a number of students.

Items 4, 6 and 7 were selected for inclusion in the final examination, Form E.

Achievement Test - Unit VII

Percent Responding To Each Item

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1. In a region underlain by flat-lying sedimentary rocks, the surface drainage pattern is likely to be

* a. dendritic 67 52 51
  b. radial 15 0 6
  c. trellised 12 48 40
  d. none of these 6 0 3

Objectives: Difficulty: .333 .485 .486
(49) Discrimination: .265 .647 .277

2. The sketch shown below represents a portion of a topographic map.

![Topographic Map Sketch]
It indicates that from A to B there exists

a. a stream valley with steeply sloping valley walls. 6 3 9
b. a stream valley with gently sloping valley walls. 12 6 23
* c. a mountain ridge with steeper slopes facing north. 67 79 66
d. a mountain ridge with steeper slopes facing south. 15 12 3

Objectives: Difficulty: .333 .212 .343
Discrimination: .312 .147 .291

3. Rocks in western Pennsylvania were folded during the

a. Precambrian Era 15 6 6
b. Early Paleozoic Era 45 36 31
* c. Late Paleozoic Era 33 52 43
d. Cenozoic Era 6 6 20

Objectives: Difficulty: .667 .485 .571
Discrimination: .530 .214 .273

4. Standing on a high ridge in western Pennsylvania, you find this north-south trending ridge is actually the west flank of a syncline. To find older rocks you would then walk

a. northward. 9 18 6
b. southward. 15 15 9
c. eastward. 52 55 43
* d. westward. 24 6 43

Objectives: Difficulty: .758 .939 .571
Discrimination: .452 .222 .N.S.
5. The tops of major ridges in western Pennsylvania are usually supported by

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<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Post</td>
</tr>
<tr>
<td>a. limestone</td>
<td>36</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>b. shale</td>
<td>36</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>c. siltstone</td>
<td>3</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>d. sandstone</td>
<td>24</td>
<td>76</td>
<td>80</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: 0.758 0.242 0.200
(48) Discrimination: 0.247 0.469 0.388

6. When comparing surface features in the Ridge and Valley Province and the Allegheny Plateau, major differences can be seen in

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<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Post</td>
</tr>
<tr>
<td>a. stream patterns</td>
<td>12</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>b. highway trends</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>c. mountain or ridge shapes</td>
<td>24</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>d. all of the above</td>
<td>64</td>
<td>76</td>
<td>74</td>
</tr>
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Objectives: Difficulty: 0.346 0.242 0.257
(50, 53) Discrimination: 0.496 0.285 0.479

The block diagram shown below represents a region in the Ridge and Valley Province. The crest of mountain "A" is supported by a rock formation of Silurian age, having an attitude shown by dotted lines. Mountain "C" has identical rocks—same formation, age and attitude. No faulting or slippage of rock formations has occurred. Questions 7-10 refer to this diagram.
7. Rocks at point "B" are most likely to be

* a. shale.  
  b. sandstone.  
  c. conglomerate.  
  d. quartzite.

Objectives: Difficulty:  .667  .455  .343  
Development: .250  .169  .363

8. Rock structure above point "B" can be reconstructed. This structure is a (n)

* a. anticline.  
  b. syncline.  
  c. homocline.  
  d. isoline.

Objectives: Difficulty:  .424  .455  .343  
Development: .273  .564  .611

9. Which of the periods listed below best represents the age of rock formations at "B"?

a. recent  
  b. Mississippian  
  c. Ordovician  
  d. Devonian.

Objectives: Difficulty: .636  .424  .514  
Development: .129  .443  .466

10. Concerning availability of coal deposits in this region, which of the following statements is true?

a. Coal deposits are likely; they would tend to follow ridges "A" and "C" just below ridge-tops.  

b. Coal deposits are likely; they would tend to be found in the valley following a north-south line along point "B".
c. Coal deposits are not likely because the entire region is underlain by sedimentary formations.

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<td>27</td>
<td>9</td>
<td>14</td>
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* d. Coal deposits are not likely since they would have been eroded away a long time ago.

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<td>9</td>
<td>9</td>
<td>23</td>
</tr>
</tbody>
</table>

Objectives:
(50,53)

Difficulty: 0.909 0.909 0.343
Discrimination: 0.426 0.311 0.363

Analysis of Presentation

Before entering carrels students grasped items related to drainage patterns and reconstructing anticlinal structures. Of interest is item 2 related to objective 47. Students were able to describe terrain from the topographic diagram given in the item.

Greatest gains were registered on items related to objectives contrasting differences between the two provinces, and items placing geologic events within geologic time periods. Almost all items indicated relatively high improvement from pretest to post test.

Items 4, 5 and 6 were considered acceptable for inclusion into the final examination, Form E.

Achievement Test - Unit VIII

Percent Responding To Each Item

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<tbody>
<tr>
<td>1. A bar scale on a map appears as 1 inch=4 miles. To determine the total</td>
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</table>
area represented by this map, we must also know the map's

   a. fractional scale.  9  26  21
   b. contour interval.  15  6  7
   c. latitude.  9  3  0
   * d. dimensions.  68  65  72

Objectives: Difficulty:  .324  .353  .276
(43) Discrimination:  .487  .363  .496

2. In order to estimate thickness of various sedimentary formations from a topographical map of the Grand Canyon, one must consult

   a. the bar graph.  0  6  3
   b. the fractional scale.  0  0  0
   * c. contour lines and interval.  32  41  52
   d. both b and c above.  68  53  45

Objectives: Difficulty:  .676  .588  .483
(54) Discrimination:  .416  .460  .390

3. From the appearance of the topography of the Colorado Plateau region, it is apparent that most of the surface material has been removed by

   a. wind activity.  9  3  3
   * b. stream activity.  41  76  79
   c. glacial activity  12  3  7
   d. an equal combination of the above.  38  18  10

Objectives: Difficulty:  .588  .235  .207
(55) Discrimination:  .377  .309  .527

4. Present-day corals may be said to be

   a. planktonic forms.  41  18  17
   b. nektonic forms.  15  3  3
   * c. sessile, benthonic forms.  38  68  59
   d. vagrant, benthonic forms.  3  12  21

Objectives: Difficulty:  .618  .324  .414
(56) Discrimination:  .207  .531  .693
5. Entrenched meanders found in the San Juan River system are evidence of

a. faulting of rock layers in the region.  
   12  9  0

b. presence of layers of resistant and non-resistant rocks along the path of the stream.  
   47  24  24

* c. elevation of the region.  
   38  65  69

d. folding of older rocks at depth.  
   3  3  7

Objectives: Difficulty: .618 .353 .241
(61) Discrimination: .677 .493 .581

6. Rejuvenation, a process associated with the Colorado Plateau region, is best illustrated by

a. volcanics in the Ship Rock area.  
   3  0  7

* b. streams along the San Juan River.  
   76  79  76

c. Indian cliff houses at Spruce Tree House.  
   6  0  0

d. deposits of sediments into Lake Mead.  
   15  21  17

Objectives: Difficulty: .235 .206 .241
(61) Discrimination: .349 .433 .589

7. In the Colorado Plateau region, rocks found on a mesa overlooking a nearby river valley can be said to be younger than those found in the valley bottom. The basis for this statement is the concept of

a. Uniformity of Process  
   26  35  52

* b. Superposition  
   47  44  34

c. Fossil correlation.  
   15  15  14

d. Isostatic adjustment.  
   12  6  0

Objectives: Difficulty: .529 .559 .655
(59) Discrimination: .535 .671 .382
8. A certain fossil is abundant, has a wide geographic distribution, and is easy to identify. Further, the organism that produced the fossil has maintained the same appearance throughout geologic time. This fossil is NOT a good index fossil because

- it has a wide geographic distribution
- ease of identification may be misleading.
- it will appear the same in successive strata.
- of all of the above reasons.

Objectives: Difficulty: .559 .500 .586
(58) Discrimination: .473 .343 .562

9. The table below describes ranges of three fossils found in a layer of sedimentary rock:

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>FROM</th>
<th>UP TO AND INCLUDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil A</td>
<td>Early Cambrian</td>
<td>Early Ordovician</td>
</tr>
<tr>
<td>Fossil B</td>
<td>Late Cambrian</td>
<td>Late Ordovician</td>
</tr>
<tr>
<td>Fossil C</td>
<td>Middle Cambrian</td>
<td>Late Cambrian</td>
</tr>
</tbody>
</table>

The age of this fossil assemblage is closest to

- Late Cambrian
- Early Ordovician
- Late Cambrian through Early Ordovician
- Early Cambrian through Late Ordovician

Objectives: Difficulty: .971 .882 .759
(60) Discrimination: .018 .450 .093
10. Fossils A, B and C (see item 9) were not likely collected from which of these locations?

   a. Near the base of San Juan River Canyon.  
   b. Just below the rim of the Grand Canyon (town of Grand Canyon)*  
   c. Indian Cliff dwellings of Spruce Tree.  
   * d. none of these*  

<table>
<thead>
<tr>
<th></th>
<th>Form B Pre</th>
<th>Form B Post</th>
<th>Form A Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>35</td>
<td>32</td>
<td>28</td>
</tr>
<tr>
<td>b.</td>
<td>29</td>
<td>44</td>
<td>48</td>
</tr>
<tr>
<td>c.</td>
<td>3</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>d.</td>
<td>29</td>
<td>18</td>
<td>17</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .706 .824 .828  
(61) Discrimination: .030 .120 .308

Analysis of Presentation

Items 1 and 6 dealing with determination of map area and the process of rejuvenation were most familiar to students entering the laboratory.

Restriction of fossil ranges was most familiar.

Greatest gains (items 3, 4 and 5) showed an increase in understanding of processes of erosion, terminology for mode of life and significance of entrenched meanders.

Items 6, 7 and 9 were selected for inclusion into the final examination, Form E.
1. Rocks containing fossils of which of the below would probably be oldest?

<table>
<thead>
<tr>
<th></th>
<th>Form B Pre</th>
<th>Form B Post</th>
<th>Form A Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Sharks</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>b. Dinosaurs</td>
<td>14</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>* c. Trilobites</td>
<td>71</td>
<td>52</td>
<td>56</td>
</tr>
<tr>
<td>d. Ammonites</td>
<td>14</td>
<td>19</td>
<td>26</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .286 .476 .444
(66) Discrimination: .382 .582 .278

2. Rivers of the Great Plains of Kansas are characterized by

<table>
<thead>
<tr>
<th></th>
<th>Form B Pre</th>
<th>Form B Post</th>
<th>Form A Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. many falls and rapids.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b. very steep gradients and v-shaped valleys.</td>
<td>10</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>* c. many tributaries and much lateral erosion.</td>
<td>52</td>
<td>71</td>
<td>70</td>
</tr>
<tr>
<td>d. entrenched meanders and ox-bow lakes.</td>
<td>38</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .476 .286 .296
(62) Discrimination: .354 .515 .114

3. Physiographic provinces are defined on the basis of

<table>
<thead>
<tr>
<th></th>
<th>Form B Pre</th>
<th>Form B Post</th>
<th>Form A Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>* a. a distinctive landscape pattern.</td>
<td>76</td>
<td>71</td>
<td>41</td>
</tr>
<tr>
<td>b. regions being separated by drainage divides.</td>
<td>5</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>c. climate and vegetation.</td>
<td>0</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>d. types of bedrock.</td>
<td>19</td>
<td>24</td>
<td>44</td>
</tr>
</tbody>
</table>

Objectives: Difficulty: .238 .286 .593
(63) Discrimination: .101 .367 .294
4. The great forces that elevated rocks along the Allegheny Front in Pennsylvania and along the Front Ranges of the Rockies in Colorado are reflected in the present topography of both regions. Which statement below is a true one, concerning these forces?

a. Both forces took place during the same geologic eras.  
* b. Rocks of the Allegheny Front were uplifted first.  
c. Rocks of the Allegheny Front were uplifted later.  
d. We do not know the age relationship between these two forces.

Objectives: Difficulty: Discrimination:
(66)  .762  .714  .444
(65)  .324  .374  .198

5. A good indicator of degree of upwarp of sedimentary rocks found west of the Rocky Mountain Front is found in the study of

a. cross-bedding.  
b. mudcracks.  
c. height of hogbacks.  
* d. bedding-plane attitude.

Objectives: Difficulty: Discrimination:
(65)  .429  .429  .370
(65)  .645  .592  .530

6. When viewed on maps showing the east side of the Front Ranges, trends of linear ridges (hogbacks) are seen to be sinuous rather than straight. This is due to

a. depth of stream erosion being varied.  
* b. broad flexures in rock formations.
7. The better-known ski resorts (Vail, Aspen) are located nearly two hours travel time to the west of Denver. The reason for this is that

   a. slopes are steeper, longer towards the west. 38 57 52
   * b. greater precipitation is available further west. 14 29 37
   c. more populous regions are found in these areas. 0 0 0
   d. mountain peaks are nearly twice as high as those in the Front Ranges near Denver. 48 14 7

8. All but one of the terms given below are associated with a combination of rock structure and stream erosion. Which one is not?

   a. Hogback 19 10 22
   b. Mesa 71 62 56
   c. Waterfall 5 14 7
   * d. Floodplain 0 14 15

9. On a certain river in the Rocky Mountains, one sees a V-shaped valley downstream; however, the upstream portion of this same valley is U-shaped. This change in valley shape is most likely due to
10. Which of the following processes has been chiefly responsible for presence of marine sediments a mile above sea level in Colorado?

a. Folding 38 48 41
b. Isostatic Adjustment 33 29 30
c. Intrusion 29 19 22
d. Volcanic activity 0 5 7

Objectives: Difficulty: .667 .714 .704
(66) Discrimination: .576 .522 .502

11. The fact that sedimentary rocks now found at "mile-high" Colorado were once sea-level sediments is best supported by examination of outcrops of

a. Fountain sandstone. 52 38 37
b. Niobrara limestone. 33 48 59
c. Silver Plume granite 5 14 4
d. lava flows at Table Mesa. 10 0 0

Objectives: Difficulty: .667 .524 .407
(65, 66) Discrimination: .192 .534 .442
Analysis of Presentation

Pre-test analysis indicate students scored lowest on geomorphology of Front Ranges area; however, they were familiar with stream characteristics associated with the Great Plains.

Greatest gains were made on items dealing with characteristics of streams of the region, effects of glaciers producing changes in valleys and relationship of Niobrara limestone to earth history interpretation. On items showing little gain (6, 8), it is likely that these questions were too technical so that the information within these was likely overlooked by students. Items 9, 10 and 11 were selected for inclusion into the final examination, Form E.

Achievement Gains - Forms A and B

Form B represents testing of a group of students as they entered the laboratory; the same form was given to identical students upon leaving. (Each week a new group was selected for this process.) Therefore, gains should have been made on the post-tests each week, if learning has occurred, and the response has been assured. The following hypothesis was considered: There are no significant differences in the means of subgroup scores on each unit pre-test, and the means of unit post-tests taken by these same students, in each of the laboratory units.

Significant differences between means of pre-test and post-test scores were found for all laboratory unit examinations except one. Due to low attendance during the last week, it was impossible to obtain an adequate number of cases from the pre-selected random sample, therefore, Unit IX tests were not considered worthy of attention.
Table 4

Determination of T-Test (Critical Ratio)
For Unit Pre-Tests and Post-Test - Form B

<table>
<thead>
<tr>
<th>Unit</th>
<th>Test Form</th>
<th>N</th>
<th>M</th>
<th>S.D.</th>
<th>R</th>
<th>S.E.</th>
<th>Diff.</th>
<th>C.R.</th>
<th>Test of Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Pre</td>
<td>42</td>
<td>4.62</td>
<td>1.36</td>
<td>.74</td>
<td>.187</td>
<td>6.62</td>
<td>Rejected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>42</td>
<td>5.86</td>
<td>1.78</td>
<td></td>
<td></td>
<td></td>
<td>(.001)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Pre</td>
<td>40</td>
<td>3.88</td>
<td>1.98</td>
<td>.52</td>
<td>.296</td>
<td>7.82</td>
<td>Rejected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>40</td>
<td>6.20</td>
<td>1.81</td>
<td></td>
<td></td>
<td></td>
<td>(.001)</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Pre</td>
<td>44</td>
<td>5.89</td>
<td>1.73</td>
<td></td>
<td></td>
<td></td>
<td>(.01)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>44</td>
<td>6.33</td>
<td>1.84</td>
<td></td>
<td></td>
<td></td>
<td>(.001)</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Pre</td>
<td>36</td>
<td>5.36</td>
<td>1.86</td>
<td>.78</td>
<td>.204</td>
<td>4.76</td>
<td>Rejected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>36</td>
<td>6.33</td>
<td>1.84</td>
<td></td>
<td></td>
<td></td>
<td>(.001)</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Pre</td>
<td>37</td>
<td>5.51</td>
<td>1.83</td>
<td>.72</td>
<td>.475</td>
<td>2.59</td>
<td>Rejected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>37</td>
<td>6.70</td>
<td>2.04</td>
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<td></td>
<td></td>
<td>(.01)</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>Pre</td>
<td>41</td>
<td>3.73</td>
<td>1.50</td>
<td>.45</td>
<td>.310</td>
<td>4.32</td>
<td>Rejected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>41</td>
<td>5.07</td>
<td>2.14</td>
<td></td>
<td></td>
<td></td>
<td>(.001)</td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>Pre</td>
<td>33</td>
<td>4.15</td>
<td>1.37</td>
<td>.19</td>
<td>.363</td>
<td>2.74</td>
<td>Rejected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>33</td>
<td>5.15</td>
<td>1.54</td>
<td></td>
<td></td>
<td></td>
<td>(.01)</td>
<td></td>
</tr>
<tr>
<td>VIII</td>
<td>Pre</td>
<td>34</td>
<td>4.18</td>
<td>1.67</td>
<td>.53</td>
<td>.310</td>
<td>3.22</td>
<td>Rejected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>34</td>
<td>5.18</td>
<td>1.89</td>
<td></td>
<td></td>
<td></td>
<td>(.01)</td>
<td></td>
</tr>
<tr>
<td>IX</td>
<td>Pre</td>
<td>21</td>
<td>4.29</td>
<td>1.58</td>
<td>.62</td>
<td>.384</td>
<td>1.60</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>21</td>
<td>4.90</td>
<td>2.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thus, for the first eight units, significant score gains were made in each case by the students. Also of interest were unit correlations between pre-tests and post-tests (Product-Moment, Pearson r). Table 4 shows that correlation values ranged from .19 to .78; however, most values suggested at least a moderate correlation between scores gained upon entering the laboratory and achievement measured upon leaving. This would indicate that many students having better background through
reading, lecture-involvement, prior science courses, or whatever other factors that may govern success in test-taking, will tend to maintain better scores upon leaving the carrel.

Table 5

<table>
<thead>
<tr>
<th>Unit</th>
<th>Test Form</th>
<th>N</th>
<th>M</th>
<th>S.D.</th>
<th>S.E. Diff.</th>
<th>C.R.</th>
<th>Test of Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>A</td>
<td>42</td>
<td>6.40</td>
<td>1.71</td>
<td>.379</td>
<td>1.42</td>
<td>Accepted</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>42</td>
<td>5.86</td>
<td>1.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>A</td>
<td>39</td>
<td>6.21</td>
<td>2.19</td>
<td>.551</td>
<td>0.02</td>
<td>Accepted</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>40</td>
<td>6.20</td>
<td>1.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>A</td>
<td>38</td>
<td>6.55</td>
<td>2.16</td>
<td>.437</td>
<td>1.50</td>
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<td>44</td>
<td>5.89</td>
<td>1.73</td>
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<td></td>
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<td>1.41</td>
<td>.375</td>
<td>0.90</td>
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<td>1.84</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>A</td>
<td>39</td>
<td>5.77</td>
<td>1.97</td>
<td>.474</td>
<td>1.96</td>
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<td>6.70</td>
<td>2.04</td>
<td>(.05)</td>
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<td></td>
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<td>A</td>
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<td>1.78</td>
<td>.339</td>
<td>0.29</td>
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<td></td>
<td>B</td>
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<td>5.07</td>
<td>2.14</td>
<td></td>
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<td>1.54</td>
<td></td>
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<td>1.89</td>
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<td></td>
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<td>1.84</td>
<td>.607</td>
<td>0.28</td>
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<td>21</td>
<td>4.90</td>
<td>2.14</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 5 refers to the null hypothesis stated as follows: There will be no significant differences between the means of student's scores
on unit post-tests (Form B), and means of scores of unit post-tests (Form A) for any given unit. It was shown that the null hypotheses stand for each of the laboratory achievement post-tests, except one.

Tables 4 and 5 together were created to test the effectiveness of the testing program used in the design of this study. Although there is no way of testing for determination of "true" scores on these tests, the following points can be made.

1. All post-test scores were higher than pre-test scores.
2. All, except one, were significantly higher; some at the .01 level and others at .001.
3. Moderate correlation values were realized for most of the unit pre-tests and post-tests.

From this, we may conclude that the practice of pre-testing students as accomplished in this study had little effect on post-test scores. The high critical-ratio value for unit V can only be explained in terms of chance convergence of mean scores, since a survey of test items revealed nothing unusual about item characteristics.

Table 6 shows the percentage of students who were able to score high enough on testing prior to entering the carrel to warrant comparison with post-test scores as a norm. One of the assumptions underlying self-instructional techniques was that a certain number of students were better-prepared than others, hence required less instruction, direction or attention.

Unit IV deserves special comment. The high percentage reported for this laboratory was due to the pre-lab programmed section
Table 6

Student Scores on Weekly Pre-Test (Form B) Compared to Post-Test Results

<table>
<thead>
<tr>
<th>Unit</th>
<th>Percent Pre-Test Students Scoring Above Post-Test Mean</th>
<th>Percent Pre-Test Students Scoring 1 S.D. Above Post-Test Mean</th>
<th>Percent Pre-Test Students Scoring 2 S.D. Above Post-Test Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>5</td>
<td>2</td>
<td>2</td>
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<tr>
<td>III</td>
<td>24</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>IV</td>
<td>36</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>V</td>
<td>21</td>
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</tr>
<tr>
<td>VI</td>
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<td>7</td>
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<td>VII</td>
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<tr>
<td>VIII</td>
<td>20</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>IX</td>
<td>(omitted)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

on biological classification. The high correlational value (.78) also reflected this approach (see Table 4). Since a good share of achievement test for the unit included questions from the pre-lab, this figure was necessarily inflated; however, in light of the large numbers of students
entering the laboratory with advance knowledge on the subject, the programmed pre-lab may be considered a successful venture.

With regard to numbers of students showing superiority in preparation, the table indicates that on the average approximately 20 percent of the pre-test students scored somewhere above the mean of post-tests held as norms; almost five percent of these students were able to score better than one standard deviation above the post-test mean; less than one percent scored better than two standard deviations above post-test means. Or put another way, if the achievement tests designed for these units were used for grading purposes using normal distribution of scores, students could "check-out" without visiting the carrels and the results would approximate 20 percent "C" or better, 5% "B" or better, and 1% "A." Again, the post-test scores are herein considered as normative exams for this example.

**Media Assessment - Form C**

The following presentation shows the results of the mean scores obtained by the semantic differential questionnaires (Form C) administered weekly to a randomly selected group of students:

**Presentation of Data**
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Table 8
Mean Ratings of Five Instructional Media Used in All Units - "Appropriateness"

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Table 10

Mean Ratings of Five Instructional Media Used in All Units - "Interest"

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VIII. Grand Canyon
Table 11
Mean Ratings of Five Instructional Media Used in All Units - "Informativeness"

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Analysis of Presentation

Study of the Tables 7-11 demonstrates the ability of students to discriminate between the various media in terms of liking, interest, difficulty, appropriateness and informativeness. When examining positions of two points on these scales, it must be remembered that in some cases there may be no significant difference between the means reported for each score. For example, if two scores happen to have the highest possible standard deviation reported in the data (1.28 scale for "liking"), they would have to be at least 1.75 scalar units apart in order to be significantly different at the .05 level. And if both points had the smallest standard deviation (.52 -movies in Unit 2), the .05 level would be reached when they are at least .21 scalar units apart. Therefore, in reading the scale, it is necessary to allow for the fact that assessment values within one-tenth (or even two-tenths) of a unit of each other are likely to be not significantly different from one another.

Standard deviations are also a measure of relative student agreement in response to assessment. Standard deviations tended to be larger when media were low-ranked for most units; however, smaller deviations were associated with high-ranked media. The reasons for this observation are not fully understood. From data appearing in Tables 7-11, it is possible that students may have become more critical of the program as the quarter progressed and, since the earlier laboratories tended to rank higher for several reasons, it is likely that an attitude change could cause this phenomenon.\footnote{Wayne W. Welch, personal communication, Harvard University, December 15, 1968.} Welch has been deeply involved in attempting
to establish causes for negative attitude changes discovered in students involved in (Harvard) Project Physics.

Standard deviations for each of the criteria indicate students were most in agreement in assessing level of "difficulty" (S.D. = .64), then "informativeness" (S.D. = .84), "appropriateness" (.93), and in least agreement concerning "interest" (S.D. = 1.10) and "liking" (1.10) for the units as a whole. Possibly, assessment of "difficulty" may have been more uniformly interpreted since students were reporting a degree of frustration, rather than making value-judgments more remotely connected to curriculum-improvement decisions as implied in "appropriateness."

Mean scores can be interpreted in a general way. One observation is that laboratory units in the first half of the program were ranked higher than units in the second half. This statement is based on visual inspection of all the scales in a general way; however, the following tables dramatize this point.

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<td>UNIT II</td>
<td>UNIT VIII</td>
<td>UNIT IX</td>
<td>UNIT VIII</td>
</tr>
<tr>
<td>Informativeness</td>
<td>UNIT IV</td>
<td>UNIT VI</td>
<td>UNIT IX</td>
<td>UNIT VI</td>
<td>UNIT IV</td>
</tr>
<tr>
<td>Liking</td>
<td>UNIT IV</td>
<td>UNIT VIII</td>
<td>UNIT VIII</td>
<td>UNIT VIII</td>
<td>UNIT VIII</td>
</tr>
</tbody>
</table>

Tables 12 and 13 show the paucity of units of the latter-half of the course when all of the highly rated media are listed, and the predominance of these units when low-rated media are also examined in all the units. In terms of the previous statement concerning attitudinal changes affecting data in the above tables, it should be understood also that the nature of the program itself changed after laboratory unit three (see discussion of objectives in Chapter II). At least the evidence gained in interviews suggests that students were not generally as enamoured by a problem-solving situation as they were by the more familiar traditional approach (see pages 158, 160 and 163). Thus, the goals set for latter units may well represent a greater challenge than anticipated in this program, and the emphasis on using media most effectively (movies, for example) possibly should not have been expended on the earliest laboratory units.
With regard to specific media, examinations of the assessment scales covering all criteria show that movies were generally rated highest, followed in decreasing order by slides, earth materials, models, and the laboratory manual. However, this general order of preference did not appear in ratings of media within units. For example, when listing hierarchies of certain media under each of the criteria for Unit V, the following results were obtained.

Table 14

Unit V - Hierarchy of Media According to Criteria

<table>
<thead>
<tr>
<th>Relative Position</th>
<th>Liking</th>
<th>Appropriate</th>
<th>Interest</th>
<th>Informative</th>
</tr>
</thead>
<tbody>
<tr>
<td>(High) 1</td>
<td>Models</td>
<td>Models</td>
<td>Models</td>
<td>Models</td>
</tr>
<tr>
<td>2</td>
<td>Movies</td>
<td>Movies</td>
<td>Movies</td>
<td>Movies</td>
</tr>
<tr>
<td>3</td>
<td>Materials</td>
<td>Materials</td>
<td>Materials</td>
<td>Materials</td>
</tr>
<tr>
<td>(low) 4</td>
<td>(None)</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Table 14 clearly shows an exception to the general rule; movies are not rated first. When all of the units are examined in the same fashion, six of the nine labs are discovered to have nearly perfect order-relationships of media. Units I, IV and VII are omitted from the following table since there are no well-developed patterns in ranking in these units.
Table 15

Laboratory Units Consistent in Hierarchy of Media According to All Criteria**

<table>
<thead>
<tr>
<th>Position</th>
<th>UNIT II</th>
<th>UNIT III</th>
<th>UNIT V</th>
<th>UNIT VI</th>
<th>UNIT VIII</th>
<th>UNIT IX</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Materials(^4)*</td>
<td>Movies(^3)</td>
<td>Models(^4)</td>
<td>Movies(^4)</td>
<td>Slides(^3)</td>
<td>Slides(^4)</td>
</tr>
<tr>
<td>2</td>
<td>Movies(^3)</td>
<td>Materials(^4)</td>
<td>Movies(^4)</td>
<td>Slides(^4)</td>
<td>Models(^3)</td>
<td>Models(^4)</td>
</tr>
<tr>
<td>3</td>
<td>Slides(^3)</td>
<td>Slides(^4)</td>
<td>Materials(^4)</td>
<td>Models(^4)</td>
<td>Materials(^4)</td>
<td>Materials(^4)</td>
</tr>
<tr>
<td>4</td>
<td>---</td>
<td>Models(^4)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

* Refers to the fact that Materials were rated first on the basis of all four criteria, liking, difficulty, appropriateness and interest.

** The laboratory manual placed last in all units.
From table 15 it is apparent that students were able to differentiate between contributions made by various media more effectively on a unit basis and the relative positions were not in accord with overall ratings of media. We may then ask: What is so unique about various media occupying upper positions in different laboratory units? Unit IX is largely dependent upon 25 slides serving as a basis for a "field-trip" across Colorado; models (maps of various types) and materials are designed to contribute to understanding of the slides as each is viewed in sequence. Also, Unit V utilizes a three-dimensional geologic model that serves as a problem in which students spend a considerable amount of time and effort viewing movies and studying materials in order to complete a solution. Laboratory Unit II involves a detailed study of Mt. Airy Granite in various stages of decomposition, and filmed sequences, slides and fragment-filled vials are all contributions to the solution. A large number of fossil specimens are handled in Unit IV, and slides contribute to understanding their characteristics; however, the low rating of the movie for this unit definitely influences the order of media.

These descriptions of units and the nature of their top-rated media suggest that students responded to media assessment within each unit according to the medium that tended to command attention and furnish direction for studying the unit. Even in the case of Unit III, one of the two laboratories in which movies were rated highest, an argument can be made that the unit contains the greatest number of single-concept sequences interlaced effectively throughout the entire laboratory.
In connection with the laboratories mentioned in the preceding paragraphs, it is significant to point out that most all of the high-rated media were judged to be moderately difficult on the semantic differential scale. This is in opposition to what seems to be a general pattern relating media assessment to level of difficulty. However, in many cases it can be demonstrated that students tended to select high ratings for media judged to be less difficult, or the converse was often true.

Highest ratings were given in all criteria to the manual representing the first three weeks, and this part of the manual was judged to be least difficult. The portion of the manual serving Units IV, VIII and IX was consistently rated low across all criteria, yet this same part of the manual was assessed to be most difficult. When examining reactions to earth materials, the first four laboratories shared top scores across all media, with Units I and II rated uppermost in nearly all cases; however, both of these units were rated as least difficult. Slides also exhibited this same trend as top-rated Unit I and Unit IX slides were judged to be least difficult. Movies, however, did not show any such relationship between level of difficulty and ratings. In fact, the movies for Unit IV, rated as most elementary, were judged to be most inappropriate, least-liked, most uninteresting and uninformative. In this regard, the investigator concludes that there is danger in over generalizing these data in evaluation. This view was stated earlier as a result of an experimental try-out of the media assessment questionnaire.\textsuperscript{44}

The assessment scales presented on pages 116 to 122 are the result of a highly experimental instrument, that was used for the first time (according to the knowledge of the investigator) as a means for evaluating media. In using this technique for media assessment the following analysis is indicative of usefulness of the scale.

1. The spread of mean scores was satisfactory for differentiating between points on the scale in all cases except ratings of student assistance, or amount of help sought on attitudes of laboratory assistants. (These latter items were deleted from the report since data were too restricted within the scale.)

2. Standard deviations of attitude responses were effective in estimating agreement of student responses. Such deviations indicated best accord in rating level of difficulty and less agreement in assessing laboratory units in the last half of the quarter.

3. General trends were suggested by these data: however, these trends should be identified in studies similar to this one. Once established, they can be investigated thoroughly. These data suggest a number of areas in which correlations may have existed between media assessment and levels of difficulty. Perhaps attitudinal changes on the part of students affected assessment responses. Or, there is the question of how students normally oriented toward a traditional laboratory program reacted to a program requiring totally different behavioral and thinking processes.
4. More specific trends in terms of viewing these data within each laboratory unit, or in tracing the position of a unit's media across various criteria, were helpful in understanding the effect of instructional techniques on students. The data indicate that students were impressed by media contributing much to the structure of the unit and they were not "overpowered" in making judgments by a universal preference for movies.

5. Specific suggestions in terms of curriculum revision by the students are put forth by these data. Obviously, students were very satisfied with the single-concept films (with the notable exception of the movie for Unit IV), and one should consider the lack of films in the last three units as a detriment to the program. Also, the experimental "tracked-format" used in the manual for Unit VIII as a means for reinforcement did not come out well in the ratings. Further study of the problem of adequate reinforcement should be considered before adopting this format throughout the entire manual.

Finally, it is significant to note that the students were critical enough in their assessment that mean scores did fall significantly below the neutral value of 3.00, as the data show. However, in all of the measurements obtained and represented, less than one percent of the mean points fell below the neutral level.
Forty-five students were randomly selected from the total number (263) completing the General Attitude Questionnaire. Seven forms were returned and, of those returned, five were unsigned, one was checked in all spaces and on another a student indicated refusal to fill it out. Therefore, approximately 95 percent were returned in usable form. Also, after the random sample had been selected from the list of students present during the final examination, three had to be dropped from the sample since attitude data were lacking.

The mean attitude score for the sample selected was 7.18 and the standard deviation was 1.78. Scores ranged from 2.06 to 8.87, with a median value of 7.91. The median was important because of the heavy accumulation of scores toward the upper end of the scale. The statement that corresponds to the median value was \textit{The AVT program has its merits and fulfills its purpose quite well.}

\section*{Analysis of Data}

Students exhibited a positive attitude toward the AVT program. The inherent mean of the attitude scale was set at value 5.50 and this point conformed to the neutral statement \textit{My likes and dislikes for this program balance one another.} Nearly 81 percent of the mean scores were at or above the neutral statement. Sixty-eight percent of the mean scores were bracketed by the neutral statement and the positive statement \textit{Anyone who takes this program is bound to be benefited.} Ninety-five percent of the scores were found between the upper limit and the statement \textit{I could}
do very well without the AVT laboratory.

In a recent study using this scale, it was reported that 68 percent of the mean scores were between the neutral and highest reported positive statement. Considering the fact that the inherent mean and ranges of the scales used in both studies were nearly identical, it is possible to state that college students reacted much more positively in the present study, than high-school students reacted to the CHEM STUDY materials in the study cited. Druger mentioned to the investigator that possibly one quarter of his biology students indicated negative feelings toward his audio-tutorial program, which is patterned after that of Postlethwait. Unfortunately, there are no formal studies available for further comparisons. The only accurate statement that can be made pertaining to this report is that four out of five students in the population cited in this report selected statements from an attitude instrument indicating overall positive feelings toward the AVT program.

It should be pointed out that attitude scores were not significantly different when the sample was grouped according to sex, and a t-test for significance was performed as shown in Table 16.

The hypothesis states that there was no significant difference between mean attitude scores obtained by students when grouped according

45 Sharon Kuhn Corbett "An Investigation of Certain Attitudes of a Selected Sample of chemistry students toward the CHEM study course in Columbus, Ohio, and their reactions toward specific aspects of the CHEM study course" unpublished M.A. Thesis, The Ohio State University, 1966.

46 Dr. Marvin Druger, Syracuse University, personal interview at the National Science Teachers Association Convention, Dallas, Texas, 1969.
Table 16

Comparison of Mean Attitude Scores of Males and Female Students Obtained from Form D

<table>
<thead>
<tr>
<th>Sex</th>
<th>Total Numbers</th>
<th>Degrees of Freedom</th>
<th>Mean Attitude Score</th>
<th>S.D.</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>21</td>
<td>40</td>
<td>7.20</td>
<td>2.15</td>
<td>.071</td>
</tr>
<tr>
<td>Female</td>
<td>21</td>
<td></td>
<td>7.15</td>
<td>1.73</td>
<td></td>
</tr>
</tbody>
</table>

To sex. Table 16 very clearly shows the null hypothesis cannot be rejected. To register a significant difference at the .05 level with 40 degrees of freedom, t would have to be equal to 2.02.

Relationships of Certain Variables to Achievement

Using Stepwise Regression Analysis, the effects of the variables Grade Point Average, Average Time in Carrels and Attitudes Toward the AVT Program were tested. In this section, data from the final examination based on Form E (see appendix) are presented first as the criterion variable. This, in turn, is followed by data from, and analysis of, the remaining variables.

This analysis was performed upon 42 cases randomly selected from the population during the last week of the program.

Achievement - Form E

The mean achievement score, as measured by Form E, was 16.11 and the median score was 16.0. Scores ranged from 5 up to 28 on this
30-item test. A Kuder-Richardson reliability estimate of 0.675 was obtained which, when corrected by the Spearman-Brown Formula, ultimately yielded a value of 0.861 for a hypothetical 90-item examination. Mean item difficulty was 0.463 and none of the items discriminated negatively. Thus, the selection of items from each of the unit tests to create a final examination of good reliability and average difficulty has been a success.

Grade Point Average and Form E

G.P.A. scores ranged from 0.91 to 3.58. The mean was 2.35, and the standard deviation 0.543. These scores were drawn from undergraduates primarily, and the mean number of quarter-hours accumulated by the end of Winter Quarter, 1969 was 76.9, ranging from 13 to 194.

The correlation between grade-point average alone and achievement was 0.598. The calculated value of t, 4.82, was much larger than the required value of 2.85 or greater to establish significance at the .05 level. Since the AVT program was designed to serve the needs of general education, the fairly high level of correlation between success in the total university situation, as measured by grade-point average and success in Form E, points out that the program had a wide

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appeal. One may assume that a variety of thought processes are involved in the many disciplines presented to undergraduates. If the final were to reflect a type of reasoning, skills or conventions peculiar to neology, one would not expect much of a correlation to exist.

Average Carrel-Time and Form E

Average carrel time varied from one unit to another as shown in Table 17.

Table 17

<table>
<thead>
<tr>
<th>Unit</th>
<th>Low</th>
<th>High</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>35</td>
<td>100</td>
<td>69</td>
<td>70</td>
</tr>
<tr>
<td>II</td>
<td>15</td>
<td>195</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td>III</td>
<td>45</td>
<td>220</td>
<td>83</td>
<td>75</td>
</tr>
<tr>
<td>IV</td>
<td>40</td>
<td>210</td>
<td>76</td>
<td>70</td>
</tr>
<tr>
<td>V</td>
<td>40</td>
<td>212</td>
<td>97</td>
<td>95</td>
</tr>
<tr>
<td>VI</td>
<td>45</td>
<td>215</td>
<td>82</td>
<td>80</td>
</tr>
<tr>
<td>VII</td>
<td>35</td>
<td>180</td>
<td>73</td>
<td>65</td>
</tr>
<tr>
<td>VIII</td>
<td>60</td>
<td>270</td>
<td>114</td>
<td>100</td>
</tr>
<tr>
<td>IX</td>
<td>30</td>
<td>210</td>
<td>74</td>
<td>67</td>
</tr>
</tbody>
</table>

Table 17 indicates very few students actually spent two hours during weekly visits to carrels; in fact, the percentage of students spending two hours or more for a particular unit reached a high of 22
percent in Unit VIII, then dropped to 18 percent in Unit V, 12 percent in Unit VII, and below 10 percent for the remaining units.

Correlation between average carrel-time and achievement measured by Form E produced a small and negative \( r \) of \(-0.076\). This value is not significant since \( t \) is 0.61 and 2.65 is needed for significance at the .05 level.

Attitude and Form E

The average attitude score measured by Form D was 7.19 with a standard deviation of 1.81. Attitude scores ranged from 8.83 to 2.06.

Correlation between attitude and achievement as measured by Form E yielded a positive correlational coefficient (\( r \)) of .150. The value of \( t \) in this correlation was 1.42, which was not significant (.05 level) for this study since it was lower than 2.85.

Analysis of Achievement and All Other Variables

Coefficients of correlation resulting from Stepwise Regression performed on the data from the random sample concerning achievement (Form E), attitude (Form D), Grade-Point Average and Carrel-Time appears in Tables 18 and 19.

Table 18 shows the best indicator of achievement (grade-point) was followed by attitude, and then carrel-time. The B values, representing weights based on standard scores indicated carrel-time contributed to multiple \( R \) by a factor of approximately 8 to 1; whereas attitude was 4 to 1. The independent variable attitude, although not
Table 18
Correlation Matrix, Form E and Variables

<table>
<thead>
<tr>
<th></th>
<th>G.P.A.</th>
<th>Booth Time</th>
<th>Attitude</th>
<th>(Criterion) Achievement*</th>
</tr>
</thead>
<tbody>
<tr>
<td>G.P.A.</td>
<td>-.265</td>
<td>-.056</td>
<td>.599</td>
<td></td>
</tr>
<tr>
<td>Carrel Time</td>
<td>.061</td>
<td>-.076</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitude</td>
<td></td>
<td></td>
<td>.150</td>
<td></td>
</tr>
</tbody>
</table>

*Achievement (Criterion)

Table 19
Prediction of Achievement (Form E) From Attitude (Form D), Average Carrel-Time and Accumulated Grade-Point Average

\[ R = .631^* \]
\[ R^2 = .398 \]
\[ N = 42 \]
\[ F = 8.38 \]
\[ p \, F(df=3,38) = 2.85 = .05 \]

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>r with criterion</th>
<th>B</th>
<th>b</th>
<th>t</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade-point (Accum.)</td>
<td>.598</td>
<td>.6298</td>
<td>.4801</td>
<td>4.82</td>
<td></td>
</tr>
<tr>
<td>Avg. carrel time</td>
<td>-.076</td>
<td>-.0798</td>
<td>-.0042</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>Attitude</td>
<td>.150</td>
<td>.1795</td>
<td>.4113</td>
<td>1.42</td>
<td></td>
</tr>
</tbody>
</table>

*Multiple correlation coefficient resulting from placing all of the independent variables in the analysis:
significant in this study, contained the possibility that a larger $N$ might increase $t$ to a significant level since the obtained value was not much below the required level.

On the basis of these data, the variable of grade point average was the best predictor of achievement in the AVT laboratory. If, however, two students with identical grade-points were considered, the next best predictor included bi-variables grade-point average and attitude. The data suggest that the average amount of time spent in carrel use contributed least to achievement.

Academically successful students spent less time in carrel study and achieved better than other students. They may naturally also tend to be somewhat more critical of the program. On the other hand, students who are less successful academically spent more time in the carrels, achieved less, but were more responsive to the program since it provided an open schedule, assistance, and the opportunity to proceed at a slower pace if desired.

**Open-Scheduling of Visits**

Carrel cards contained records of the visits made by students. The degree of accuracy in record-keeping was at a high level since the investigator and laboratory aides, in particular, personally handled the cards as students entered and left the laboratory. On the average, perhaps three to five cards per laboratory unit contained errors or omissions.
Students were asked to arrange visits at their own convenience between 8:00 a.m. and 5:00 p.m. on weekdays, and 7:00 p.m. to 9:00 p.m. on Monday and Wednesday nights. The following figures represent patterns of student visits in the 10:00 a.m. lecture section. Lectures were held on Tuesdays, Wednesdays and Fridays, with an optional "movie-day" on Mondays.

Analysis of Visits

Figures 8-11 were selected as typical graphs of patterns of visits to the laboratory. Students did not appear at optimal times despite advice given in lecture meetings. The graphs show they visited in large numbers at the end of each week or during peak hours of the day. The graphs do not show the numbers waiting in line during these times. Most curves were bimodal, with mid-morning and afternoon peaks. While interpreting these graphs it should be kept in mind that the 10:00 a.m. lecture section met Tuesdays, Wednesdays and Fridays, with an optional "movie-day" on Mondays. Also, students in the 8:00 a.m. lecture section were able to pre-empt carrels on Thursdays and Fridays by virtue of their proximity to the laboratory.

Fig. 12 shows population decline based upon periodic lecture attendance and examination roster checks (see dotted line). The dashed line, representing the number of students completing weekly units also shows a steady decline. Fig. 14 depicts attendance in terms of percentage. The changes in slopes of all these lines may be related to a
Fig. 8: Carrel attendance during the first week of instruction.
Fig. 9: Carrel attendance for the third week of instruction.
Fig. 10: Carrel attendance for the sixth week of instruction.
Fig. 11: Carrel attendance for the ninth week of instruction.
Fig. 12: Number of students completing each laboratory (dashed line) and estimate of population during the program (dotted line).

Fig. 13: Number of carrel visits each week.
Fig. 14: Percent of students not completing laboratory units.
number of factors. No doubt mid-quarter examinations given during the third and fourth weeks and the fifth and sixth weeks were a factor. Also, the level of difficulty and length of each laboratory affected attendance. Fig. 13 shows students made the most number of visits in the third week; however, there are peaks during the sixth and eighth weeks that suggest a high number of multiple visits were made by students during these times.

Audio-Tape Interviews

Three categories are represented on the following pages, 1) Laboratory Materials and Manual, 2) Individual Instruction and Assistance and 3) General Comments. Each comment within quotes was taken from a separate interview. Also, a few selected interviews are presented in their entirety. In all, 35 students were interviewed for this part of the report.
"I thought that the earth materials, the rocks, the fossils, and the minerals were the most interesting labs that I took and they were the most /sic/ easiest to follow. Also, the films and the slides were very colorful and they helped explain a lot of the written material in the lab manual. The area that I did not like very well was the topographic and geologic map part, mainly because I could not follow it myself and I just hated to keep asking the lab assistant over and over again to explain it to me, . . . maybe a group would have been better in this area than just doing it by yourself . . ."

"The movies were excellent: I really enjoyed them. Maybe there could be a few more of them. The slides were adequate. That, I thought was lacking in a great degree: there wasn't /sic/ enough slides . . ."

"On the whole, I really think that all the labs were very good, except for that one that was the longest one - that had the pre-lab with the little yellow pages, programmed pre-lab, and all that. I think it was completely useless. I got really frustrated, it was so long and I don't think it applied to any of the things that we took, and I hated it, but other than that the labs were O.K."

"I think the way the laboratory was arranged for this course was extremely beneficial because the students were given some freedom in which they could use the laboratory at any time they wished and did not have a scheduled time when they had to do the lab . . . I felt that the lab manual was very good; it was explicit enough . . . easy to understand . . . not hard on the students to come in and do the lab by themselves without a great deal of assistance."

"I think the films are good; they always relate. The slides are good, too, especially these last ones are beautiful. The maps are a little bit confusing. There are so many of them at one time. I think it could be cut down to fewer maps, or one comprehensive map would be better."

"All the earth materials, the films and slides were more than adequate. I think I've learned more this way than I would any other way. Everybody's been more than anxious to help me, and I think this course, I mean the lab session, helps people to think for themselves . . ."
"I think the films are very good - detailed, short, easy to understand and easy to follow. Also the slides were pretty clear and they weren't very complicated and they were easy to understand and easy to follow . . . . The topographic maps were very good, easy to follow, not too complicated and I learned a great deal from them."

"I felt that all the materials, the rocks and the fossils and minerals, were pretty well arranged and pretty well provided . . . in the beginning the films were pretty good, but then the films tapered off and the last three or four lessons there weren't any films, and this sort of took away from the interest involved. The films were sort of a treat and that's one reason I liked to come. The slides were good . . . there should have been more. There was [sic] only three or four slides for each lesson, and I thought this was kind of poor. The maps were good, but again I lost interest when we got to the map part. I thought that was kind of boring."

"The slides and films were beautiful, they were really interesting; they helped a lot. The lab thing [manual] that was put together was easy to understand, but the worst thing about it was that it didn't seem to tie in with any of our lectures and things. It was really hard to understand; you had to do a lot of it on your own. Otherwise, it was O.K."

"The slides, films, and earth materials are all good. The laboratory itself I've enjoyed. I think it's one of the better labs I've come to because you can go at your own pace. I think that the one section in the lab that has to do with fossils, . . . is in the wrong place. It should be placed somewhere else, it just didn't seem to fit in at the time . . . I have enjoyed the way it has been set up. I think I've found it more interesting than most other science courses."

"The earth materials, rocks and fossils and minerals, have been exceptionally helpful. Films are good, they keep your attention. The same with the slides. The maps and topographic and geologic maps are unbelievably easy to follow because the course is designed for that."

"The geology lab, the film part, was instructive. It was good because you could always show the film for two or three times if you didn't understand it the first time . . . earth materials, the rocks, the fossils, and the minerals . . . were good because . . . you noticed that they [materials] could change; you knew that you had to test them . . . because you realized that they didn't always look the same all the time, . . . you would not have known this with just a one-hour lab or if you just looked at one specimen . . . we had several specimens . . . and could see how they changed from specimen to specimen . . . . The slides were good because you could repeat it [sic] and that was especially helpful on the topographic map part because that part was the hardest for me to understand, and being able to look at the slides again helped me learn that much easier . . . ."
"I think the films and the slides helped very much in the lab. They tended to point out various things needed to help us understand the . . . lab. I was quite interested by the topographic and geologic maps . . . ."

"The laboratory's programs were well correlated with the book; however, because of the lack of an instructor . . . I thought it was hard to follow the material. Topographic maps and fossils . . . was /slg/ hard to understand. The films and the slides were coordinated well and the instructors were always there; however, this material was way too hard."

"As far as the AVT laboratory program is concerned, the materials we have (the rocks and fossils) are very interesting. The slides are very interesting, and they do help quite a bit because you can see exactly some of the formations and geological processes that we have been talking about in class."

"I think the slides and the films have been helpful and it's good to see the things that the labs talk about. I think the schedule is best. You can come in when you want to because it's to your advantage when you have less time. I think the labs have been clear, for the most part. The rocks and other specimens have helped and the maps have been good."

"I thought the earth materials, the rocks . . . fossils and minerals, were interesting because they related to the different parts of the country where they are found in the map sections, and the films and slides were useful, . . . The laboratory assistance was excellent. I never had to wait more than a few seconds if I needed help."

"My feelings about the laboratory the past few weeks have been mixed. Section 8 I found pretty difficult - the part about the fossils . . . The first part Unit VII wasn't too bad, but the last part I didn't care much for. I think maybe we could have had more films or slides for the last part of Section 8. The last laboratory, Laboratory 9, I found much more interesting than the last few and the slides were real good. The maps were good on the last one Unit IX . . . easy to follow, and maybe we should have had some answers to help us on some of the things, because it's hard to get help."

"I thought the films were pretty good. They were very interesting; however, sometimes it was kind of aggravating when they were inoperable, but on the whole, I enjoyed them very much."

"The films are excellent in showing the places that you normally couldn't see unless you travel there by yourself. And the slides in being able to go back and look at them if you don't understand something whereas in a classroom lecture it would pass by and you would never be able to go back unless you consult the teacher after class . . . the only objection I would have would be . . . fossils we studied before we got to them in the text, but it made the text reading easier."
"I think the films and the slides are very good. . . . It's better than just reading material . . . And the rocks, and fossils, and minerals; it's good that you can have them in the lab and everything. You can look at them and know what's being discussed in the lab."

"The materials, the rocks, the fossils, and the minerals were very good because they were right there and you could see them. The films were excellent, I feel that I learned quite a bit from them. The slides were also good. The maps were at times hard to understand and . . . I would look for a long time to find a certain city or feature."

"I think the films and the slides of the laboratory program were excellent . . . It [sic] helped me to understand them much easier, understand the different things that were being said, . . . especially when it came to the rock formations, how they were formed . . . and everything. I think it [audio-visual instruction] was a great help . . . slides . . . should be numbered. Many times I went through two or three slides before I realized that the slides I had projected started from the back; people hadn't fixed them so they would start from the beginning . . . But I thought the slides were excellent, and I think that they were a very good part of the program, and I learned more from them . . . than anything else."

"I think the films and the slides were very helpful. I wish we would have more of them. I think materials were interesting, but not adequately defined. They need to give more examples, and give better explanations as to how to recognize these examples. The maps were good, but they didn't go into enough detail. They weren't studied long enough. Assistance in lab was very good. You got help whenever you needed it, and at times when you even didn't want it . . . Self-instruction is alright. There are times when I could have used a little more help . . . a little more help from the manual in explaining things to me, giving me a better definition, and go [sic] into more detail . . ."

"The slides were very interesting. Some are just . . . a waste of time, but basically they are very tightly drawn; they hold your interest, maybe just out of curiosity, but they still help out tremendously in your lab work."
"The laboratory assistance was very, very good. People came and asked if we understood everything; I thought that was really very good. As far as self-instruction goes, it was good if you're that kind of a person, but I think it depends on the kind of person you are too, as to how much you get out of it . . ."

"Self-instruction, . . . was very good because it made me . . . think more for myself than having it told to me and in other ways it was . . . a hindrance because you didn't like to think of things like this many times. But the instructors . . . and the assistants of the laboratory were of great help because they did come around and explain things to you which I felt was really great . . . I felt the lab was more educational to me than the lectures and it helped me to understand the textbook a lot more . . ."

"My only comment would be that I would prefer a classroom discussion type because of the information that could be gained from other students and their discussion. In the self-instruction laboratory, if a student isn't sure of an answer, he can look at the answer and find it, but he can't have an in-depth discussion of how to arrive at this answer. If he isn't sure of it, he can ask the assistant and get the answer, but he cannot arrive at it in a methodological way . . . as in a classroom discussion. That's my only criticism."

"All the lab assistants are great, but I really felt like a "klutz" asking for their help all the time. I felt kind of stupid because there the thing was right in front of me."

"Laboratory assistance . . . was good. The teacher's assistants were always willing to help you. . . . maybe the average student or any student . . . needs . . . more assistance. Because these laboratory assistants have so many people they have to see and help that small group discussions . . . could help people on problems that you can't . . . discuss with the assistant in a short period of time."

"Laboratory assistance was very good . . . Self-instruction is . . . easier and you're not really pushed to learn. It's not hard to follow and . . . it makes learning more fun. The open scheduling of visits . . . is a pretty good idea mainly because you don't have to strictly schedule your time . . . You can just . . . go in when you have the time . . . Overall, I think the whole lab is pretty decent."

"The laboratory assistance was fair. I don't think it could have been too much better, but sometimes it was hard to get anybody's attention. The idea of self-instruction was good and . . . the best part of the lab was the fact that you could go anytime you wanted to and usually didn't have too much trouble getting a lab booth."
"I think laboratory assistance here is good. Sometimes there is not quite enough of it. There were one or two or even three lab assistants that were sometimes always busy and you can't always get assistance when you need it, but generally when you do get the assistance it is very good."

"I think the answers should be posted and . . . a small group discussion would be good in the course because it would help us to understand it better. But I like the self-instruction method because it gives you a chance to do it at your own speed. I like the AVT instruction because . . . it's a better way of learning than doing it in a big group. There was always a laboratory assistant if you need it."

"I thought that the whole carrel system was very fine. You had a way to get into it and you weren't bothered by other people coming up to you all the time to see exactly how you were doing. You were more or less up to your own which is the only way you will be able to learn in this sort of situation."

"I think the labs in general have been helpful. I haven't been able to attend as many as I would have liked to, I'm about three behind right now. I . . . am not the most disciplined student in the world and the idea of the AVT (doing it whenever you'd like to) would be better for someone more disciplined, . . . because . . . I procrastinate. I imagine most people are the same way, and that's why I am behind on some of my assignments. The course in general, I think, is very good."

"I feel that the films and the slides that are presented here are very helpful in the labs. The maps have also been very helpful . . . topographic and geologic both . . . Coming to a lab where you are your own, it's difficult, but with the help of the instructors that are here, it makes it much more easy. If there were more instructors, perhaps this would be better. Because when you run into the difficult parts, . . . if there were more assistants here, this looking at answer sheets wouldn't be necessary. The open scheduling . . . has been . . . good, for you don't have the pressure of finishing the lab during a certain period. You can come in any time you want, any time you are free between classes and so on and work it out. If you don't get done, come back during another time."

"Regarding the laboratory assistants, . . . every time I asked the lab assistants for some help, they were more than happy to assist me, and they kept coming back to see if I had any problems. They helped make the labs much easier and all of them should be commended for it. They really did help me a lot. Without them I don't think I could have gotten through the labs."
"The lab assistance has always been real good. The graduate students are more than helpful, which is good because the labs are complicated and you do have to concentrate on them. It is a lot of self-instruction and it's up to the individual if they want to understand it or not. I mean you can come in and just look at the answers; if you spend the time to understand it you will learn a lot more. This says open scheduling of visits is very good because with everyone's different schedules it's hard to get in here every week and it's nice that you can come over here at your own convenience. Also, whenever you feel like learning geology you can come over and learn it when you feel like learning it — when you're in the mood for geology."

"I would say laboratory assistants leave something to be desired. Sometimes these individuals looked upon you as being somewhat dumb or below them. They didn't try to help you very much. But the self-instruction I was especially interested in. I enjoyed it very much. I would prefer learning myself and only calling on help when it's necessary. This goes back to the previous condescending assistants, and you hesitate to call on someone if they don't show an interest in you and try to show you where you've made your mistakes."

"I think the laboratory assistance was very good. Whenever I had a question, they were always willing to go into pretty detailed instruction with me. The first couple weeks I had trouble with scheduling. I had to stand in line several times, and this can be a little annoying. But after the first two weeks, it seemed that there were always open times. If I had to wait, it was only for a couple minutes."

"I find that the earth materials and films and slides and maps are all very excellent; however, what I find lacking is the personal contact with your instructor. You're left all by yourself. You don't have anyone that you feel close to, that you can ask questions. Sure, the laboratory assistants were always willing to help, but I don't like being enclosed in a carrel all the time. I have enjoyed the course very much."

"The laboratory assistant was helpful in some ways, but I couldn't understand many of his comments, his nationality or something. I criticize it, but I guess I have learned in some ways, like today I came in and I couldn't find some of the information right away. Now when I'm getting into it, I'm beginning to understand it a little bit. I think we should have possibly had some kind of further instruction about this, cause we'll go in and we'll have a test on it and our lecturer doesn't relate his lectures at all to this and we're given questions on the test and I have a hard time recalling some of the information because he doesn't relate them."

"I would like to say that self-instruction is more important in the AVT laboratory program and it enables you to pace yourself at a rate you feel is most adequate, especially in handling the rocks yourself and looking at them with a magnifying glass."
"I think that . . . open scheduling is a good idea because sometimes . . . you can come in and do the lab instead of worrying about . . . how to schedule this around this, and . . . to do it at a certain time. I makes it kind of convenient. I think the materials is presented very well. The only complaint that I do have is the impersonality of the whole program . . . there isn't enough instructor-to-student relationship, and you don't exactly know what is the most important thing that you should learn and what should be stressed and what shouldn't be stressed. The lab assistants do a good job of answering questions . . . but sometimes you are . . . in too much of a hurry and I . . . just don't want to take the bother to ask the lab instructor. They'll [other students] just copy the answer down off the sheet and just not worry about whether they have got it right or not, and check with a couple of friends and see how they did."

"I think everybody seems really very helpful . . . They answer your questions as best they can. I've had lab assistants that have stayed with me practically the whole time I was here because I didn't understand anything."

"The laboratory assistance was generally good. At times I felt they didn't quite explain enough to me. The idea of the self-instruction was good. The open scheduling of visits was good because I could come in when I was able to . . .; however, sometimes I felt the certain lesson for the week was a little too long cause I would spend at least two hours in here and I would get frustrated at the end."

"The laboratory assistants are very helpful; they are always walking around trying to help you, and the manual was very easy to understand. I liked the idea . . . that I can come any time I want. I usually came on Monday. Alot of times I couldn't, and I could come on Friday then."

"The laboratory assistants are very helpful, they are well qualified. If you are stuck on any program, they will gladly assist you; but most of all, the self-instruction is very well explained. The assistance is not needed, generally. The advantages that I see of this program are that you learn at your own rate and you may stay as long as you want. The only way you can learn is by doing, and in the AVT program you learn more . . . than if you were being taught by someone else."

"I like the idea of being able to work at your own speed and not having anyone really pressing you, making you hurry or slow down or anything else. It's the way you want to do it yourself. I think you can learn more this way than having specific schedule that you have to follow. Having it the way that we did in this laboratory . . . you can go along at your own speed and the material is usually really helpful."
"You get a lot of laboratory assistance whenever you need it; there's always somebody there to help you. The lab manual is set up so you can't get lost and you learn something out of it. The AVT instructions are to my advantage because they help you learn on your own and there is always help if you need it. The lab manual always goes along with the text and lectures of the week, and the book helps."

"I feel that . . . self-instruction is good in that it gets each individual to come to lab and to figure out things for himself, but sometimes I think you begin just looking up the answers and are not really understanding what you are doing. It . . . gets to a point where you're guessing and you're not understanding the full value of it, and I think this would be the only value of having an actual instructor working right with you for the full time. . . ."
General Comments

"I think the main advantage in the AVT instruction is that the student is able to go at his own rate of speed and the fact that he has to organize himself... to dig out the material himself helps him to learn better than if someone stands up and lectures to him."

"I think the AVT lab is good. It presents material in a manner that can be easily understood. I think the open scheduling of visits is extremely good. You can work it into your own schedule, do it whenever you want, take your time on it."

"I think the idea of being able to work it into my schedule is very helpful, ... any time during the week I can come in is fine ... The stuff is always here and if you're a little behind you've got the one set up so I can work last week's lab, and this has happened a couple of times. And I've always found all the equipment here, and I feel that this is much better for me than just the regular laboratories I've been used to. I can work at my own pace and there is always someone around to help when I need it."

"As far as the relationship to the text and the lectures, I think it follows pretty much. I think the lab is good. I think this way of doing it is better than ... having it maybe in a group, because if you take time you can spend as much time as you want and you can look at the slides as many times as you want - the films, or anything else there is. So I think the lab is a really good idea."

"I would prefer this type of course to a text-oriented course in that I feel I know so much ... useful information for going out in the world and seeing things around me and knowing what's happening. It's much more related outside the university and outside of the textbook."

"Actually being able to look at some of the rocks (there seemed to be plenty of samples) some things I didn't understand, and there seemed to be help around. I'm not a geology major or anything like that, but the way lab was run made it a little more interesting for me and made it seem a little more worthwhile. ... I just felt ... I was really getting something out of the course because of this individualized instruction. And overall I think it's a pretty good program."

"I enjoyed the lab so far pretty well. I feel ... that I may have been able to do a little better if I would have been in a laboratory with a regular instructor and some more classmates. But the material that was presented here in the lab and that material that was available for us for this AVT instruction was ... organized very well. There was never any time that I was really hung up on anything. I had plenty of help with the laboratory assistants, and the maps were very good."
"I feel that the AVT lab has been of sufficient help to me. I think the films have been very good and the rocks and fossils and things have been better than what I have noticed in the pre-packaged samples that the other classes have used."

"I found the slides and the films rather helpful. Occasionally I had to go over them maybe two or three times in order to get the material. But on the whole, I really enjoyed the AVT program and I think it's alot more to the advantage of the student to do it this way than by having a regular laboratory session."

"Well, I think that . . . I learned alot more than I would have out of a regular - say biology or zoology lab-type course where you work more so in groups than you do individually. And I feel . . . I've had to search for the answers and find them on my own, rather than letting someone else do them."

"I feel that this course has been fairly informative. I think it would probably be more interesting than the other lab from what I've gathered from other students."

"I feel that this AVT laboratory has given me a much better chance to understand the material. It seems that I work much slower than many people and this laboratory gives me time to spend as much time as I want to examine the material until I'm sure I'm familiar with it and a much deeper level of understanding in this manner."

"During my participation in the laboratory program, I've found that the laboratory experiments have been very interesting, something that wasn't offered in my high school or junior high . . . I was able to work at my own pace without having to . . . work . . . in a group. I was able to take the things that I was interested in, such as fossils, I was able to work more with this or in the areas that I was interested in rather than working in different groups."

"I found that the first half of the lab section was very easy. I enjoyed the films and the slides and I enjoyed coming to lab. They explained everything and I could take my time, whereas probably with a lab class I would have just one hour to try to understand all this . . . I'm a slow person in learning and I need all the time I can get. But I also find that this last half is very hard and difficult."

"I think the AVT lab is a real good program because you . . . work by yourself . . . with all the helpful movies, slides and maps. And with the assistance you really get a chance to help yourself. Also . . . you can come in at any time. I've come in the evening classes a couple of times and it was real quiet and the assistant could give you more help if you needed it. I think it's a real good course. The films are . . . well presented and the slides show just what your particular lab for that week is about. Personally, I think it's a real good idea. I'm glad I got this course."
"From the very beginning, I really liked it because we had all those rocks and the lab was really interesting. I could really figure out the answers on my own, but when we got to the end of it (the maps) I didn't like it at all because the lab became confusing and I couldn't find anything on the map that the manual was asking for."

"On the whole, I thought that this course was well-prepared. If you wanted help or anything, it was always available. All the people in here were very courteous and would help you with any problems you had. I like the way that you could come in and take this whenever you wanted to or review it again, so you could be sure you got it."

"This course is really interesting. I like it a lot better than the ordinary lab where you have to just go in and sit down and identify rocks. I think I've learned more this way."

"I think this laboratory has been a waste of time completely. I don't see the use for it."

"AVT labs really help me so far, it's kept my attention and I've learned something through them, I think more than I would through a lab with the instructor."

"The only thing that isn't good is that the labs aren't always related to the text or to the discussion. I think it might be better if we'd have a recitation time to go over some problems that we come across in lab and tie them in with the text and the lectures."

"I did very well in the first few labs, but in the last couple of weeks I have really gotten lost because the lecture is going quite fast and with trying to read and finish the book I'm getting everything kind of confused. And by the time I get into lab and it says: "Do you remember reading such and such? I don't remember reading it and I don't really know what I'm doing. Other than that, the lab has been very helpful and I enjoyed just working by myself on the things. I don't know if it was too much material or too fast. Maybe I didn't retain enough from the first labs to carry over, but I'm pretty lost and I'm not too satisfied with the last two weeks of lab work."

"I found these labs very helpful. A lot of times I read the chapters over and I didn't quite understand what they were about. Then I would go to the lab on Monday afternoon, spend as much time as I liked. And then I reread the chapters and everything just seemed to fit together - the films and the slides were very helpful in explaining what everything was about."

"I think the AVT lab is very helpful and I like the open schedule because it just allows for more freedom when you come in, but complete more work in one day. It allows freedom that way. The lab assistance you get is quite helpful. One good thing about the course
is the materials and the slides . . . because you can actually see the formations of the rocks. You can examine different geologic concepts as they are and I just think it's very helpful."

"I feel that the Geology 100 AVT lab this quarter has been very beneficial. I thought that showing slides and movies was very good way of taking it off paper and putting it as if you were actually there studying it. I feel, however, that the course could have been better if possibly there would have been a little more small group discussion or something because the difficulty of each lesson does get progressively higher as you go along. And the last few lessons, I feel, were particularly difficult."

"Basically the system is very well set up. You get all the help that you need, all that you want. The films that we have are set in very closely with the material that we use . . . such as the material that we used from the Rocky Mountains and the maps . . ." 

"I think, the slides and films really help you to see some of the things that are very hard to picture without the use of the visual aids. I think overall the program is alot better than the ordinary laboratory."

"I thought the lab wasn't coordinated . . . as closely as it could have been and I really miss . . . the relationship that you have with fellows in a classroom. And I didn't really enjoy the lab as it is this way as much I think I would have if it would have been in class. I think perhaps I would have even paid closer attention if it would have been in class."

"My problem has been to integrate the whole thing, to correlate all of the little bits of knowledge . . . and put it all together. I don't seem to be able to do this very well. Some of the labs have been very successful and . . . with others I don't think I've learned too much. The . . . more recent labs (the ones towards the end) I seem to have gotten more from. I think at the beginning you don't really understand what's coming off half the time. Maybe they should have a larger section explaining things or something. Maybe I just haven't put enough preparation into it."

"I think the program was beneficial. It's just that after about the first three weeks, I let myself get behind and therefore the labs weren't quite as meaningful as they could have been and they've become more complicated. I'd like to see . . . a help session set up where once a week we could go and have help in the lab work. Other than that, I've enjoyed it and I think it's interesting."

"One disadvantage I see in the program is that the lectures and the text do not closely tie in to the lab. You go into lab (say on a Monday) and the material that you will discuss in class that week is not
closely tied to the material. I would suggest that the program be set up so that you discuss the material beforehand . . . and then the following week you discuss it in . . . lab . . . .

"It would have been alot better if . . . on Thursday (the day that we didn't come to class) . . . we could have met in small groups and discussed what was talked about in lecture and what we did in lab. . . . Otherwise, for someone who isn't going into geology, the course is fairly decent."

"First of all, I think the AVT laboratory program is worthwhile but I think there are some areas which could be improved. The films and the slides . . . are a lot of help but I think there is something lacking. We seem to be at sort of a disadvantage because we don't get the help that the students who are in the regular labs get, and yet I think it's a better program than the regular program, but I think there's a need for more supervision; there's just something lacking. I think that the solution to this problem is to have maybe one recitation per week for the AVT students, or something along this line. Somewhere where they could get together and discuss things and ask questions and clear things up."

"I think the one thing that might be lacking is the small group discussion when we could get together with other people taking the course and discuss different things to find out how they feel about the course and about rocks and geology in general . . . ."

"First of all, I think that the answers should be posted because if you make a mistake at the beginning of the lab and you're not sure of it, then it can influence the whole lab and throw all your answers off. And so this way you can double check; if you do make a mistake, you can correct it."

"I think the answers should definitely be posted because it helps when you know where you are. I don't believe in cheating or looking on the sheet before you've answered the question, but I think that in this last lab with no answers I wasn't quite sure so I wished I could have known exactly what they were."

"As far as the scheduling of visits, I think I would like to see more evening times open because, the way your classes are scheduled, if you come in for the lab it is quite crowded and you are not able to get in towards the latter part of the week which again makes it more difficult getting in. So I think if there would be maybe three or four nights during the week that you could come in for the lab."

"The relationship to the text and lectures was good . . . The lab went along pretty much with your textbook. The lectures were sometimes harder to find in the book and in the lab. The lectures were a little bit different, they didn't always follow just right with what you were studying but more or less they did. Sometimes Dr. Meyer would be a little
bit ahead of us, and then sometimes maybe he'd be a chapter behind us, but the idea was if you read ahead then you could understand the lectures alot better. The lab is probably easier to understand than lectures because you can stay here as long as you want whereas in lectures you've got 45 minutes and you can't see the movie over again or you can't see the professor over again."

"I think perhaps the text covers the material we need for lab, but the lectures don't seem to correlate . . . the lectures in the early part of the week aren't along with the lab, so if you're going to lab in the early part of the week you don't have enough material really from lectures to do the lab."

"Relationship to the texts and lecturers is fairly close. I think the lab could be added to by a little touching on it in the class . . . to sort of explain the parts where most students have trouble."
"I'm a former AVT lab student, I took it the first quarter it was offered . . . and I've been asked to make some comments on what I think of the program. I am now enrolled in Geology 102 (having skipped the 101 course) and I think that the AVT lab helped me immensely in . . . 102, and that I knew more of the processes that were going on, and was able to correlate the things that we were learning in this lab better than if I had had the regular course. I also appreciate the AVT lab because it gave me a chance to work as an individual at the speeds that I wanted to and when I wanted to. At the times I came in, the lab instructors were usually not too busy, and if I had questions to ask them they usually gave me more information than I asked for which has been very helpful. So I highly recommend the AVT lab."

"I thought the labs were well conducted through the beginning of the period, but I thought the last three labs were much more complicated and took a lot longer than the first ones. I got a lot out of this and I think that more programs should be conducted this way rather than the standard lab that I had in zoology and biology both. I got more out of this because I could go at my own speed. I was hindered by the slower students that took more time to grasp the understand . . . that pushed ahead of other people that were majoring in that field. I thought the films were very good and they helped . . . you understand what they were talking about. I thought at the end (the maps - I have had geography which helped me) . . . they pushed kind of fast. I think if the kids who haven't had a similar course before that taught maps, it went entirely too fast. I thought the slides were fairly good . . . but a few of them were not necessary . . . yet most of them helped. I did like the instructors coming around. I thought they were very helpful. If you raised a flag or needed help in some way, they were very willing to help. I thought that the text had little to do with the course. I thought you could get along without it. I thought he was very good, but I thought the text was unnecessary. I did like the lab manual and I liked the idea of posting the answers so you can check on yourself."

"I think the audio-visual instruction is good because you can sit down and progress at your own speed without anybody rushing you, you don't have to keep up with the rest of the class if you don't want to. I like to take my time at things like this, especially when I'm looking at examples and things on display. It isn't as if I have to pass one thing on to another person, like it was when I took geography at another college in which we were all in one big lab and we all had to go at the same pace. I really like this, I think it's a very good idea and it's more exploring on your own."
"I felt the beginning of the course was more beneficial to me because I could associate what I was studying in lab and in class from the text with nature. Being an art major, science is extremely difficult for me to comprehend, but the beginning of the course (the first half) was more practical and . . . I did learn something. And right now this business with the topographical maps and historic part is extremely difficult to study. I don't see how it will even come in handy or benefit me in my future. The idea of individualized lab I feel is kind of unique. I've never had a science course with a lab before, but the fact that we're sitting in a confined booth with no distractions and we have the films and we have the specimens and we have help if we need it is kind of a good way to study, concentrate, etc."

"I like the open scheduling of visits because if you don't feel like coming in on one certain day, you can do two the next week or three if you get really far behind. It fits in better with the rest of your classes and you're not compelled to come in on one certain day."

"I liked the rocks and the minerals, I think they were good samples, they weren't very small, they were large enough to really see into them and study them and get a good idea of what their contents were. The films and the slides were both good: I liked them very well. I liked the slides the best because they were good color . . . interesting and they had on . . . one topic . . . maybe one or two slides related to it, and this has helped a lot because you didn't get just one view. You got a lot of views. I especially liked the maps. The two labs that were on the maps, I liked . . . very much. I like maps anyway and this did help because I never did learn to read a map too well and it's not only going to help me in geology, it helps me in a lot of other things. The assistance was good. Whenever I needed assistance, I just raised the flag and within a minute somebody would be there to help me, and they were very understanding. If you really didn't understand something, they'd take the time to help you . . . I liked the area manual where they had the frames that were self-instruction, where you could do it at home. You could go through and you could go back and the questions that you could fill in and you could check yourself and if you needed to, you could go through the whole thing over again and double check. And it was on the hard area, the classification, and I think this was good because you didn't have to come back to the lab and go through it again. You could do it at home or at your convenience. That's another thing I liked about the labs; they were at your convenience. And if you had a test the next day, and you couldn't make it to the lab, you could wait when you'd be at ease and you'd have plenty of time to go through it maybe another day. Overall, I think the labs were a lot better than an in-class lab for the fact that they were on tape and you could double check and you could go back and you could work at your own speed and you weren't worried about time and there wasn't any lack of assistance. And, overall, I think they were worthy of praise, I really liked them. I think I learned more in this type of a lab than I would in another type when you're there in a classroom and you have to go at the professor's rate not at your own, and this way you could just go at your own speed and I think it helped a lot."
Analysis of Interviews

In general, interviews support the conclusion presented earlier, in connection with the study on attitude, that students favor the program. Most often cited was the open schedule that permitted students to work the laboratory into their own schedules. Several students in the sample requested more movies and many were satisfied with audio-visuals. Also, interviews support the idea that there was widespread satisfaction with the earlier laboratories and a concern for the difficulty of later ones. Laboratory assistants received much praise and several suggestions for improvement of the program came forth. Matching of information presented in interviews and the semantic differential scale appears to be a useful procedure in curriculum revision.

In the next chapter, some of the recommendations reiterate ideas taken from taped interviews and incorporate them with data from the rest of the study.
CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The overall purpose of the study was to investigate the audiovisual tutorial program serving as a laboratory for Introductory Geology 100 at The Ohio State University. An examination of the goals and description of the laboratory provided a basis for establishment of the program as a general education oriented course at the university level. All students enrolled in Introductory Geology 100 at The Ohio State University during Winter Quarter, 1969, and assigned to the 10:00 a.m. lecture section, were included in the population.

Two tests were administered by the investigator: unit achievement tests each week of the program (Form A - Post-test and Form B - Pre-test and Post-test) and a final examination (Form E). Two questionnaires were also given by the investigator: a modified version of media assessment instrument (Form C) and a modified version of Remmers' and Silance's attitude questionnaire. Careful carrel-use records were maintained by students under the supervision of the investigator and student aides. Audio-tape interviews were conducted by the investigator. Grade-point averages were taken from students' personal records.

Item analysis was performed utilizing the 1620 computer at The Ohio State University, as was the Stepwise Regression analysis of variables contributing to achievement.
Analysis of the data shows that the students scored significantly higher on post-tests than on pre-tests in eight of the nine laboratory units. Approximately 20 percent of the students scored above the post-test mean of another group of students, without having entered the carrel for study. Students rated movies as best-liked media; the slides, materials and models; however, differences in rankings occur in units. The Semantic Differential questionnaire provides information useful to curriculum revision but generalizations can be overdone. Concerning attitude, four out of five students had positive attitudes toward AVT instruction. Attitude and average time in carrels contributed very little to achievement scores on Form E, the final examination. The best predictor was grade-point average as a relative measure of success in the total university setting. There was no significant difference found between attitude scores of men and women.

Study of patterns in carrel-use suggests needed improvements for parceling facilities. However, taped interviews establish open-schedule as important to the students. Interviews were also in accord with data derived earlier in study concerning evaluation of this program.

Conclusions

Conclusions in terms of the literature and measurement conducted during the data-collection phase are presented in this section. Those associated with the literature search are as follows:
Conclusion - Literature

1. There is genuine concern by many geology departments as to the proposed nature of undergraduate geological education, especially for the non-science major.

2. Innovations in geology curriculum have been attempted by many universities in the past several years; however, the use of audio-tutorial laboratories has been advanced primarily by other sciences, notably biology.

3. Audio-tutorial programs have grown considerably in numbers within the last decade. These programs have been developed exceptionally well in many cases; however, reports of success are almost universally stated in terms of the experience of the instructor, rather than from carefully collected data.

Conclusion - Achievement

Conclusions of this study associated with measurements and randomly collected data are:

1. Objectives for the AVT program approach higher cognitive levels commencing with Unit IV and largely remain concerned with problem solving, application, and synthesis of ideas throughout the rest of the program.

2. A presentation with discussion of each achievement item was not possible in the report; however, generally
consistent gains are reported in each unit in knowledge unique to the laboratory programs. Such knowledge includes: interpretations of earth history, skills in laboratory techniques and analysis of landscapes. Of importance was the finding that students score very well on pre-test items dealing with the programmed pre-lab on classification of fossils; therefore, it should be considered a successful innovation.

3. There were significant differences (.05) between the scores of students on pre-test examinations and scores of a different group of students taking the same examination as post-test in each of the laboratory units except Unit IX. Except for Unit V, there were no significant differences at the (.05 level) between scores obtained by the same two groups just mentioned as post-tests. In seven of the nine units, students taking both the pre-test and post-test scored as well as students taking only the post-test format.

4. Concerning preparation and individual difference, 5 to 36 percent of the students (depending upon the unit) were able to score above the mean of the unit post-tests before entering the carrels; 0 to 13 percent were able to score one standard deviation above the post-test mean; 0 to 3 percent were able to score three standard deviations above the post-test mean.
5. There were moderately high correlations between pre-tests and post-tests, ranging from .19 up to .78. In conjunction with Conclusion 5, it was apparent that most students maintain relative standings before and after the carrel experience, either as a result of, or in spite of individual pacing.

Conclusion - Assessment of Media

6. In all areas such as liking, interest, difficulty, informativeness, and appropriateness, students agreed less on low-ranked media than on those ranked highly.

7. Students were in most common agreement in assessing "difficulty" on this instrument.

8. Units I, II and III received higher rankings across all media than did the remaining units.

9. Overall, movies were rated highest in all areas by students. Slides, earth materials, models and the laboratory manual followed movies in ranking.

10. Ranking of media by units showed significant changes and agreement in relative standings of media attributable to impact of media on the student within a given unit.

11. In many cases students selected high ratings for media judged to be less difficult; however, exceptions within this generalization can be analyzed in detail.
12. Over 99 percent of the mean values covering all media, in all units, fell above the inherent means of every criterion scale.

13. The media assessment questionnaire was a useful instrument for determining affective responses of students toward media used in the audio-visual tutorial laboratory for Introductory Geology at The Ohio State University. In terms of rating "software and hardware" the means were significantly different along the scales and it seems apparent that students exercised powers of discrimination in evaluation. In terms of rating the nature of laboratory assistance, the responses were very favorable; however, they were not distinguishable from one unit to the next. Also in rating the laboratory assistants, the students were enthusiastic in rating the degree of help, but no differences were seen from unit to unit. Finally, there was the spectre of attitude change. Taped interviews indicate that a number of students were not happy with the objectives of the latter part of the program; however, complexities in attitudinal changes due to factors external to and within the course need investigation before general findings using this media assessment form can be accepted.
Conclusion - Attitude Toward AVT Instruction

14. Eighty percent of the students in the random sample selected statements from the attitude questionnaire yielding mean scores above the inherent neutral value for the scale.

15. The median value achieved on the modified Remmers' and Silances' Scale to Measure Attitude corresponds to the statement The AVT Program had its merits and fulfilled its functions well.

16. There were no significant differences in student attitude scores, measured by Form D, between students grouped according to sex, in the population defined by this study.

Conclusion - Taped Interviews

17. Many students indicated preference for the first three laboratories and detected the shift in emphasis in the more difficult units IV-IX.

18. Concern for immediate reinforcement was registered. Students generally wish to have answers available and expressed dissatisfaction with Units VIII and IX, which do not provide direct reinforcement.

19. The single-concept films were well liked by the students; several in the sample expressed the view that movies were missed in the last few units.
20. Students overwhelmingly favored the open-laboratory policy. Many cited the convenience of this policy in their total university schedule as a major reason for liking the AVT program.

21. Many students expressed positive views toward individual pacing, staying as long as they pleased, viewing materials and media as often as they liked, and generally progressing at their own rate. This view was most often expressed by students who readily admit having difficulty with science.

22. Students were divided on the issue of laboratory assistance vs. individualized instruction. Some were pleased to be able to "go at it on their own"; others were high in praise of the graduate assistants and often relied upon their help.

23. Several constructive comments were offered by students in connection with the program. Mostly, these concerned means for better integration of text, lectures, and laboratory, or the need for small discussion groups to develop more interaction between students.

Conclusion - Carrel Visits

24. In none of the units was there an average carrel-use time of two hours. This figure was arbitrarily selected during the writing stage and did not take into consideration the
fact that very little time was wasted by the student in the
carrel; whereas in conventional instruction many factors
interrupt learning by an individual.

25. Graphs representing carrel use, plotted against time of
day, indicate a bimodal pattern. The morning "peaks"
were affected by swarms of students leaving the 10:00 a.m.
lecture. Also, at 9:00 a.m., the 8:00 a.m. lecture section
filled the booths. Peak activity again appeared by mid-
afternoon.

26. On a weekly basis, students tended to avoid the laboratory
the first part of the week; consequently, each week there
was a waiting line for booths by Thursday. The phenomenon
occurred regularly, despite admonitions and frequent advice
given in lectures concerning this danger.

27. On an hourly basis, students did not appear in significant
numbers between 8:00 a.m. and 10:00 a.m.

28. With regard to units, there was a steady decline in the
numbers of students in attendance reaching a low of 72
percent by Unit IX.

Recommendations

Data collected in this study relate to curriculum development
and program improvement, and they suggest further research.

Single-concept films were used successfully in this program,
as indicated by students' reactions to this medium and their achievement
in many items. Films were presented only in the earlier units, however, and it is recommended that they be developed for later, more difficult ones. If funds do not allow films throughout the entire program, the curriculum-maker is well-advised to consider where this medium would provide best assistance to students.

That films need not be the focus of attention in AVT instruction is demonstrated by student preference for other media in certain units of this program. Students can be overwhelmed if the unit does not carefully integrate media. In a number of laboratory units students indicated approval of a certain medium or earth material in relation to its contribution as guiding force in that particular unit. It is recommended that the media-assessment scales and other data presented in this report be used as a basis for revision by weighing the relative effects of various media employed in each unit.

The media-assessment questionnaire was a useful tool. In fact, AVT programs are particularly suited to this type of assessment. Generalizations over the entire program, however, must be handled with great care because affective responses to the same type of media may well be colored by attitudinal changes. If such changes do exist, and they are recorded in this data, further research should establish the nature of the changes and the source(s) from which they stem.

Student performance in the AVT laboratory indicates that many of the original tenets of the proposal for this program were substantive. For example, individuals did pace themselves in this program as the data suggest. Some students were much better prepared than others for
the laboratory, required less average carrel-time and were able to remain at the top in terms of achievement. For others, science is a long hard pull and, although they spent longer periods of time in the carrels (to their apparent satisfaction), they will continue to achieve less. Also, males and females have equally good attitudes toward this program, despite the oft-stated notion that girls have difficulty with geology or cannot be comfortable operating audio-visual equipment.

The study on attitude suggests that one out of five students hold negative attitudes toward the AVT program. Further research should be undertaken to find the roots of these attitudes. It would be interesting to know what percent of the students are negatively disposed to self-instruction, being enclosed in a carrel, waiting in lines, the laboratory format, or even to geology itself. On the other hand, the data showed that attitudes toward AVT had little, if any, affect on achievement and the problem becomes purely academic for some curriculum-workers.

Laboratory assistance was considered important by some students; other students express the view that assistance could be exempted totally. This is another area for research in AVT instruction. Ideally, since most students were not familiar with AVT instruction, it would be helpful to know in advance (by some screening device in conjunction with student petition) how many students prefer to use the laboratory without assistance. Several carrels could be reserved for this purpose, and the graduate assistant could then work with students really wanting assistance.
Students were able to regulate their individual schedules to varying degrees. However, many in the population in this study did not respond by coming in during "off hours" or "off days." The 24 booths were able to handle 500 students, but as numbers increase, this will become a more serious problem. It is recommended that a combination work/waiting room or area be designated for the AVT laboratory.

An alternative to the open schedule is to assign students specific carrel times during the entire quarter. Another variation would be to have a sign-up sheet on which students could reserve a carrel for the forthcoming week. However, such arrangements restrict the freedom to come whenever one wishes and, as one respondent stated, "today I may not feel like studying geology."

The matter of reinforcement needs further study in this program. Answers were provided in nearly all of the laboratory units. Many students depended upon the answers and the program (for some) developed into a "fill-in" exercise. Data showed that students were vigorously opposed to Unit VIII, which involves a branching program for obtaining answers. They were also opposed to Unit IX, which they rated as an enjoyable laboratory with good slides, but one that "tests" the student by having him furnish all answers. Yet, students were opposed to the programmed pre-lab of Unit IX but achieved well (as a group) on items related to this part of the program. Perhaps this is manifestation of the "low difficulty-high rating" syndrome reported by the investigator in the chapter reporting student assessment of media.

It is recommended that the AVT program should be given to students with
answers provided in each carrel, to others without answers and possibly to another group with an experimental "branching" manual. Achievement items and the questionnaires used in this study can then be applied to these groups for the sake of comparison.

A model for evaluation of audio-tutorial programs has been considered and applied in this study. In the opinion of the investigator, the model has supplied information valuable for future revision of the program, and these data could serve as a basis for comparison as new studies are instituted. In audio-tutorial systems, objectives and goals can be specified since there is uniformity in information presented. Students are also available for sampling. Further, a great amount of information can be collected and processed.

For these reasons, those connected with audio-tutorial instruction in all fields, at all levels, should be encouraged to use this model or develop their own for the purpose of curricular improvement.
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Projects and Reports


Unpublished Material


APPENDIX I - Final Examination
1. How many GENERA are represented in the following list?

   Pantha les
   Felis pardalis
   Panthera onca
   Lynx rufus

   a. One  
b. Two  
c. Three  
d. Four

2. In the Colorado Plateaus region, rocks found on a mesa overlooking a nearby river valley can be said to be younger than those found in the valley bottom. The basis for this statement is the concept of:
b. Superposition.  
c. Fossil Correlation.  
d. Isostatic Adjustment.

3. Deposition of sediments in a stream increases as:
   a. stream velocity decreases.  
b. stream velocity increases.  
c. particle size decreases.  
d. volume of water increases.

4. On a hypothetical planet having a circumference of 44,000 miles, our latitude-longitude system superimposed on the planet would result in which of the following?
   a. Each degree of latitude and longitude equals approximately 120 miles.  
b. Each degree of longitude at the equator equals approximately 80 miles.  
c. Each degree of longitude equals approximately 120 miles.  
d. Each degree of longitude at the equator equals approximately 120 miles.

5. An analysis of minerals present in gabbro would be closest to:
   a. 30% quartz, 20% biotite and 50% feldspar.  
b. 5% feldspar and 95% augite.  
c. 40% feldspar, 30% augite and 20% biotite.  
d. 80% feldspar and 20% augite.

6. Rock salt deposits in the earth were formed:
   a. by the evaporation of sea water.  
b. by neutralization of NaOH in the rocks with HCl.  
c. as molten halite cooled.  
d. from calcite.

7. The tops of major ridges in western Pennsylvania are usually supported by:
   a. limestone.  
b. shale.  
c. siltstone.  
d. sandstone.

8. Rejuvenation, a process associated with the Colorado Plateau region, is best illustrated by:
   a. volcanics in the Ship Rock area.  
b. stream valleys along the San Juan River region.  
c. Indian cliff houses at Spruce Tree House.  
d. deposits of sediments in Lake Mead.

9. On a certain river in the Rocky Mountains one sees a V-shaped valley downstream; however, the upstream portion of this same valley is U-shaped. This change in valley shape is most likely due to:
   a. differential erosion of dissimilar rock types.  
b. glacial erosion upstream; stream erosion downstream.  
c. glacial erosion throughout the entire valley.  
d. stream erosion upstream; glacial erosion downstream.

10. When comparing surface features in the Ridge and Valley Province and the Allegheny Plateau, major differences can be seen in:
    a. stream patterns.  
b. highway trends.  
c. mountain or ridge shapes.  
d. all of the above.
11. Two rock specimens from different parts of the world are known to contain quartz, mica and feldspar. In order to classify them properly, the next step is to determine the
   a. density and specific gravity of each rock,
   b. proportions of each mineral present,
   c. cleavage angles of the minerals in each rock,
   d. hardness of each rock specimen.

Study of sedimentary structures such as those listed below in questions 12 and 13 yields information as to the environment during rock formation. This information may be:

I. Direction of current
II. Top and bottom of beds
III. Nature of site- deep ocean, mud flat, sand bar, etc.

With regard to each structure listed in 12 and 13,

If it yields information on I and II only, select A on your answer sheet.
If it yields information on II and III only, select B on your answer sheet.
If it yields information on I and III only, select C on your answer sheet.
If it yields information on I, II and III, select D on your answer sheet.

12. Mudcracks
13. Cross-bedding

Questions 14-16 concern the following observations of a rock:

1. The rock is light colored.
2. It is composed of large crystals which are easily visible to the unaided eye.
3. It contains appreciable amounts of quartz and feldspar.

Check each of the statements below (14-16) to see if it is contradictory to the observations given above.

If observation 1 contradicts the statement, darken A on the answer sheet.
If observation 2 contradicts the statement, darken B " " " "
If observation 3 contradicts the statement, darken C " " " "
If NONE of the observations contradict the statement, darken D on the answer sheet.

14. The rock may have a granular fabric.
15. The rock may be felsite.
16. The rock may have formed near the surface.
17. In diagram I, surface "Z" is most nearly like the surface
   a. at Q.
   b. between "F" and "K".
   c. between 1 and 4.
   d. between "D" and 2.

18. In diagram I, which of the geologic events listed below is oldest?
   a. Intrusion of "A"
   b. Intrusion of "D"
   c. Folding of 1, 2, 4 and 6
   d. Erosion of surface "Z"

19. Standing on a high ridge in western Pennsylvania, you are aware that
   this north-south trending ridge is actually the west flank of a syn-
   cline. To find older rocks, you would then walk
   a. northward.
   b. southward.
   c. eastward.
   d. westward.

20. Which of the following processes has been chiefly responsible for the
   presence of marine sediments a mile above sea level in Colorado?
   a. Isostatic adjustment
   b. Folding
   c. Intrusion
   d. Volcanic activity

21. Rocks weather because they are
   a. exposed to carbon dioxide (CO2).
   b. not stable in the presence of water.
   c. oxidized by oxygen dissolved in water.
   d. not at equilibrium with the environment.

22. The best way to distinguish quartzite from sandstone is
   a. to apply dilute HCl to each.
   b. in observing and measuring cleavage faces.
   c. by observing the surface of fracture with a lens.
   d. by recording color differences between the two.

23. When comparing two 30-minute topographic maps from different parts of the United
   States (Alaska vs. Ohio), it may be said that
   a. both maps represent the same number of square miles.
   b. the Alaskan map contains a smaller number of square miles.
   c. the Ohio map contains a smaller number of square miles.
   d. the fact that they are called 30-minute sheets has nothing to do with areas
      involved.
24. All samples of granitic gneiss and marble are alike in that they are
   a. of the same composition.
   b. foliated.
   c. derived from similar parent rocks.
   d. metamorphic.

25. The fact that sedimentary rocks now found at "mile-high" Colorado were once sea
    level sediments is best supported by examination of outcrops of:
   a. Fountain sandstone.
   b. Niobrara limestone.
   c. Silver Plume granite.
   d. lava flows at Table Mesa.

26. Given the following locations.....

   Place 1 at lat. 20° N., long. 50° E.
   Place 2 at lat. 30° N., long. 60° E.
   Place 3 at lat. 30° N., long. 60° E.
   Place 4 at lat. 20° N., long. 50° E.

   ......which of the places listed below are farthest from each other?

   a. Place 1 and place 4
   b. Place 2 and place 3
   c. Place 2 and place 4
   d. All places are the same distance from each other.

27. On what basis do scientists conclude that fossil corals required a warm, shallow-
    water environment?
   a. The composition of rocks in which fossil corals are found.
   b. The geographic distribution of fossil corals.
   c. Most present-day corals live in this type environment.
   d. Corals are composed of calcium carbonate.

28. A unit of rock distinguished by its fossil content is a
   a. zone.
   b. layer.
   c. facies.
   d. formation.

29. According to Mohs' Scale of hardness
   a. absolute values are not assigned to minerals.
   b. diamonds are about nine times harder than talc.
   c. minerals not having cleavage appear as higher values.
   d. the force applied to each mineral type must be equal.

30. The table below describes the ranges of 3 fossils found in a layer of sedimentary
    rock:

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>FROM</th>
<th>UP TO AND INCLUDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil A</td>
<td>Early Cambrian</td>
<td>Early Ordovician</td>
</tr>
<tr>
<td>Fossil B</td>
<td>Late Cambrian</td>
<td>Late Ordovician</td>
</tr>
<tr>
<td>Fossil C</td>
<td>Middle Cambrian</td>
<td>Late Cambrian</td>
</tr>
</tbody>
</table>

   The age of this fossil assemblage is closest to:
   a. Late Cambrian.
   b. Early Ordovician.
   c. Late Cambrian through Early Ordovician.
   d. Early Cambrian through Late Ordovician.
APPENDIX II - Media Assessment Questionnaire
UNIT ONE - THE MINERALS OF GRANITE AND GABRO

ITEM I. Movie for entire unit - "INTRODUCTION", "CLEAVAGE" and "HARDNESS"

<table>
<thead>
<tr>
<th></th>
<th>1. Dull, tedious, thought of other things</th>
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<th>Interesting, held my attention</th>
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<td>2. Repeated what I already knew</td>
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<td>Informative, presented new material</td>
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<td>3. Too easy to follow, too elementary</td>
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<td>Too difficult to follow, too advanced</td>
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<td>4. I did not like this way of presenting the material</td>
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<td>I liked this way of presenting the material</td>
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<td>5. Did not fit in well with other lab activities</td>
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<td>Fit in well with other lab activities</td>
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ITEM II. Slide (Arrangement of granite and gabbro with associated minerals)

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</table>

ITEM III. Earth materials - Use of whole and crushed granite and gabbro plus associated common minerals

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<td>---</td>
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<td>---</td>
<td>---</td>
<td>Too difficult to follow, too advanced</td>
</tr>
<tr>
<td></td>
<td>4. I did not like this way of presenting the material</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>I liked this way of presenting the material</td>
</tr>
<tr>
<td></td>
<td>5. Did not fit in well with other lab activities</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>Fit in well with other lab activities</td>
</tr>
</tbody>
</table>
ITEM IV. Earth Models - Hardness

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dull, tedious; did not complete</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Repeated what I already knew</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Too easy to follow, too elementary</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>I did not like this way of presenting the material</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Did not fit in well with other lab activities</td>
<td></td>
</tr>
</tbody>
</table>

ITEM V. Laboratory assistance.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>This unit provided no reinforcement in giving answers whatsoever</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Lab assistants remain aloof, indifferent to my queries</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Lab assistants are never available to answer questions</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>I did not seek nor receive assistance during this unit</td>
<td></td>
</tr>
</tbody>
</table>

ITEM VI. Laboratory Manual - Response to the manual as a whole.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dull, tedious, thought of other things</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Repeated what I already knew</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Too easy to follow, too elementary</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>I did not like the way the manual presented the material</td>
<td></td>
</tr>
</tbody>
</table>

Interestingly, held my attention
Informative, presented new material
Too difficult to follow, too advanced
I liked this way of presenting the material
Fit in well with other lab activities
This unit provided all of the answers, as needed
Lab assistants are sympathetic and eager to help in response to my queries.
Lab assistants are always available to answer questions.
I sought for, and received assistance several times during this unit.
Interesting, held my attention
Informative, presented new material
Too difficult to follow, too advanced
I liked the way the manual presented the material
UNIT II.0 - IGNEOUS FABRIC
THE WEATHERING OF IGNEOUS ROCKS

ITEM I. Movies for entire unit - "Formation of Lava," "Experimental Granite" and "Introduction."  
1. Dull, tedious; thought of other things --- --- --- --- --- Interesting; held my attention.
2. Repeated what I already knew --- --- --- --- --- Informative; presented new material.
3. Too easy to follow; too elementary --- --- --- --- --- Too difficult to follow; too advanced.
4. I did not like this way of presenting the material --- --- --- --- --- I liked this way of presenting the material.
5. Did not fit in well with other lab activities --- --- --- --- --- Fit in well with other lab activities.

ITEM II. Slides - Thin sections of granite and gabbro, Mt. Airy quarry wall.
1. Dull, tedious; thought of other things --- --- --- --- --- Interesting; held my attention.
2. Repeated what I already knew --- --- --- --- --- Informative; presented new material.
3. Too easy to follow; too elementary --- --- --- --- --- Too difficult to follow; too advanced.
4. I did not like this way of presenting the material --- --- --- --- --- I liked this way of presenting the material.
5. Did not fit in well with other lab activities --- --- --- --- --- Fit in well with other lab activities.

ITEM III - Earth materials - Igneous rocks, associated minerals, Mt. Airy "decomposition suite" and mineral-filled vials.
1. Dull, tedious; did not hold my attention --- --- --- --- --- Interesting; held my attention.
3. Too easy to follow; too elementary --- --- --- --- --- Too difficult to follow; too advanced.
4. I did not like this way of presenting the material --- --- --- --- --- I liked this way of presenting the material.
5. Did not fit in well with other activities --- --- --- --- --- Fit in well with other activities.
ITEM IV. Earth Models — (None)

ITEM V. Laboratory assistance

1. This unit failed to reinforce by not providing suitable answers. --- --- --- --- The unit provided answers as needed.

2. Lab assistants are aloof, indifferent to my queries. --- --- --- --- Lab assistants are sympathetic, eager to help in response to my queries.

3. Lab assistants are never available on request to answer questions --- --- --- --- Lab assistants are always available upon request to answer questions.

4. I never sought for or received assistance during this lab. --- --- --- --- I sought for and received assistance several times during this lab.

This item is your most general response to this unit.

ITEM VI. Laboratory Manual — Please respond to the Manual, keeping in mind also our intent to produce a guide to the total unit and its various media.

1. Dull, tedious; thought of other things --- --- --- --- --- Interesting, held my attention.


3. Too easy to follow, too elementary --- --- --- --- --- Too difficult to follow, too advanced.

4. I did not like the way the Manual presented the material --- --- --- --- --- I liked the way the Manual presented the material.

ITEM I. Movies for entire unit - "INTRODUCTION," "SETTLING VELOCITIES," "ABRASION" and "CROSS-STRATIFICATION."

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dull, tedious; thought of other things, interesting, held my attention.</td>
<td>---</td>
</tr>
<tr>
<td>2.</td>
<td>Repeated what I already knew, informative, presented new material.</td>
<td>---</td>
</tr>
<tr>
<td>3.</td>
<td>Too easy to follow, too elementary, too difficult to follow, too advanced.</td>
<td>---</td>
</tr>
<tr>
<td>4.</td>
<td>I did not like this way of presenting the material, I liked this way of presenting the material.</td>
<td>---</td>
</tr>
<tr>
<td>5.</td>
<td>Did not fit in well with other lab activities, fit in well with other lab activities.</td>
<td>---</td>
</tr>
</tbody>
</table>

ITEM II. Slides - Three slides show proper arrangement on chart; ripple mark directions and cross-stratification

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dull, tedious; passed them by, interesting, held my attention.</td>
<td>---</td>
</tr>
<tr>
<td>2.</td>
<td>Repeated what I already knew, informative, presented new material.</td>
<td>---</td>
</tr>
<tr>
<td>3.</td>
<td>Too easy to follow, too elementary, too difficult to follow, too advanced.</td>
<td>---</td>
</tr>
<tr>
<td>4.</td>
<td>I did not like this way of presenting the material, I liked this way of presenting the material.</td>
<td>---</td>
</tr>
<tr>
<td>5.</td>
<td>Did not fit in well with other lab activities, fit in well with other lab activities.</td>
<td>---</td>
</tr>
</tbody>
</table>

ITEM III. Earth Materials - Various sedimentary rocks and minerals, ripple marked, mud cracked and cross-stratified specimens.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Rating</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dull, tedious, did not hold my attention, interesting, held my attention.</td>
<td>---</td>
</tr>
<tr>
<td>2.</td>
<td>Repeated what I already knew, informative, presented new materials.</td>
<td>---</td>
</tr>
<tr>
<td>3.</td>
<td>Too easy to follow, too elementary, too difficult to follow, too advanced.</td>
<td>---</td>
</tr>
<tr>
<td>4.</td>
<td>I did not like this way of presenting the material, I liked this way of presenting the material.</td>
<td>---</td>
</tr>
<tr>
<td>5.</td>
<td>Did not fit in well with other activities, fit in well with other activities.</td>
<td>---</td>
</tr>
</tbody>
</table>
ITEM IV. Earth Models - Rock classification flow-chart found in booth.
1. Dull, tedious, did not hold my attention --- --- --- --- --- --- Interesting, held my attention
2. Repeated what I already knew --- --- --- --- --- --- Informative, presented new materials
3. Too easy to follow, too elementary --- --- --- --- --- --- Too difficult to follow, too advanced
4. I did not like this way of presenting the material --- --- --- --- --- --- I liked this way of presenting the material.
5. Did not fit in well with other activities --- --- --- --- --- --- Fit in well with other activities.

ITEM V. Laboratory assistance
1. This unit did not provide suitable answers when needed. --- --- --- --- --- --- The unit provided sufficient answers, as needed.
2. Lab assistants are aloof, indifferent to my queries --- --- --- --- --- --- Lab assistants are sympathetic, eager to help in response to my queries
3. Lab assistant are never available upon request to answer questions. --- --- --- --- --- --- Lab assistants are always available upon request to answer questions.
4. I never sought for, or received assistance during this lab. --- --- --- --- --- --- I sought for, and received assistance several times during this lab.

ITEM VI. Laboratory Manual -- This item is a more GENERAL response to the unit; the Manual should be considered in its role as GUIDE to all activities.
1. Dull, tedious, thought of other things --- --- --- --- --- --- Interesting, held my attention
2. Repeated what I already knew --- --- --- --- --- --- Informative, presented new material
3. Too easy to follow, too elementary --- --- --- --- --- --- Too difficult to follow, too advanced
4. I did not like the way the Manual presented the material --- --- --- --- --- --- I liked the way the Manual presented the material
5. Manual did not effectively relate unit to prior unit(s) --- --- --- --- --- --- Effectively related unit to prior unit(s)
## UNIT FOUR - THE USE AND SIGNIFICANCE OF FOSSILS

### ITEM I. Movies for entire unit - "Introduction to Fossils."

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dull, tedious; thought of other things</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>2.</td>
<td>Repeated what I already knew</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>3.</td>
<td>Too easy to follow, too elementary</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>4.</td>
<td>I did not like this way of presenting the material</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>5.</td>
<td>Did not fit in well with other lab activities</td>
<td>*** *** *** *** ***</td>
</tr>
</tbody>
</table>

### ITEM II. Slides -- Views of brachiopod and cephalopod showing parts.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dull, did not use</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>2.</td>
<td>Repeated what I already knew</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>3.</td>
<td>Too easy to follow, too elementary</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>4.</td>
<td>I did not like this way of presenting the material</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>5.</td>
<td>Slides did not fit in well with other lab activities</td>
<td>*** *** *** *** ***</td>
</tr>
</tbody>
</table>

### ITEM III - Earth materials -- fossil trays and rock samples

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dull; did not hold my attention</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>2.</td>
<td>Repeated what I already knew</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>3.</td>
<td>Too easy to follow, too elementary</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>4.</td>
<td>I did not like this way of presenting the material</td>
<td>*** *** *** *** ***</td>
</tr>
<tr>
<td>5.</td>
<td>Fossils did not fit in well with other activities</td>
<td>*** *** *** *** ***</td>
</tr>
</tbody>
</table>
ITEM IV - Earth Models -- Blue, Green and Red River block diagram

1. Problem; did not hold my attention. --- --- --- --- --- Interesting; held my attention

2. Problem repeated what I already knew --- --- --- --- --- Informative, presented new material

3. Too easy to follow, too elementary --- --- --- --- --- Too difficult to follow, too advanced

4. I did not like this way of presenting the material --- --- --- --- --- I liked this way of presenting the material

5. Problem did not fit in well with other unit activities --- --- --- --- --- Problem fit in well with other unit activities

ITEM V. Laboratory assistance

1. The unit did not provide suitable answers when needed. --- --- --- --- --- The unit provided sufficient answers, as needed

2. Lab assistants are aloof, indifferent to my queries. --- --- --- --- --- Lab assistants are sympathetic, eager to help in response to my queries.

3. Lab assistants are never available upon request to answer questions --- --- --- --- --- Lab assistants are always available upon request to answer questions

4. I never sought for, or received assistance during this lab. --- --- --- --- --- I sought for, and received assistance several times during this lab.

ITEM VI. Laboratory Manual -- This item as a more GENERAL response to the unit; the Manual should be considered as a GUIDE to all activities. Programmed section and the post-lab are part of this assessment too.

1. Dull, tedious; thought of other things --- --- --- --- --- Interesting, held my attention

2. Repeated what I already knew --- --- --- --- --- Informative, presented new material

3. Too easy to follow, too elementary --- --- --- --- --- Too difficult to follow, too advanced.

4. I did not like the way the Manual presented the material --- --- --- --- --- I liked the way the Manual presented the material

5. Did not effectively relate unit to prior unit(s) --- --- --- --- --- Effectively related unit to prior unit(s)
UNIT FIVE - METAMORPHIC ROCKS

ITEM I. Movie -- "Model Making"

1. Dull, thought of other things
2. Repeated what I already knew
3. Too easy to follow, too elementary
4. I did not like this way of presenting the material
5. Did not fit well with other lab activities

ITEM II. Slides (None)

ITEM III. Earth materials -- metamorphic rocks

1. Dull, thought of other things
2. Repeated what I already knew
3. Too easy to follow, too elementary
4. I did not like this way of presenting the material
5. Materials did not fit in well with other unit activities

ITEM IV - Earth models -- Plastic Fence Model, Problem, Event Cards

1. Dull problem: did not hold my attention
2. Problem repeated what I already knew
3. Too easy to follow, too elementary
4. I did not like this way of presenting the material
5. Problem did not fit in well with other unit activities

Materials: Interesting; held my attention
Informative, presented new material
Too difficult to follow, too advanced
I liked this way of presenting the material
Material fit in well with other activities
Interesting; held my attention
Informative, presented new material
Too difficult to follow; too advanced
I liked this way of presenting the material
Problem fit in well with other activities
ITEM V. Laboratory Assistance

1. The unit did not provide suitable answers when needed --- --- --- --- --- The unit provided sufficient answers
2. Lab assistants are aloof, indifferent to my queries --- --- --- --- --- Lab assistants are sympathetic, eager to help in response to my queries
3. Lab assistants are never available to answer questions upon request --- --- --- --- --- Lab assistants are always available to help on request
4. I never sought for, or received, assistance during this lab. --- --- --- --- --- I sought for, and received, assistance several times during this lab.

ITEM VI. Laboratory Manual -- This item is a more GENERAL response to the unit; The Manual should be considered as a GUIDE to all activities

1. Bull,tedious,thought of other things --- --- --- --- --- Interesting, held my attention
2. Repeated what I already knew --- --- --- --- --- Informative, presented new material
3. Too easy to follow, too elementary --- --- --- --- --- Too difficult to follow, too advanced
4. I did not like the way the Manual presented the material --- --- --- --- --- I liked the way the Manual presented the material
5. Manual did not effectively relate unit to prior unit(s) --- --- --- --- --- Manual effectively related unit to prior unit(s)
ITEM I.  Movie -- "Contour Lines".

1. Dull, thought of other things
   | | | | | | Interesting; held my attention
2. Repeated what I already knew
   | | | | | | Informative, presented new material
3. Too easy to follow, too elementary
   | | | | | | Too difficult to follow, too advanced
4. I did not like this way of presenting the material.
   | | | | | | I liked this way of presenting the material.
5. Did not fit in well with other lab activities
   | | | | | | Fit in well with other lab activities

ITEM II. Slides -- Contour map of Pikes Peak

1. Dull, did not use
   | | | | | | Interesting, held my attention
2. Repeated what I already knew
   | | | | | | Informative, presented new material
3. Too easy to follow, too elementary
   | | | | | | Too difficult to follow, too advanced
4. I did not like this way of presenting the material.
   | | | | | | I liked this way of presenting the material.
5. Slide did not fit in well with other lab activities
   | | | | | | Slide fit in well with other lab activities

ITEM III -- Earth materials -- (None)

ITEM IV -- Earth Models -- Plastic Globes, 7.5 minute topo maps

1. Dull, did not hold my attention
   | | | | | | Interesting, held my attention
2. Models only repeated what I already knew
   | | | | | | Models informative, presented new material
3. Too easy to follow, too elementary
   | | | | | | Too difficult to follow, too advanced
4. I did not like this way of presenting the material.
   | | | | | | I liked this way of presenting the material.
5. Models did not fit in well with other activities
   | | | | | | Models fit in well with other activities
ITEM V. Laboratory Assistance

1. The unit does not provide suitable answers when needed

2. Lab assistants are aloof, indifferent to my queries

3. Lab assistants are never available to answer questions upon request

4. I never sought for, or received assistance during the lab.

Item VI. Laboratory Manual -- This item is a more GENERAL response to the unit; the Manual should be considered as a GUIDE to all activities.

1. Lull, tedious, thought of other things

2. Repeated what I already knew

3. Too easy to follow, too elementary

4. I did not like this way of presenting the material

5. Manual did not effectively relate this unit to prior unit(s)
ITEM I. MOVIES -- (None)

ITEM II. Slides -- aerial views of mountains in Pennsylvania

1. Dull, did not use | === === === === | Interesting; held my attention
2. Repeated what I already knew | === === === === | Informative; presented new material
3. Too easy to follow, too elementary | === === === === | Too difficult to follow, too advanced
4. I did not like this way of presenting the material | === === === === | I liked this way of presenting the material
5. Slides did not fit in well with other lab activities | === === === === | Slides fit in well with other lab activities

Item III. Earth materials -- rocks from Pennsylvania

1. Dull; did not hold my attention | === === === === | Interesting; held my attention
2. Materials unnecessary; repeated what I already knew | === === === === | Materials informative, presented new material
3. Too easy to follow, too elementary | === === === === | Too difficult to follow, too advanced
4. I did not like this way of presenting materials | === === === === | I liked this way of presenting materials
5. Materials did not fit in well with other activities | === === === === | Materials fit in well with other activities.
ITEM IV. Earth Models - Frankstown, Altoona and Pittsburgh topo-maps

1. Dull, did not hold my attention
   --- --- --- --- --- Interesting; held my attention

2. Maps only repeated what I already knew
   --- --- --- --- --- Maps informative, presented new material.

3. Too easy to follow, too elementary
   --- --- --- --- --- Too difficult to follow, too advanced

4. I did not like this way of presenting the material
   --- --- --- --- --- I liked this way of presenting the material

5. Maps did not fit in well with other activities
   --- --- --- --- --- Maps fit in well with other activities

ITEM V. Laboratory assistance

1. The unit does not provide suitable answers when needed
   --- --- --- --- --- The unit provides sufficient answers as needed

2. Lab assistants are aloof, indifferent to my queries
   --- --- --- --- --- Lab assistants are sympathetic, eager to help in response to my queries.

3. Lab assistants are never available to answer questions upon request
   --- --- --- --- --- Lab assistants are always available to help upon request.

4. I never sought for, or received assistance during this unit
   --- --- --- --- --- I sought for, and received, assistance several times during this lab.

ITEM VI. Laboratory Manual -- This item is more GENERAL response to the unit; the Manual should be considered as a GUIDE to all activities

1. Dull, tedious, thought of other things
   --- --- --- --- --- Interesting; held my attention

2. Repeated what I already knew
   --- --- --- --- --- Informative; presented new material

3. Too easy to follow, too elementary
   --- --- --- --- --- Too difficult to follow, too advanced

4. I did not like this way of presenting the material
   --- --- --- --- --- I liked this way of presenting this material

5. Manual did not effectively relate this unit to prior unit(s)
   --- --- --- --- --- Manual effectively related this unit to prior unit(s)
FORM C8
UNIT EIGHT - THE COLORADO PLATEAUS

ITEM I. MATERIALS -- (NONE)

ITEM II. Slides -- Views of Lake Mead, Mexican Hat and Monument Valley

1. Dull, did not use  
   $$$ $$$ $$$ $$$ $$$  
   Interesting; held my attention

2. Repeated what I already knew  
   $$$ $$$ $$$ $$$ $$$  
   Informative, presented new material

3. Too easy to follow, too elementary  
   $$$ $$$ $$$ $$$ $$$  
   Too difficult to follow, too advanced

4. I did not like this way of presenting the material  
   $$$ $$$ $$$ $$$ $$$  
   I liked this way of presenting the material

5. Slides did not fit in with other lab activities  
   $$$ $$$ $$$ $$$ $$$  
   Slides fit in well with other lab activities

ITEM III. Earth materials -- Grand Canyon rocks and fossil cards

1. Dull, did not hold my attention  
   $$$ $$$ $$$ $$$ $$$  
   Interesting, held my attention

2. Materials repeated what I already knew  
   $$$ $$$ $$$ $$$ $$$  
   Materials informative, presented new material

3. Too easy to follow, too elementary  
   $$$ $$$ $$$ $$$ $$$  
   Too difficult to follow, too advanced

4. I did not like this way of presenting information  
   $$$ $$$ $$$ $$$ $$$  
   I liked this way of presenting information

5. Materials did not relate well to other unit activities  
   $$$ $$$ $$$ $$$ $$$  
   Materials related well to other unit activities

ITEM IV - Earth Models -- large chart of Grand Canyon, Topographic maps of Mexican Hat, Gouging, Shiprock and Soda Canyon, Bright Angel topo and geologic map and geologic cross-sections.

1. Dull; did not hold my attention  
   $$$ $$$ $$$ $$$ $$$  
   Interesting, held my attention.

2. Models only repeated what I already knew  
   $$$ $$$ $$$ $$$ $$$  
   Models informative, presented new material.

3. Too easy to follow, too elementary  
   $$$ $$$ $$$ $$$ $$$  
   Too difficult to follow, too advanced

4. I did not like this way of presenting the information  
   $$$ $$$ $$$ $$$ $$$  
   I liked this way of presenting information
ITEM IV - continued

5. Models did not relate well to other lab activities
   Models fit in well with other lab activities

ITEM V. Laboratory assistance

1. The unit does not provide suitable answers when needed
   The unit provides sufficient answers as needed.

2. Lab assistants are aloof, indifferent to my queries.
   Lab assistants are sympathetic, eager to help in response to my queries.

3. Lab assistants are never available to answer questions upon request.
   Lab assistants are always available to help upon request.

4. I never sought for, or received assistance during this unit.
   I sought for, and received assistance several times during this lab.

ITEM VI. Laboratory Manual -- This item is a more GENERAL response to the unit the Manual should be considered as a GUIDE to all unit activities.

1. Dull, tedious, thought of other things
   Interesting, held my attention

2. Repeated what I already knew
   Informative, presented new material

3. Too easy to follow, too elementary
   Too difficult to follow, too advanced

4. I did not like this way of presenting the material
   I liked this way of presenting the material

5. Manual did not seem to relate this unit to prior unit(s)
   Manual related this unit to prior unit(s) well
ITEM I. MOVIES -- (None)

ITEM II. Slides -- over two dozen slides taken along the route of the trip across Kansas and Colorado

<p>| | | | | | |</p>
<table>
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</tr>
</thead>
<tbody>
<tr>
<td>1. Dull, did not hold my attention</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>Interesting; held my attention</td>
</tr>
<tr>
<td>2. Repeated what I already knew</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>Informative; presented new material</td>
</tr>
<tr>
<td>3. Too easy to follow, too elementary</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>Too difficult to follow, too advanced</td>
</tr>
<tr>
<td>4. I did not like this way of presenting the material</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>I liked this way of presenting the material</td>
</tr>
<tr>
<td>5. Slides did not fit in well with other activities</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>Slides fit in well with other activities</td>
</tr>
</tbody>
</table>

ITEM III. Earth materials -- rock specimens from Rocky Mountains

<p>| | | | | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1. Dull, did not hold my attention</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>Interesting; held my attention</td>
</tr>
<tr>
<td>2. Materials repeated what I already knew</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>Materials informative, presented new material</td>
</tr>
<tr>
<td>3. Too easy to follow, too elementary</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>Too difficult to follow, too advanced</td>
</tr>
<tr>
<td>4. I did not like this way of presenting information</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>I liked this way of presenting information</td>
</tr>
<tr>
<td>5. Materials did not relate well to other activities in the unit</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>Materials related well to other unit activities.</td>
</tr>
</tbody>
</table>
ITEM IV. Earth Models -- highway maps, geologic map (fig. 9-1) and a drawing of Rocky Mt. front (fig. 9-2)

1. Dull, did not hold my attention
2. Models only repeated what I already knew
3. Too easy to follow, too elementary
4. I did not like this way of presenting the information
5. Models did not relate well to other lab activities

ITEM V. Laboratory assistance

1. The unit does not provide sufficient answers when needed
2. Lab assistants are aloof, indifferent to my queries
3. Lab assistants are never available to answer my questions upon request.
4. I never sought or received assistance during this unit.

ITEM VI. Laboratory Manual -- This item is more GENERAL response to the unit, the manual should be considered as a GUIDE to all unit activities.

1. Dull, tedious, thought of other things
2. Repeated what I already knew
3. Too easy to follow, too elementary
4. I did not like this way of presenting the material
5. Manual did not seem to relate this unit to prior unit(s) well.
APPENDIX III - Attitude Questionnaire
FORM D

1. I am very excited about the AVT laboratory program.
2. If I had my way, I would compel everybody to take this AVT program.
3. The AVT laboratory program is of great value.
4. I really enjoy the AVT laboratory.
5. The AVT laboratory sessions fascinate me.
6. The merits of this laboratory program far outweigh the defects.
7. Anyone who takes the AVT laboratory program is bound to be benefited.
8. The AVT laboratory program is a good program.
9. The AVT laboratory program teaches methodical reasoning.
10. This laboratory program serves the needs of a large number of students.
11. All lessons and all methods used in the AVT laboratory are clear and definite.
12. The AVT laboratory program has its merits and fills its purpose quite well.
13. The AVT laboratory is not receiving its recognition in colleges and universities.
14. This laboratory program is not a bore.
15. This laboratory program has its drawbacks, but I like it.
16. The AVT laboratory program might be worthwhile if it were presented right.
17. My likes and dislikes for this laboratory program balance one another.
18. The AVT laboratory program will benefit only the brighter students.
19. I could do very well without the AVT laboratory program.
20. The minds of students are not kept active in the AVT laboratory.
21. I am not interested in the AVT laboratory Program.
22. This laboratory program does not teach you how to think.
23. The AVT laboratory program is dull.
24. The AVT laboratory program does not hold my interest at all.
25. I have no desire for this laboratory program.
26. I have seen no value for this laboratory program.
27. I would not advise anyone to take this laboratory program.
28. The AVT laboratory program can benefit me.
29. This laboratory program is a waste of time.
30. Nobody likes the AVT laboratory program.
31. I detest the AVT laboratory.
32. Words cannot express my antagonism towards the AVT laboratory program.
33. I hate the AVT laboratory program.
DIRECTIONS (FORM D)

In this survey you are asked to select those statements which best express your own feelings toward the Audio-Visual Tutorial laboratory.

Place a plus (✓) by the numbers of statements which best express your feelings toward this laboratory. Please confine your reactions to the laboratory program only.

Thank you.

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