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INDIVIDUALIZING COLLEGE GEOLOGY

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An Audio-Tutorial Instructional Approach to Individualizing College Geology

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ABSTRACT

This developmental project investigated four basic problems associated with the teaching of an undergraduate physical geology course. These were: (a) how to effectively present the concepts and principles of earth science to a large number of students; (b) how to include a laboratory experience for each student; (c) how to adapt instruction to deal with student variations in scientific background; and (d) how to determine amount of student control in an individualized course. Results of the study showed that the audio-tutorial approach effectively solved the problems.

An Audio-Tutorial Instructional Approach to Individualizing College Geology

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An innovative approach in the teaching of introductory physical geology is the audio-tutorial system which has been developed at Florida State University. The purposes in developing the undergraduate course, Geology 102, were: (a) to integrate laboratory exercises with instructional material; (b) to allow students to learn at their own rate; (c) to individually assist students in course learning; and (d) to establish objectives with corresponding instructional materials and evaluation instruments which would remain consistent from quarter to quarter and serve as a basis for integrating physical geology with two other introductory geology courses. Hypothesized was that the audio-tutorial (A-T) design would result in a course that would be both more efficient and effective than the previous instructional methods. Since the proposed A-T course was to be self-instructional, a major concern of the project was the amount and degree of student control over the rate of learning. To test this variable two types of learner control were investigated; self-pacing and partial self-pacing.

Method

Geology 102 was offered during the three quarters of the (fall, winter, and spring) academic year, 1970-71, at Florida State University. No other sections of Geology 102 were offered during these three quarters.

Students enrolled in the course were required to register for three hours lecture and one hour laboratory credit. The two general educational goals of the course were: (a) for the student to comprehend how a scientist, especially an earth scientist, operates; and (b) for the student to apply a scientific method of analysis to his own observations of geologic phenomena and formulate basic explanations about what he observes. There were no specified prerequisites for the course.

Instructional materials. The instructional materials were produced following these procedures: (a) analysis of the content and behaviors to determine the units of instruction; (b) development of the materials, according to the analyses, into self-instructional packets; and (c) design of audio-tapes which presented content, directed students through the various programmed activities, and provided feedback on exercises.

Evaluation methodology was based on constructing unit tests which were congruent with each unit's (a total of nine units) instructional objectives. Fall quarter unit tests were multiple choice with items being scored as correct or incorrect. Unit tests for winter quarter were changed to include fill-in-the-blank, short answer, and other formats appropriate to the unit objectives. Unit tests remained essentially the same for the spring quarter, except for a number of short-answer items which were revised so that scoring would be more objective. The final examination served as the measure of total course achievement and was compiled from a previously developed multiple-choice item pool.

Learning center. A classroom in the geology building was renovated to serve as a learning center for the geology course. The center

was equipped with 12 study carrels, each equipped with a tape recorder, slide projector, headphones, models, maps, and other materials which were applicable to all units of instruction. A laboratory table was placed in the center of the room which contained larger equipment and materials necessary to perform many of the laboratory exercises. A small conference room was included in the center to provide a meeting place for informal discussions between the instructor and students, and students with students. When the student entered the center, he was directed to record the time, unit number, and carrel number where he was working. An electric time check and a time card were provided for this purpose.

Procedure. Three pacing schemes were designed to investigate the variable of learner control over rate of acquisition. Students enrolled in the fall quarter were given a self-paced instructional course. A new instructional unit was introduced every week during a general assembly period held in a large lecture hall. The only restriction on the self-pacing was that the final examination had to be taken during the university scheduled examination period. Students not completing the course were given "incompletes" which had to be finished by the end of the succeeding quarter.

For the winter quarter, students were required to complete a unit within two weeks after the unit was introduced in the general assembly. This partial self-pacing program gave students control over rate of learning within the given unit, but set limits on going too slow or too fast from one unit to the next.

At the beginning of the spring quarter, all students enrolled in Geology 102 were randomly assigned to one of two self-pacing groups. Students assigned to the first group were allowed, after completing the

first of the nine units by the end of the second week, to work through the remaining eight units in the self-pacing mode. Students who were assigned to the second group were required to take a unit test within two weeks after a unit was introduced. All students were required to complete all units by the end of the quarter and were required to take the final examination during the examination period.

Results

Effectiveness. Instructional effectiveness can be inferred when student learning results in the desired level of competency. To adequately measure student acquisition of the objectives for Geology 102 a time-series data analysis of unit performance was used. The time-series procedure allowed the measuring of students' performance per unit throughout the course. Although point totals on the unit tests differed per quarter, it was possible to investigate trends in unit performance by dividing the mean unit score by the total unit score. Unit objectives remained the same for the three quarters. An analysis of the unit mean scores showed that for winter quarter the percent of objectives achieved for the units was higher than the fall quarter. The mean increase between the fall academic quarter and the winter quarter was five percentage points. A slight increase of student performance on unit tests occurred again for the spring quarter.

A second measure of effectiveness of the developed instructional system was the gain of performance from the pretest to the posttest. The only pretest comparable to the final examination was given during the winter quarter. Results from a paried t ratio test showed that students did significantly ($p < .05$) better on the posttest ($M = 35.3$) than the

pretest (M = 18.4). The magnitude of gain was 17 points from a possible point total of 56. Assuming that the winter quarter pretest was an adequate measure of students' performance, and is representative for Geology 102 classes, another comparision of pretest-posttest gain would be the winter pretest-fall posttest difference. (Note: The fall posttest was the same as the winter posttest.) Using a t ratio test the results showed a significant ($p < .05$) performance difference between the two sets of scores (fall M = 34.3). The spring quarter final had a number of items in common with the winter final, therefore, scaled scores were compared. The estimated scores were analyzed with a t ratio test which resulted in a significant ($p < .05$) gain of posttest (M = 35.6) over the winter pretest. A 17-point gain was the same as the winter quarter gain. The students in the three quarters had similar mean scores on the posttest.

A third measure of instructional effectiveness questioned how posttest performance in the developmental courses compared with posttest performance in previous Geology 102 courses. Final examination data were available for students enrolled in Geology 102 during the fall quarter, 1969, and the winter quarter, 1970. Performance was scaled using subscores obtained from items which were identical among finals (Gullikson, 1968). The total achievement score on the Florida 12th Grade test was used as a covariate for ability differences between groups.

The scaling technique (Gullikson, 1968) was used to compare the fall and winter developmental courses with the two previous years' courses (fall, 1969; winter, 1970). Because of unequal variances, the Cochran and Cox (1957) adjusted t ratio was used in several of the comparison tests. Fall, 1970 students (M = 32.3) performed significantly ($p < .05$) better on the scaled items of the posttest than the fall, 1969 students (M = 20.2).

Course requirements for winter, 1971, showed a consistently higher ($p < .05$) student performance ($M = 37.1$) than the winter, 1970 students ($M = 29.2$). This analysis of final examination performance indicated that the A-T approach was more effective than the two previous conventional courses in teaching the content of Geology 102.

Efficiency. Developmental programs should cut the time and effort expended by the student. When learning progresses too slowly, the cost in time and effort exceeds motivation and reinforcement and the student "drops out." Individualized instruction is designed to provide the student with reinforcement of learning by allowing him to perceive his own gains. If the instruction is more efficient, the student will want to study more, not less. This assumption was investigated by the two levels of learner control, self-paced and partial self-paced. The analysis of the self-pacing versus partial self-pacing will be reported with a comparison of instructional time for the two spring (1971) developmental levels with previous conventional Geology 102 courses. Time data for the developmental courses were calculated from the student time cards. In calculating the total in-class time, seven and one half hours of general assembly time was added to the spring, 1971 learning center times (Table 1). Although exact time spent by students under the conventional type of instruction was not available for comparison with the audio-tutorial approach, an estimate was obtained according to the following rationale. The course previously consisted of three lectures per week; the time spent in lecture would be equal to three times 50 minutes, or 150 minutes. The developmental course provided laboratory credit, which previously required two periods per week. Therefore, an additional 100 minutes per week would have been spent by students in the previous course. A total of 250 minutes

per week was spent by the student in lecture and laboratory exercises. This would result in a total of 41.7 hours being spent in the conventional lecture-laboratory geology course during the average ten-week quarter (Table 1). Time spent studying "outside" under the conventional system was estimated at a conservative one and one-half hours per week. This estimate would add 90 minutes per week or 15 hours of outside study per quarter.

TABLE 1. Instructional Time: Conventional and Spring Quarter Audio-Tutorial

Comparison	In-Class	Out-Class	Total
Conventional	41.7	15.0	56.7
Self-Paced	32.0	17.6	49.6
Partially Self-Paced	42.0	16.9	59.0

Note.--Numerals represent hours

Students enrolled in the self-paced program of the audio-tutorial course spent nine hours less in a formal instructional situation than students in the conventional course (Table 1). The partially self-paced students spent approximately the same amount of time as the conventional course students. Time spent outside the class for the A-T students was about equal to the conventional course estimated time. Total student hours for the self-paced course was seven hours less than conventional time. When this efficiency data is interacted with the effectiveness data, the assumption that students will learn more in less time when instructional design principles and individualization techniques are used is empirically validated.

Student judgements. Another method of measuring course effectiveness is to ascertain the perceptions of the participants, i.e., students and teachers. An end-of-course questionnaire showed positive feelings from both students and teachers toward the self-instructional A-T methodology. Students' attitudes toward Geology 102 were also positive. The teachers felt that the students spent less time in formal instruction, but learned more. This assumption was confirmed after they reported their perspectives on the course.

Conclusion

The purpose of this developmental project was to design an individualized college course using a multimedia approach capable of presenting the unique characteristics of physical geology. Methodology for implementation included identifying behaviors that students were to exhibit at the conclusion of instruction, selecting appropriate media to display the objectives, preparing instructional materials to teach the objectives, and constructing evaluation instruments to assess student acquisition of the specified behaviors. Data on effectiveness and efficiency were collected to investigate the audio-tutorial system of instruction. By use of formative evaluation techniques the course was revised twice before a summative evaluation was made comparing the course with previous courses taught with the traditional method of the professor's lecture. This final evaluation showed that the students not only learned from pretest to posttest, but that in all cases the A-T students significantly outperformed those previous course students. Results of the effectiveness data seemed to indicate that students in a self-instructional course can perform not only at the same level, but even better, than in more conventional

systems. While the time to criterion process of the A-T approach indicated that performance output can be efficiently improved by appropriate manipulation of the learning environment.

Student control of the learning time contributed to decrease in nonproductive class time usually associated with conventional approaches to instruction. When given minimal control of learning by the course structure, students in this study demonstrated that defined levels of performance can be maintained. The time data for the spring self-pacing students showed a decrease in class attendance during the middle weeks of the quarter, with a rapid increase towards the end. This would suggest that given the opportunity to finish the course earlier than scheduled, students could compress the time required to complete formal college coursework. Thus, the combined findings of student performance and time to criterion strengthened the empirical data that the two investigated hypotheses are acceptable procedures in instructional design for college instruction.

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