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THE DIFFERENTIAL EFFECT OF INTERIM TESTING IN THE USE OF AN AUTO-INSTRUCTIONAL PROGRAM IN AN AREA OF GENERAL SCIENCE FOR TEACHERS.

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PUB DATE AUG 67
CONTRACT OEC-2-7-068294-0177
EDRS PRICE MF-$0.09 HC-$2.00 50P.

DESCRIPTORS- *ACADEMIC ACHIEVEMENT, *COLLEGE SCIENCE, *EVALUATION, *GENERAL SCIENCE, *INSTRUCTIONAL PROCEDURES, *PROGRAMED INSTRUCTION, ATOMIC STRUCTURE, CHEMICAL BONDING, LEARNING, RETENTION, TEACHER EDUCATION, TESTING, AUBURN, SEQUENTIAL TEST OF EDUCATIONAL PROGRESS, NELSON DENNY READING TEST

THE EFFECT OF INTERIM TESTING ON THE IMMEDIATE ACHIEVEMENT AND THE SUBSEQUENT RETENTION OF COLLEGE SCIENCE STUDENTS IS EXAMINED. EXPERIMENTAL AND CONTROL GROUPS WERE RANDOMLY SELECTED FROM TWO INTACT GENERAL SCIENCE CLASSES FOR STUDENTS OF TEACHER EDUCATION. BOTH GROUPS WERE TAUGHT ATOMIC STRUCTURE AND BONDING THROUGH THE USE OF PROGRAMED MATERIALS. RESULTS OF PRETESTS FOR READING LEVEL AND SCIENCE ACHIEVEMENT WERE USED TO ESTABLISH ABILITY GROUPS. BOTH GROUPS WERE TESTED AT THE CONCLUSION OF THE INSTRUCTIONAL PERIOD, FOR SCIENCE ACHIEVEMENT, AND 6 WEEKS LATER FOR RETENTION. FIVE INTERIM TESTS WERE ADMINISTERED TO STUDENTS IN THE EXPERIMENTAL GROUP. A QUESTIONNAIRE WAS USED TO ASCERTAIN STUDENT'S OPINIONS OF THE PROGRAM. ANALYSIS OF COVARIANCE WAS USED TO COMPARE POST-TEST ACHIEVEMENT AND RETENTION TEST SCORES. STUDENTS IN THE AVERAGE AND LOW ABILITY SUBGROUPS OF THE EXPERIMENTAL GROUP MADE SIGNIFICANTLY HIGHER SCORES ON THE ACHIEVEMENT POST-TEST AND THE RETENTION TEST THAN DID STUDENTS IN SIMILAR SUBGROUPS OF THE CONTROL GROUP. EXPERIMENTAL STUDENTS IN THE HIGH ABILITY SUBGROUP WERE SIGNIFICANTLY BETTER ON ONLY THE RETENTION TESTS. STUDENT OPINIONS INDICATED THEY PREFERRED PROGRAMED INSTRUCTION FOR CERTAIN COURSE UNITS. (AG)

FINAL REPORT

PROJECT NO. 6-8294
CONTRACT NO: OEC-2-7-068294-0177

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AUGUST 1967

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

Office of Education
Bureau of Research

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Project No. 6-8294
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August, 1967

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

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I. INTRODUCTION

The Problem

The major purpose of this project was to determine among college students at Auburn University enrolled in elementary and in secondary teacher education the effect of interim testing on immediate achievement and subsequent retention on the material learned about atomic structure and bonding taught by means of programed instruction. Additional purposes were: (1) to evaluate the effect of interim testing on material learned by students of varying abilities in science, and (2) to assess students' opinions concerning the use of programed instruction and interim testing.

The Background

Increasing use of auto-instructional materials is being made at all educational levels. In the past considerable attention has been given to the effectiveness of learning by comparing achievement scores between the pretest and posttest. Meager attention, however, has been given to the effect of interim testing on immediate achievement and retention on learning.

For some time the principal investigator has been interested and involved in the use of programed materials in the teaching of science and in seeking to improve learning as it relates to teacher education.

With the increasing pace of the knowledge explosion and the changing complexities of our dynamic culture, teacher education is realized to a greater extent to be a continuous process extending beyond the formal college classroom setting.

Rogers (21:15) stated that teacher education is best considered as being basically the learning of a continuing process of learning and that it is most likely to occur when the learning is of the experiential type.

The investigator has become increasingly aware of the need for attitudinal changes among students toward continuing self-improvement. Training techniques in the auto-instructional area which would acquaint and involve them with available and adaptable materials in order to prepare them as effectively and efficiently as possible have received considerable attention.

The results of this project have: (1) provided additional evidence of the effect of interim testing on immediate achievement and retention on learning, and (2) demonstrated how to more effectively utilize programing methodology in the area of investigation.

Review of Related Literature

Shell (26:39-52) in 1966, in similar research compared an experimental group (N-34) with a control group (N-34) on the effects of interim testing on immediate achievement and subsequent retention while teaching atomic structure and bonding to college students by programed instruction. He found the results to be significant ($P < .01$) on both posttest and retention test scores.

Shell's findings revealed significant differences at the .01 level when comparing high ability, average ability and low ability groups on posttest scores. On retention scores, average and low ability experimental subjects achieved significantly ($P < .01$), while high ability experimental students achieved at the .05 level of significance. In this research ten interim tests (the manipulated variable) were given to the experimental group as specified portions of the program were completed by each subject.

Extensive research on the use of programed instruction and teaching machine procedures has been conducted over the past ten years. The results indicate strongly their effectiveness on learning in a variety of subject areas which extend from the primary grades through adult education.

Plattor (25:15) found that at the college level programed instruction was not only effective, but also economical as an instructional medium. Williams(23:974) reported that programed instruction, despite great promise, had gained acceptance slowly in undergraduate teaching.

Jacobs (24:38) found a significant difference between means in favor of high school chemistry groups when taught by "machine" as compared to the conventional manner.

Skinner (22:969-977) reported in 1958, that through programing methodology he could have students initiate a desired performance.

Research reviews by Lumsdaine and Glaser (9), Fry, Bryan, and Rigney (5:8) have reported that automated instruction could promote learning.

Pressey (20), Hughes (17), and Porter (13) reported superior performance with the use of programed instruction.

Jacobs (24:138) stated from a review of sixteen studies "that teaching machines have been effective in the field of education for teaching material ranging from elementary school spelling and arithmetic through college psychology and statistics."

These and other studies show that programed instruction when compared to the lecture-demonstration method of teaching is at least as effective and is usually a more efficient method of teaching (22:977).

Previous research reveals that frequent testing and positive reinforcement through feedback increases achievement levels of college students.

One of the few generalizations clearly supported by research on college teaching is that knowledge of results enhances learning. Jones (18:5-70) found in 1923, that immediate testing after a psychology lecture resulted in improved retention. In 1951, Fitch, Drucker and Norton (15:1-20) reported that experimental students received higher scores in government on monthly tests as a result of non-credit weekly quizzes when compared to the non-quizzed control groups. May and Lumsdaine (12) concluded that learning from films is enhanced by participation and feedback. Maize (19:22-28), Guetzkow, Kelley, and McKeachie (16:193-209) found greater improvement in learning among subjects when immediate evaluation of work was done in class.

Shell (26:30) reported in reviewing twenty-eight studies on interim testing, that he found no evidence of interim testing involving programed materials. He concluded, however, from the research on the effect of interim testing on learning during traditionally taught courses, "that with few exceptions, interim testing coupled with immediate knowledge of results had a significant positive effect on learning and subsequent retention."

Mouly (11:293) found that the ability to learn and the ability to retain are positively related. Essentially the two abilities are phases of the same process; therefore the greater the degree of adequacy of immediate achievement the greater the retention.

Mouly (11:293) reported also that retention is facilitated by the student's realization that he was to be tested at some later time. This "intent to remember" is related to the basic concept of motivation, which leads the student to make periodic review (formal or informal), and thereby makes a more intensive impression at the time of learning.

1. The above studies indicate that frequent testing in traditionally taught courses and during programed instruction enhances immediate achievement as well as subsequent retention. Programed materials have been shown to be at least as effective in teaching as traditional methods.

2. Retention and the quality of initial learning have been shown to be positively related.

Purposes of Research

Objectives

The objectives of the research project were to investigate the following:

1. The effect of interim testing on the immediate achievement of students when taught atomic structure and bonding by programed instruction.

2. The effect of interim testing on immediate achievement of high ability students when taught atomic structure and bonding by programed instruction.

3. The effect of interim testing on immediate achievement of average ability students when taught atomic structure and bonding by programed instruction.

4. The effect of interim testing on immediate achievement of low ability students when taught atomic structure and bonding by programed instruction.

5. The effect of interim testing on subsequent

retention of students when taught atomic structure and bonding by programed instruction.

6. The effect of interim testing on subsequent retention of high ability students when taught atomic structure and bonding by programed instruction.

7. The effect of interim testing on subsequent retention of average ability students when taught atomic structure and bonding by programed instruction.

8. The effect of interim testing on subsequent retention of low ability students when taught atomic structure and bonding by programed instruction.

Hypotheses

The objectives of the research were stated as null hypotheses in order to determine the statistical significance of the results:

1. HO_1 There will be no difference in the immediate achievement level in science attained by:

   a) the group which received programed instruction with interim testing in atomic structure and bonding; and,

   b) the group which received programed instruction in atomic structure and bonding without interim testing.

2. HO_2 There will be no difference in the immediate achievement level in science attai .ed by:

   a) the high ability group which rec. ived programed instruction with interim testing in atomic structure and bonding; and,

   b) the high ability group which received programed instruction in atomic structure and bonding without interim testing.

3. HO_3 There will be no difference in the immediate achievement level in science attained by:

   a) the average ability group which received programed instruction with interim testing in atomic structure and bonding; and,

b) the average ability group which received programed instruction in atomic structure and bonding without interim testing.

4. HO_4 There will be no difference in the immediate achievement level in science attained by:

a) the low ability group which received programed instruction with interim testing in atomic structure and bonding; and,

b) the low ability group which received programed instruction in atomic structure and bonding without interim testing.

5. HO_5 There will be no difference in retention level in science attained by:

a) the group which received programed instruction with interim testing in atomic structure and bonding; and,

b) the group which received programed instruction in atomic structure and bonding without interim testing.

6. HO_6 There will be no difference in the retention level in science attained by:

a) the high ability group which received programed instruction with interim testing in atomic structure and bonding; and,

b) the high ability group which received programed instruction in atomic structure and bonding without interim testing.

7. HO_7 There will be no difference in the retention level in science attained by:

a) the average ability group which received programed instruction with interim testing in atomic structure and bonding; and,

b) the average ability group which received programed instruction in atomic structure and bonding without interim testing.

8. HO_8 There will be no difference in the retention level in science attained by:

a) the low ability group which received programed instruction with interim testing in atomic structure and bonding; and,

b) the low ability group which received programed instruction in atomic structure and bonding without interim testing.

II. METHOD

Population and Sample

The major purpose of this project was to determine among college students at Auburn University enrolled in elementary and in secondary teacher education the effect of interim testing on immediate achievement and subsequent retention on the material learned about atomic structure and bonding taught by means of programed instruction. The research involved two intact undergraduate classes of (N-48) each as assigned through normal university registration procedures during the fall quarter, 1966. The students were enrolled in the course "General Science for Teachers" (SED 473). The appropriateness of selecting intact groups for this project is justified in terms of Campbell and Stanley's Non-equivalent Control Group Design (2:217) and by Kerlinger (7:347).

An experimental group and a control group were chosen by random selection. The experimental class and the control class met daily at 8:00 a.m. and 9:00 a.m., respectively. Each class met for fifty minutes per day, five days per week, during the fall quarter, 1966.

Students in both the experimental and control groups were also ability grouped into high, average, and low categories based on their <u>STEP</u> science scores. There were sixteen subjects each in the high ability, the average ability, and the low ability groups in both the experimental and control classes.

In the experimental class (N-48) the <u>STEP</u> converted scores and percentile range respectively of ability groups were as follows: (1) Low ability - 267-281 (2-46 percentile); (2) Average ability - 282-292 (16-78 percentile); (3) High ability - 293-302 (46-91 percentile) (28:23).

In the control class (N-48) the <u>STEP</u> converted scores and the percentile range respectively of ability groups were as follows: (1) Low ability - 263-281 (0.5-46 percentile); (2) Average ability - 282-290 (16-72 percentile);

(3) High ability - 291-314 (39-99.2 percentile) (28:23). The arithmetic mean of the STEP converted scores of the experimental and control groups were: 285.34 and 285.00 respectively.

Instrumentation

To accomplish the purposes of the study the following instruments were selected:

1. Chemistry I - Atomic Structure and Bonding and the accompanying Response Book (4) were commercially available and were used as the programed text material. The book is a linear program and consists of 804 frames. It is designed to teach the fundamental concepts of atomic structure and bonding.

This text was selected as the learning task in this investigation for a number of reasons. It appeared to be of an appropriate difficulty for the subject population. It presented a topic most of which was new to all learners. It was of sufficient length to adequately analyze the hypotheses of the study.

2. Cooperative Sequential Tests of Educational Progress (STEP) - Science, Form 1A, Parts 1, 2 (27) were used to determine the science ability levels in both the experimental and control groups. STEP scores were used as a covariant in the statistical analysis. This test is designed for college freshmen and sophomores in order to measure their ability to use science knowledge to solve problems. The choice of this test was based upon an evaluation by George C. Mallison (1:882).

3. Nelson-Denny Reading Test, Vocabulary-Comprehension-Rate, Form B (29) was used to determine the reading levels of the subjects and was used as a covariant in the statistical analysis. The choice of this test was based upon reviews by David B. Orr (1:1077) and Agatha Townsend (1:800).

4. A revision by the principal investigator of the final examination supplied by the publisher of the programed textbook was used as a Pretest, Posttest and Retention Test (see Appendix A). The pretest was administered following the giving of the Nelson-Denny Reading Test and the STEP science test at the beginning of the research project. The posttest was administered following the completion of the program and the retention test was administered six weeks later. All subjects in the experimental

and control groups received three identical tests.

5. Five non-credit interim tests (the independent variable) were prepared and administered by the principal investigator (see Appendix B) to the experimental group (N-48) only during the study of the programed text. These tests were given to subjects as they completed specified portions of the programed material. Each test was graded immediately so that each subject could know the results. No explanations were made by the investigator unless requested to do so.

6. A student questionnaire (see Appendix C) prepared by the principal investigator was administered to the total sample (N-96) at the completion of the program to ascertain subjects' opinions concerning the use of programed instruction and interim testing.

7. A sixty-three frame linear program (8:164-176) dealing with the use and value of programed material was given to all subjects prior to the study of the programed text to assist them in becoming more competent in the use of programed instruction.

The Design

Two intact undergraduate classes of (N-48) each enrolled in "General Science for Teachers" (SED 473) were used in the conduct of the research. An experimental group and a control group were chosen by random selection. Subjects in both the experimental and control groups were ability grouped into high, average, and low categories of (N-16) each based on their STEP Science Test scores.

A 2 x 3 analysis of Covariance of factorial design was used to test the hypotheses and to determine the statistical significance (3:94). The .05 level of significance was required for the rejection of the null hypotheses.

The rationale for using the analysis of Covariance was given by McNemar (10:373) and by Kerlinger (7:347-351).

The pretest, Nelson-Denny Reading Test and STEP scores were used as covariant adjustments to statistically equate both groups for comparison in the global sense. Only the pretest and Nelson-Denny Reading Test were used to equate groups for comparative statistical treatment of ability groupings.

At the conclusion of the programed instruction the pretest was readministered to each group as a posttest to determine science achievement (the dependent variable). Six weeks later the posttest was readministered as a retention test to determine the science knowledge retained.

Five interim tests (the manipulated variable) were administered to the experimental group (N-48) as specified portions of the programed text were completed.

A student questionnaire was administered to the total sample (N-96) to ascertain students' opinions concerning this program.

From previous experience with this text, the investigator felt that ten class periods were of sufficient length to allow all subjects to complete the program. Each subject was to work at his own pace. At the beginning of each day's session, subjects were given their respective programed texts and response books which were furnished by the instructor. Similarly at the close of each session, programed materials were returned. All work on the program was done in class and no outside work was assigned or encouraged.

Collection and Analysis of Data

Data were collected for experimental purposes through use of the following instruments: (1) Pretest, Posttest and Retention test on Atomic Structure and Bonding; (2) Nelson-Denny Reading Test; (3) STEP Science Test; and (4) Student Opinion Questionnaire on the atomic structure and bonding program.

The pretest, Nelson-Denny Reading Test and STEP science scores obtained at the beginning of the project, were used for covariant adjustments to statistically equate the experimental and control groups for comparison in the global sense. Only the first two of these tests were used to equate the high, average and low ability groups for comparative statistical analysis.

At the conclusion of the investigation the pretest was readministered to both groups as a posttest. Six weeks later the posttest was readministered to both groups as a retention test.

Five interim tests were given the experimental group (N-48) during the study of the programed text. Interim testing was the manipulated variable in the research project. The dependent variable was science achievement.

The Student Questionnaire was administered to the total sample (N-96) to obtain subjects' reactions to this approach of programed instruction.

A 2 x 3 Analysis of Covariance, using the F test, was performed to determine the effect of interim testing on immediate achievement and subsequent retention of the experimental group as compared to the control group. See Figure 1.

The Auburn University IBM 7040 EDP System 1/0 was used. The program utilized was: BMDO3V-Analysis of Covariance, Version of July 22, 1965, Health Sciences Computing Facility, UCLA.

FIGURE 1

ANALYSIS OF COVARIANCE
(2 X 3 EXPERIMENTAL DESIGN)

	Experimental Group (Interim Testing)	Control Group (Non-Interim Testing)
High Ability	Adjusted Posttest and Retention Scores	Adjusted Posttest and Retention Scores
Average Ability	Adjusted Posttest and Retention Scores	Adjusted Posttest and Retention Scores
Low Ability	Adjusted Posttest and Retention Scores	Adjusted Posttest and Retention Scores

III. THE RESULTS

Measurement of Immediate Achievement

The analysis of covariance of the posttest scores of the experimental and control groups were:

1. The F ratio of 12.68 (df 1/88) on the immediate effect of interim testing for the experimental group (N-48) and the control group (N-48) exceeded the critical value (6.90) at the .01 level of signficance (see Table 1). The null hypothesis was rejected.

2. The F ratio of 0.38 (df 1/28) on the immediate effect of interim testing on the high ability students (N-16) of the experimental group and the high ability students (N-16) of the control group did not exceed the critical value (4.20) at the .05 level of significance (see Table 2). The null hypothesis was not rejected.

3. The F ratio of 4.80 (df 1/28) on the immediate effect of interim testing on the average ability students (N-16) of the experimental group and the average ability students (N-16) of the control group exceeded the critical ratio (4.20) at the .05 level of significance (see Table 3). The null hypothesis was rejected.

4. The F ratio of 7.16 (df 1/28) on the immediate effect of interim testing on the low ability students (N-16) of the experimental group and the low ability students (N-16) of the control group exceeded the critical ratio (4.20) at the .05 level of significance (see Table 4). The null hypothesis was rejected.

Measurement of Retention

The analysis of covariance of the retention test scores of the experimental group and control group were:

1. The F ratio of 28.10 (df 1/88) on the effect of

TABLE 1

ANALYSIS OF COVARIANCE OF POSTTEST SCORES OF THE EXPERIMENTAL GROUP AND OF THE CONTROL GROUP

Source of Variation	Adjusted Sum of Squares	df	Mean Square	F	P
Testing Procedures	978.86	1	978.86	12.68	<.01
Ability Levels	93.29	2	46.64	0.60	ns
Interaction (Procedures x Level)	416.48	2	208.24	2.70	ns
Within Groups	6792.00	88	77.18		
Total	8280.63	93	89.04		

TABLE 2

ANALYSIS OF COVARIANCE OF POSTTEST SCORES OF THE HIGH ABILITY STUDENTS OF THE EXPERIMENTAL GROUP AND THE HIGH ABILITY STUDENTS OF THE CONTROL GROUP

Source of Variation	Adjusted Sum of Squares	df	Mean Square	F	P
Testing Procedures	14.31	1	14.31	0.38	ns
Within Groups	1065.35	28	38.05		

TABLE 3

ANALYSIS OF COVARIANCE OF POSTTEST SCORES OF THE AVERAGE ABILITY STUDENTS OF THE EXPERIMENTAL GROUP AND THE AVERAGE ABILITY STUDENTS OF THE CONTROL GROUP

Source of Variation	Adjusted Sum of Squares	df	Mean Square	F	P
Testing Procedures	211.06	1	211.06	4.80	<.05
Within Groups	1231.48	28	43.98		

TABLE 4

ANALYSIS OF COVARIANCE OF POSTTEST SCORES OF THE LOW ABILITY STUDENTS OF THE EXPERIMENTAL GROUP AND THE LOW ABILITY STUDENTS OF THE CONTROL GROUP

Source of Variation	Adjusted Sum of Squares	df	Mean Square	F	P
Testing Procedures	1082.12	1	1082.12	7.16	<.05
Within Groups	4231.78	28	151.14		

interim testing on retention of the experimental group (N-48) and of the control group (N-48) exceeded the critical value (6.90) at the .01 level of significance (see Table 5). The null hypothesis was rejected.

2. The F ratio of 11.24 (df 1/28) on the effect of interim testing on retention of the high ability students (N-16) of the experimental group and the high ability students (N-16) of the control group exceeded the critical value (7.64) at the .01 level of significance (see Table 6). The null hypothesis was rejected.

3. The F ratio of 5.28 (df 1/28) on the effect of interim testing on retention of the average ability students (N-16) of the experimental group and the average ability students (N-16) of the control group exceeded the critical ratio (4.20) at the .05 level of significance (see Table 7). The null hypothesis was rejected.

4. The F ratio of 9.57 (df 1/28) on the effect of interim testing on retention of the low ability students (N-16) of the experimental group and the low ability students (N-16) of the control group exceeded the critical ratio (7.64) at the .01 level of significance (see Table 8). The null hypothesis was rejected.

Similar significant statistical results were obtained when the investigator compared a t test treatment of the data with the F test project findings. The t test used was an adaptation of IBM System/360 Scientific Subroutine Package (360-CM-03X), IBM Technical Publications Department, 112 East Post Road, White Plains, N. Y., 10601.

Student Questionnaire

An opinion questionnaire was administered to both the experimental and the control groups at the completion of the programed learning experience to ascertain subjects' reactions to this method of instruction.

The following are summaries of the ninety-six subjects' (total sample) responses to each item:

Item 1. The use of the programed text on the unit of atomic structure and bonding has meant that:

---(a) I have gotten more out of this unit using this method.

TABLE 5

ANALYSIS OF COVARIANCE OF RETENTION TEST SCORES OF THE EXPERIMENTAL GROUP AND OF THE CONTROL GROUP

Source of Variation	Adjusted Sum of Squares	df	Mean Square	F	P
Testing Procedures	5181.12	1	5181.12	28.10	$<.01$
Ability Levels	863.27	2	431.63	2.34	ns
Interaction (Procedures x Level)	183.26	2	91.63	0.50	ns
Within Groups	16223.64	88	184.36		
Total	22451.29	93	241.41		

TABLE 6

ANALYSIS OF COVARIANCE OF RETENTION TEST SCORES OF THE HIGH ABILITY STUDENTS OF THE EXPERIMENTAL GROUP AND THE HIGH ABILITY STUDENTS OF THE CONTROL GROUP

Source of Variation	Adjusted Sum of Squares	df	Mean Square	F	P
Testing Procedures	1512.63	1	1512.63	11.24	<.01
Within Groups	3768.42	28	134.59		

TABLE 7

ANALYSIS OF COVARIANCE OF RETENTION TEST SCORES OF THE AVERAGE ABILITY STUDENTS OF THE EXPERIMENTAL GROUP AND THE AVERAGE ABILITY STUDENTS OF THE CONTROL GROUP

Source of Variation	Adjusted Sum of Squares	df	Mean Square	F	P
Testing Procedures	943.33	1	943.33	5.28	<.05
Within Groups	5003.19	28	178.69		

TABLE 8

ANALYSIS OF COVARIANCE OF RETENTION TEST SCORES OF THE LOW ABILITY STUDENTS OF THE EXPERIMENTAL GROUP AND THE LOW ABILITY STUDENTS OF THE CONTROL GROUP

Source of Variation	Adjusted Sum of Squares	df	Mean Square	F	P
Testing Procedures	2334.42	1	2334.42	9.57	$<.01$
Within Groups	6833.52	28	244.05		

---(b) It has made no difference in my learning.
---(c) I would have learned more about this unit through the conventional lecture-demonstration method.

Eighty-nine subjects felt that they had learned more by using the programed method. Five believed that it had made no difference in learning. Only two felt that they would have learned more through the conventional lecture-demonstration approach.

Item 2. In other similar courses, I would:

---(a) Prefer to have all of the course programed.
---(b) Prefer certain units of the course programed.
---(c) Prefer not to use programs at all.

Ninety-two of the ninety-six subjects preferred to have certain units of the course programed. Four preferred to have all of the courses programed.

Item 3. What courses or units, if any, would you like to see taught using this method?

The preferred rank-order of the subject area courses desired to be taught utilizing this method were: (1) mathematics and related courses, (2) physical sciences, (3) social and behavioral sciences, (4) biological sciences, (5) language arts, and (6) technical courses. Eight felt that almost any course could be improved by some programing. Approximately fifty percent of the subjects thought that mathematics and physical science courses could be improved by this method.

Item 4. What did you like best about this method of learning?

The characteristics of programed instruction which were liked in order: (1) thirty-five liked the self-pacing, (2) twenty-four liked the small steps, (3) thirteen preferred immediate confirmation, (4) student testing was most helpful to thirteen, and (5) ten liked the active responding feature.

Item 5. What did you like least about this method of learning?

The majority of complaints centered around expressions such as, boring, repetitious, too long and monotonous. Other complaints involved such observations as: (1) missed the class discussion and class questions and answers, (2) material was ambiguous in places and superficial in treatment at times, (3) no way to eliminate material not needed and (4) hard to find an answer to what one wants to know. A few felt that they had to hurry.

Item 6. Do you intend to use programed instruction methods when you become a teacher?

Only two felt that they did not want to use programed material in teaching. Forty-seven others believed they would use the method from abundantly to sparsely based upon adaptability to the subject taught and availability of the material. Thirty-four felt that they would like to use some programed instruction. Eleven were uncertain about the use of the material.

Item 7. Were you tested frequently enough?

The experimental group of forty-eight subjects all felt that they were tested frequently enough. The experimental group received five non-credit interim tests besides the pretest, posttest and retention tests.

The control group (N-48) which did not receive the interim tests, expressed some degree of need for testing during the programed instruction.

Item 8. Write down any additional comments you might have about any aspect of your experience with programed instruction.

For many, this was their first experience in programed instruction. Their responses were generally enthusiastic with comments, such as: (1) much better understanding of chemistry as compared to a whole year of study in high school, (2) good for difficult material and should be made available to students having difficulty, and (3) excellent for adult education and slow learners. Some subjects believed that any teacher should consider using programed instruction, but cautioned that one should constantly reevaluate. Several experimental subjects observed that immediate grading of interim tests helped facilitate learning and retention.

IV. DISCUSSION

The effects which interim testing had on immediate achievement using programed materials in atomic structure and bonding were as follows:

1. On the total sample - the experimental group (N-48) which received interim tests made significantly higher scores on posttest ($P < .01$) when compared to the control group (N-48).

2. On ability groupings in science -

   a) High ability subjects (N-16) receiving interim testing failed to achieve at the .05 level of significance when compared to the control subjects (N-16) on posttest.

   b) Average ability subjects (N-16) receiving interim tests made significantly higher scores on posttest ($P < .05$) when compared to the control subjects (N-16).

   c) Low ability subjects (N-16) receiving interim tests made significantly higher scores on posttest ($P < .05$) when compared to the control subjects (N-16).

The effects which interim testing had on retention using programed materials on atomic structure and bonding were as follows:

1. On the total sample - the experimental group (N-48) which received the interim tests made significantly higher scores on the retention test ($P < .01$) when compared to the control group (N-48).

2. On ability groupings in science -

   a) High ability students (N-16) receiving interim tests made significantly higher scores on the retention test ($P < .01$) when compared to the control students (N-16).

b) Average ability students (N-16) receiving interim tests made significantly higher scores on retention test ($P < .05$) when compared to the control students (N-16).

c) Low ability students (N-16) receiving interim tests made significantly higher scores on retention test ($P < .01$) when compared to the control students (N-16).

Student opinions concerning the use of programed instruction as a means of instruction in atomic structure and bonding were: (1) approved by a large majority and plan to use it in future teaching, (2) prefer certain course units programed, especially in mathematics and science, (3) liked best the self-pacing and small steps, (4) repetitious aspects disliked by a small number, (5) experimental group felt that interim testing was frequent enough.

V. CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

The statistical significance of the findings of this project illustrate the effectiveness of interim testing when used with programed instructional materials. It was concluded that:

1. Students who learned atomic structure and bonding coupled with interim tests achieved significantly on immediate achievement and retention.

2. High ability students who learned atomic structure and bonding coupled with interim tests achieved significantly on retention, but failed to achieve significance on posttest.

3. Average ability students who learned atomic structure and bonding coupled with interim tests achieved significantly on immediate achievement and retention.

4. Low ability students who learned atomic structure and bonding coupled with interim tests achieved significantly on immediate achievement and on retention.

5. Student opinions were highly favorable toward programed instruction used in this project. Most subjects felt they had received more from this unit by the auto-instructional technique, and most of them plan to use it in teaching. Their opinions indicate a desire to some extent for programed learning in a wide variety of subject-matter areas. Experimental subjects indicated they strongly favor the interim tests. A few students indicated some boredom due to repetitiousness in the program.

Implications for teacher education would include:

1. Interim testing can be used to increase learning effectiveness among students enrolled in programed and traditional courses or units in the university setting.

2. Interim testing can be used to increase learning effectiveness among student groups with varying abilities.

Some recommendations as a result of this experiment would include:

1. That this type experiment be replicated in a variety of subject-matter areas and on various maturity levels.

2. That this type experiment be conducted in conjunction with other teaching methodology to determine the possibility of increased learning effectiveness.

3. That this type experiment be repreated using other factored variables such as personality characteristics and anxiety levels.

4. That this type experiment be replicated sequentially (longitudnal study) to determine the effectiveness of concept-attainment and concept-formulation.

5. That this type experiment may be used by innovative teachers to become involved in action or experimental research in order to better evaluate their teaching and to add to the growing body of research knowledge.

VI. SUMMARY

This project sought to determine among college students enrolled in elementary and in secondary teacher education at Auburn University the effect of interim testing on immediate achievement and subsequent retention of material learned about atomic structure and bonding taught by the means of programed instruction. Additional purposes were: (1) to evaluate the effect of interim testing on material learned by students of varying abilities in science, (2) to assess students' opinions concerning the use of programed instruction and interim testing.

Research evidence of the value of programed instruction and interim testing has accumulated in a variety of subject areas in recent years. However, few studies have attempted to achieve the purpose of this project which was to compare the learning of groups that was brought about by interim testing during the use of programed materials.

The objectives of the project were to investigate the effect of interim testing on (1) immediate achievement, and (2) subsequent retention by teacher-education students who studied atomic structure and bonding taught by programed instruction. These objectives were related to the following four categories: (a) the total sample (global sense), (b) high ability students, (c) average ability students, and (d) low ability students.

Eight null hypotheses were stated to test the objectives at the .05 level of significance.

The research involved two intact classes (N=48) as assigned through university registration in the course "General Science for Teachers" (SED 473). An experimental group and a control group were chosen by random selection. Students in both the experimental and the control groups were also ability grouped into high, average and low categories based on the STEP science scores. There were sixteen subjects each in the high ability, average ability, and low ability groups in both the experimental class and the control class.

Pretest, Nelson-Denny Reading Test, and STEP science scores were used for covariant adjustments to statistically equate both classes for comparison in the global sense. Only the first two tests were used to equate respect ability groups in order to compare them statistically.

At the conclusion of the study the pretest was administered to each group as the posttest. Six weeks later the posttest was readministered to both groups as a retention test. Posttest and retention test achievement scores are the dependent variables in the research.

Five interim tests were given the experimental group of forty-eight subjects during the study of the programed text. Interim testing was the manipulated variable in the research project.

An opinion questionnaire was administered to both the experimental and control groups at the completion of the program.

A 2 x 3 Analysis of Covariance, using the F test, was performed to determine the effect of interim testing on immediate achievement and subsequent retention of the experimental group as compared to the control group.

The findings were as follows: Subjects administered interim tests, when compared to the control group - (1) made significantly higher scores on posttest ($P < .01$) and retention test ($P < .01$); (2) high ability students failed to achieve at the .05 level on posttest, but were significant at ($P < .01$) on retention test; (3) average ability students made significantly higher scores on posttest ($P < .05$), and retention test ($P < .05$); low ability students made significantly higher scores on posttest ($P < .05$), and retention test ($P < .01$).

Student opinions of programed instruction were: (1) most students planned to use programed instruction in future teaching, (2) prefer certain course units be programed, especially in mathematics and science, (3) liked best the self-pacing, and small steps, (4) disliked most the repetitious aspects and (5) those in the experimental group felt interim testing was frequent enough.

Implications for teacher education would include: (1) interim testing can be used to increase learning effectiveness among students enrolled in programed or traditional courses or units in the unversity setting, (2) interim testing can be used to increase learning effectiveness among student groups of varying abilities.

Recommendations as a result of this experiment would include the following:

1. This type experiment should be replicated in a variety of subject-matter areas and on various maturity levels.

2. This type experiment should be conducted in conjunction with other teaching methodology, such as class discussion, to determine the possibility of increasing learning effectiveness.

3. This type experiment should be repeated using other factored variables such as personality characteristics and anxiety levels.

4. This type experiment should be replicated sequentially (longitudnal study) to determine the effectiveness of concept-attainment and concept-formulation.

5. This type of experiment may be used by innovative teachers to become involved in action or experimental research in order to better evaluate their teaching and to add to the growing body of research knowledge.

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APPENDIX A

PRETEST, POSTTEST AND RETENTION TEST
ON
ATOMIC STRUCTURE AND BONDING

I. 1. Name the three fundamental particles of which atoms are composed. What is the charge of each of these particles?

2. Draw a diagram of an atom with an atomic number of 22, showing the correct number of electrons in each energy level. Label the energy levels of the atom you have drawn.

3. Iron has an atomic number of 26. How many electrons does an iron atom have in energy level 3?

4. Is H_2O an element? Why?

5. What is meant by the term "stable structure"?

II. 1. What are two properties of the element sodium (at. no. 11)?

2. A certain element has the electron structure represented below. In what group does the element belong?

Energy Level	1	2	3	4	5
Number of electrons	2	8	18	18	3

3. Complete this chart. (See your periodic table.)

Name	Symbol	Atomic No.	Period	Group
		28		
Phosphorus			3	
	Kr			Inert Gas

4. Draw diagrams to represent the electron structure of each of the following atoms: A (at. no. 16), V (at. no. 23), and Sn (at. no. 50).

III. 1. What is meant by the term "ion"?

2. How many electrons will a bromine atom (at. no. 35) gain in order to achieve a stable electron structure in its outermost energy level?

3. Explain how a Ca atom could become a Ca^{++} ion.

4. What is a covalent bond?

5. Give the names of each of the following compounds.

Al_2O_3

K Cl

Cu S

6. Define electronegativity.

7. What is the oxidation number of O in Si O_2?

IV. 1. a. List three factors that affect the electronegativity of an atom.

b. Which one of these factors affects the change in electronegativity most as we move down a group?

2. Which element in each of the following pairs of elements is more electronegative?

a. Na and I b. K and Rb c. Si and Cl

3. a. Are metals or non-metals more electronegative?

   b. Which of these elements is most non-metallic?

      Se (at. no. 34)
      Zn (at. no. 30)
      Br (at. no. 35)

   c. Which of these elements is most metallic?

      O (at. no. 8)
      S (at. no. 16)
      Se (at. no. 34)

V. 1. Write the structural and electron dot formulas for CH_4.

2. What is the relationship of electronegativity to covalent and ionic bonds?

3. What is meant by the term "non-polar molecule"?

4. Distinguish between a covalent bond and an ionic bond.

5. a. Write the structural formula for water, indicating the approximate angle that the H atoms form with O.

   b. Why is the NH_3 molecule considered polar?

This is a revision of the final examination supplied by publisher of programed text: Atomic Structure and Bonding, 1962, Basic Systems Inc., Appleton-Century-Crofts. Lyons & Carnahan, New York.

APPENDIX B

INTERIM QUIZ I

Frames 1 - 245

1. The nucleus of an atom contains ________ and _________.

2. Around this nucleus ______________ move about.

3. The charge of the nucleus of an atom is _________. Explain.

4. Draw a diagram of the nitrogen atom. (Nitrogen has an atomic number of 7 and also has 7 neutrons).

5. The net charge of an atom is _________. Explain.

6. What is the general rule for the order of filling energy levels?

7. Diagram a stable atom.

8. Tell which element each symbol stands for:

a. O	d. Li	g. Na
b. H	e. Mg	h. C
c. Ca	f. Al	i. I

9. Define the term element.

10. Why is water not an element?

11. Do all atoms of the same element have the same atomic number? Explain.

12. Arrange these elements in the order they would appear in the periodic table.

    O (at. no. 8), He (at. no. 2), cl (at. no. 17), C (at. no. 6)

13. Explain the relationship between period number and number of energy levels.

INTERIM QUIZ II

Frames 246 - 384

1. All elements in group VA have _________ electrons in their outermost level.

2. Explain the relationship between atoms located in vertical columns IA, IIA, IIIA, IVA, VA, VIA, VIIA, and the number of electrons in their outermost energy levels.

3. Helium is located in which group? Which period?

4. Once energy level 3 contains 8 electrons, when does it again begin to fill?

5. When element scandium is reached, electrons are added to the ____________ energy level.

6. Describe the order of filling energy levels in period 4, from left to right.

7. Sc is formed by adding an electron to the ______________ energy level of Ca.

8. Why isn't Fe placed in group IIA of the periodic table?

9. How are elements between atomic numbers 21-30 different from the Ca structure?

10. Is group IA or group IB a transition group? Why?

11. List 2 properties that are possessed by both Na and Li.

12. List 2 properties that are possessed by both Cl and F.

13. Na and Li are in which group?

14. What can you say about the electron structures and properties of the inert gases?

INTERIM QUIZ III

Frames 385 - 544

1. Atoms have a tendency to lose or gain electrons to attain the outer energy level structure of the inert gases. Explain.

2. How might F acquire the outer electron structure of an inert gas? What would its net charge be?

3. Define ion and give 2 examples.

4. What types of ions do atoms form which are located on the right side of the periodic table? On the left side?

5. Electronegative elements are located on which side of the periodic table? Explain.

6. Ions with an octet of electrons in their outer energy levels resemble which group of elements?

7. Show by diagram how an atom of Na and an atom of F might combine.

8. Define ionic bond.

9. How are positively charged ions named? Negatively charged ions? List 2 examples of each.

10. Name the following:

    a. LiF
    b. $CaCl_2$
    c. NaI

11. How does atomic number affect the nuclear attraction for the electrons in the outer energy levels?

12. Why does the Br atom tend to attract electrons more strongly than the K atom?

13. If one atom attracts electrons more strongly than another, we say it is more electro_____________________.

14. Electropositive atoms form _________ ions. Electronegative atoms form ____________ ions.

INTERIM QUIZ IV

Frames 545 - 700

1. Why does the nucleus of the Be atom attract its electrons more strongly than the nucleus of the Li atom?

2. The force of attraction between a nucleus and an electron depends upon what 2 things?

3. Why is F more electronegative than Cl?

4. Why does electronegativity decrease as the size of the inner core increases?

5. Define shielding.

6. List the three factors that affect electronegativity and explain each.

7. Why are atoms in group VIIA considered to be non-metallic?

8. Why are metallic atoms considered to be electropositive?

9. Atomic radius increases as we go down a group. How does this affect electronegativity?

10. Define oxidation number. Use Mg in your explanation.

11. What is the difference between atoms that have positive oxidation numbers?

12. List three oxidation numbers of ions that might be formed by atoms in group IIIA.

13. What is the oxidation number of oxygen in Na_2O?

INTERIM QUIZ V

Frames 701 - 804

1. Define molecule.

2. Compare the electron structure of the hydrogen molecule with the structure of an atom of helium.

3. Explain how two chlorine atoms might form a molecule. Is this structure stable?

4. Compare a covalent bond with an ionic bond and give an example of each.

5. Under normal conditions why is molecular hydrogen more likely to exist than atomic hydrogen?

6. Give the structural formula for H_2 and for Cl_2. Also give the dot structure.

7. Diagram the H_20 molecule showing covalent bonds. What is the angle of this bond.

8. How do covalent bonds differ from ionic bonds?

9. Why do elements located next to each other in the periodic table tend to form covalent bonds?

10. Why would Na and Cl form an ionic bond between them?

11. What is the relationship of the difference in electronegativity between two atoms and ionic bonding?

12. Diagram a polar molecule.

13. Diagram a non-polar molecule and explain this structure.

APPENDIX C

STUDENT QUESTIONNAIRE

We are interested in your reactions to this method of learning. Please answer the following questions.

1. The use of the programed text on the unit of atomic structure and bonding has meant that

____(a) I have gotten more out of this unit with this method.

____(b) It has made no difference in my learning.

____(c) I would have learned more about this unit through the conventional lecture-demonstration method.

2. In other similar courses I would

____(a) Prefer to have all of the course programed.

____(b) Prefer certain units of the course programed.

____(c) Prefer not to use programs at all.

3. What courses or units, if any, would you like to see taught using this method?

4. What did you like best about this method of learning?

5. What did you like least about this method of learning?

6. Do you intend to use programed instruction methods when you become a teacher?

7. Were you tested frequently enough?

8. Write down any additional comments you might have about any aspect of your experience with programed instruction.