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TEACHING BASIC ELECTRONIC FACTS IN INDUSTRIAL ARTS: A COMPARISON OF TWO SELF INSTRUCTIONAL METHODS

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Teaching Basic Electronic Facts in Industrial Arts: a Comparison of Two Self Instructional Methods," submitted by Campbell J. Ross in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

This study compared the effectiveness of two self instructional stimulus-response methods of teaching basic electronic facts to Junior High School Industrial Arts students. One method used was ERIB, an electrical teaching device developed by the researcher, while the control method was flash cards.

The study was designed to answer two research questions. (1) Is ERIB a self instructional tool which is of value in the Junior High School Industrial Arts laboratory? (2) Is ERIB as effective as another stimulus-response means in teaching basic electronic facts to Junior High School Industrial arts students?

It was hypothesised that no significant differences in learning or retention existed between students learning information via the two systems.

The test instruments were a thirty-five item multiple choice post test and a similar retention test which was administered one week later.

The population consisted of all the Grade 8 Industrial Arts students within the Edmonton Public and Separate School Systems. The sample was 200 students, randomly selected and split into two halves.

Data were collected in the Industrial Arts laboratories during normal class periods. The data were processed by

the IBM 360/67 computer at the University of Alberta.

KR20 reliability was found to be above .78 for both the post test and the retention test, while item reliability ranged from .07 to .36.

Analysis of variance showed that significant differences occurred between the experimental and control groups.

The null hypotheses were therefore rejected.

The researcher concluded that (1) Flash cards were more efficient than ERIB, in teaching basic facts. (2) ERIB was of value in the Junior High School Industrial Arts laboratory.

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INTRODUCTION

ORIENTATION TO THE PROBLEM

The Alberta Junior High School Industrial Arts program is based on the multiple activity concept. The Department of Education Curriculum Guide for Industrial Arts (1969) defines a multiple activity program as:

> an organizational device by means of which a variety of exploratory experiences can be presented with a minimum of room and equipment. The laboratory is organized into a number of different sections representing the fields of study. Each section or bay is large enough to accommodate 4-6 students. These bays are as self-contained as possible, with provision made for the storage of tools, products and stock within them. The class is divided into three or more groups, with each group working through the course unit in the assigned bay. After the completion of the unit, in from nine to twelve weeks the groups rotate, each proceeding to another bay and new experiences (p. 4).

Therefore, at any one time, a class of Industrial Arts students will be engaged in at least three differing types of activities. Examples may be: Graphic Communications; Materials; and Electricity-electronics activities.

In such a class, it is likely that students will be functioning at various levels of cognitive learning. Gagné (1970) lists eight levels of cognitive learning. They are:

1. Signal Learning; also called conditioned response learning.

2. Stimulus-Response learning; where correct responses are reinforced to strengthen their retention.
3. Chaining; the connection of a set of stimuli and responses into a sequence.
4. Verbal Association or naming; which is a variety of chaining.
5. Discrimination Learning; or the ability to discriminate between similar perceptions.
6. Concept Learning; or the ability to classify stimuli by abstract properties.
7. Rule Learning; a chain of two or more previously learned concepts.
8. Problem Solving; the ability to use and apply previously learned rules to arrive at a solution.

According to Gagné, learning is hierarchical in nature, so, for learning to occur at a given level, it is necessary that the previous level be mastered. In other words, Stimulus-Response learning in a given area is a necessary prerequisite before Chaining, Verbal Association, Discrimination Learning, Concept Learning, Rule Learning or Problem Solving can occur.

If Gagné's theory is accepted, the Industrial Arts teacher must structure his program to ensure that appropriate learning experiences are provided for each of his student groups. However, as Frantz (1970) states:

> The demands placed on a single instructor to provide individualized attention to students in accomplishing educational goals and objectives often become insurmountable. Efforts to cope with these problems in a conventional manner usually result in inefficient use of instructional time, or the neglect of teacher attention to individual student requirements. Individualized instruction may be useful in solving (such) instructional problems (p. 38).

Bjorkquist and Lease (1965) stated that "facts are the building blocks of education (p. 18)," and must be mastered by a student before higher level learning can occur. Such is the case in the Electronics area of Industrial Arts, where it is necessary for students to learn many basic facts before conceptualization and problem solving can occur.

It is both time consuming and educationally inefficient for a teacher to instruct students in basic facts, which is essentially a stimulus-response type of learning, while other class members may need his help in order to reach higher levels of achievement.

Therefore, it is likely that the introduction of an educational aid that is able to instruct basic electronic facts will be of benefit to students in Junior High School Industrial Arts classes.

THE PROBLEM

A cognitive teaching device called Electrical Response Indicator Board (ERIB) has been made which may be able to instruct Industrial Arts students in basic electronic

facts.

The problem is that no evidence is available to support this claim.

PURPOSE OF THE STUDY

The purpose of the study is to ascertain whether ERIB can teach basic electronic facts to Junior High School Industrial Arts students as effectively as another stimulus-response self teaching means.

Specifically, the study seeks answers to the following research questions.

1. Is the ERIB system a self-instructional tool which is of value in the Junior High School Industrial Arts laboratory?
2. Is ERIB as effective as another stimulus-response means in teaching electronic facts to Junior High School Industrial Arts students?

NEED FOR THE STUDY

Baker, Fowler and Schuler (1967) expressed the view that more effective and efficient teaching methods were needed in the electricity-electronics area, due to the rapid increase of subject matter. They examined several investigations in this area and concluded that more research was needed in order to improve the quality of education, and that too little research in the electricity-electronics area was being conducted in public high schools.

Barnard (1963) wrote that Industrial Arts leaders had the responsibility to write and test instructional programs for school use. Yet Kenneke (1970) indicated that little progress had so far occurred in that field, and that

> Concerned educators must try to influence school officials and other leaders in developing conditions which will encourage experimentation with and application of autotutorial technology. Classroom teachers must be allowed to investigate and consider its merits, and use those techniques which are effective (p. 28).

Later, Kumro and Camp (1971) decried the lack of research in Industrial Education in the following terms:

> In nearly all curricular areas, empirical studies of the application of programmed materials are still badly needed. And in some areas of industrial education experimental evidence to support the value of programmed instruction is also completely lacking (p. 228).

An independent study of some Junior High School Industrial Arts facilities in Edmonton by Dyrenfurth (1970) concluded that more efficient use of the instructor's time would result if a greater quantity and variety of instructional aids were available. The students of those classes surveyed also indicated that they would prefer to use a greater variety of instructional material in the Industrial Arts laboratories.

It therefore appears certain that an experimental study, to obtain empirical data relating to the effectiveness of the ERIB device as an aid in teaching electronics material,

would be of value.

DEFINITION OF TERMS

ERIB: This is a stimulus-response teaching device, consisting of a hardware unit and software sheets. The hardware unit has a variety of separate electrical circuits plus two external probes. Completion of any one circuit via the probes causes an indicator bulb to light. The software consists of four 9" by 12" paper sheets. Each sheet contains eight or nine sets of related statements and responses, a total of thirty-five sets in all. When one of the sheets is inserted into the hardware unit, several of the circuit terminals are exposed. As the learner locates a matching statement-response set, via the probes, the reinforcing bulb lights. Incorrect responses do not complete any of the electrical circuits, therefore only correct responses are positively reinforced. A more detailed explanation appears in Appendix A, page 46.

SELF TEACHING MEANS: Flash Cards. Flash cards present a learning situation to the student. One side contains a statement plus a choice of four responses. The other side has the correct response endorsed on it. The student reads the statement, then attempts to select the correct response from the four provided. Reversing the card displays the correct answer. Flash cards are a stimulus-response teaching method and provide immediate reinforcement and

evaluation of student responses. They were selected for this study because "Through flash cards, the Industrial Arts teacher has one more effective teaching tool to satisfy the needs of his students (Bjorkquist and Lease, 1965. p. 34)."

HYPOTHESES

1. There will be no significant difference in achievement between those students who learn basic electronic facts via ERIB and those who learn via flash cards.

2. There will be no significant difference in retention between those students who learn basic electronic facts via ERIB and those who learn via flash cards.

SCOPE AND LIMITATIONS OF THE STUDY

The scope of the study was limited to Grade 8 Industrial Arts students in the City of Edmonton, therefore, the results obtained cannot be generalized beyond the defined population.

It was assumed that both the experimental and control groups were homogeneous sub-samples of the same population.

It was also assumed that both the post test and retention tests used were equivalent, as both contained the same items, only in varying order of presentation.

The comparison of the ERIB learning process to flash cards is limited to the extent that both methods offer a

choice of possible responses, and that both methods provide immediate feedback to indicate whether a correct or incorrect response was selected.

METHOD OF THE STUDY

The program was administered to each group during normal Industrial Arts periods. Eight class members were randomly assigned, four to the experimental group and four to the control group.

Each member of the experimental group was placed at an ERIB unit and shown how to insert the software sheets, and operate the probes in order to verify the correctness of a response.

Each member of the control group was provided with a set of thirty-five flash cards and told that each contained a single fact plus a choice of four responses, and the correct answer on the reverse of each card.

Both groups were allowed twenty-five minutes learning time with their respective materials, after which a common post test was given.

One week later a common retention test was administered by the classroom teacher, the test results being mailed to the researcher for analysis.

The same procedure was followed with each of the twenty-five selected classes of students.

The data to be analyzed consisted of ninety-five sets

of post and retention tests for the experimental group, and ninety-eight sets of similar data from the control group.

Item analysis tests were performed to determine the reliability of tests used in the study, while two way analysis of variance was done to test the null hypotheses.

RELATED LITERATURE

LEARNING THEORY

Gagné (1970) has described learning as "a change in human disposition or capability, which can be retained, and which is not simply ascribable to the process of growth (p. 3)." He has outlined eight categories of learning and arranged them into a hierarchy which ranges from simple to complex. His basic assumption is that each higher order learning category is dependent on mastery of those levels below it.

His hierarchy is as follows:

1. Signal Learning or conditioned response, which causes a natural reflex, such as fear, anger or pleasure to be exhibited on the presentation of a specific stimulus. Gagné states that signal learning is of little value in the field of educational learning.

2. Stimulus-response Learning, which requires that a specific action be made in response to a given stimulus. This type of learning is a matter of discrimination between correct and incorrect stimuli. Stimulus-response learning

forms the base of Gagné's hierarchy.

3. Chaining, which is the connection of a set of stimuli and responses into a sequence of events, such as are required to tie a shoelace or open a door. It is emphasised that a chain cannot be learned unless the learner can perform all the units within it.

4. Verbal Association or naming. This type of learning requires the establishment of a mediation link or mental image in order to connect the association. The learner must know each link as in a stimulus-response situation, and he must know the mediating connections between each verbal unit. This type of structure is useful when learning material such as poetry.

5. Discrimination Learning requires that the learner has, in isolation, all the required chains. In practice, stimuli are presented repetitively, followed by reinforcement of correct responses. Discrimination learning is frequently used in schools.

6. Concept Learning or the ability to distinguish by the means of a common abstract quality of classification. Stimulus objects are presented to the learner in rapid sequence, and the common link or concept elicited. New objects are introduced as a check that the concept has been understood. Concepts are abstractions, and this type of learning frees individual learners from control by specific stimuli.

7. Rule Learning. Gagné (1970) defines a rule as "an inferred capability that enables the individual to respond to a class of stimulus situations with a class of performances (p. 191)." The performances must, of course, be predictably related to the stimulus situations. The student must know all or most of the component parts and be aware of the performance expected of him. The component concepts are revised, and verbal clues for the whole rule given. When the learner can demonstrate the rule, under a variety of conditions, then this level of mastery has been achieved.

8. Problem Solving is the apex of Gagné's structure. A problem is presented which the learner must define. Possible solutions are hypothesised and tested, based on previously attained learning experiences. Problem solving is the final step in the sequence of learning.

Gagné (1970) wrote that "Typically, the learning of a topic, or part of a course of study, can be viewed as a hierarchy in which the most complex rules representing the 'endpoint' objectives require the learning of simpler rules as a prerequisite to efficient attainment (p. 212)." In other words, stimulus-response learning is a vital link in the learning process.

Skinner (1968) prefers to call stimulus-response learning 'operant learning', and defines teaching as "the arrangement of contingencies of reinforcement, to expedite

learning (p. 5)." That is, if a particular consequence, called a reinforcement , is arranged, the behaviour of an organism can be pre-determined. He emphasised that by arranging contingencies of reinforcement, machines were capable of teaching. Gagné (1970) has postulated that much learning is really a matter of discrimination between correct and incorrect stimulation, and that stimulus-response learning is resistant to forgetting, which makes it useful for school use.

PROGRAMMED LEARNING

Porter (1957) has stated that teaching efficiency may be increased by the application of the results of psychological principles derived from 'learning' experiments, and also through the use of teaching aids and devices. He defined a teaching machine as "a stimulus-response device which is capable of teaching without the mediation of the teacher (p. 126)." He theorised that a stimulus-response teaching machine was best able to meet the requirements of a teaching machine for educational use.

Espich (1967) said that most programmed materials were based on stimulus-response conditioning, and that reinforcement increased the probability of a response being repeated. In the case of programmed instruction, positive reinforcement was a stimulus presented to the learner after his response. The reinforcement of course, had to satisfy

one or more of his basic human needs, such as success. Such programs worked mainly in the cognitive domain.

There are various types of programs. Fry (1963) categorized them as either constructed response, where the student writes an answer; or multiple choice programs. The former was concerned with the ability to recall information, while the latter dealt with the ability to recognize information. Deterline (1962) has said that multiple choice programs assumed that the desired responses (learning) could be obtained by ensuring that a student pay attention and arrive at the correct response by his own sequential efforts. Of course, great care must be taken in preparing a program, for it has no value unless it produces learning in the students for whom it was intended.

Pressey (1926) has identified two factors which reduced the effect that errors (such as may be made by a student using a multiple choice program) could have on achievement. They were firstly, the law of frequency, which stated that a student may get some wrong answers, but that by chance he would get more correct than incorrect ones. Secondly, the law of recency, which stated that no matter how many incorrect responses were given, the correct answer was always the last one, and therefore more likely to be remembered, because it came closest to the reinforcement.

TEACHING MACHINES

The main advantage of using a teaching machine was, as Deterline (1962) pointed out, that it helped a teacher deal adequately with large numbers of students. Fry (1963) noted that teaching machines could relieve highly skilled teachers from routine class assignments such as rote learning and revision type activities. Similar views were expressed by Kersh (1965), Pressey (1965) and Lysaught and Williams (1963).

In a review of the literature on teaching machines, Porter (1957) discussed the electric answer board, which presented a series of questions and answers, that the student attempted to match. To check the accuracy of a guess, the student touched a contact button near the answer of his choice, with an electric probe. If the answer was correct a light flashed or a buzzer sounded. Nothing happened for incorrect choices. Porter placed this board within the category of immediate reinforcement stimulus-response devices, which included Pressey's Multiple Choice machine, Chemical Paper, the Punchboard and the Skinner Device. Although he stated that the electrical board had been used as a children's toy, Porter found no articles concerning its use in a teaching situation.

Foltz (1962) examined the types of teaching devices that were available at that time. Punchboards, Multiple

Choice Machines and Chemical Papers were available, but no reference was made to the electrical answer board, as an instructional aid for school use.

In a contribution to a publication for Industrial Arts teachers, Buetlich (1967) described an electrical teaching machine that he had made. It had provision for six question and answer sequences, and relied on the use of internal switches to alter the circuit combinations. It was used to reduce the need to repeat instructions to Industrial Arts students, but no evidence was presented to support its use as a part of the regular educational program.

The ERIB machine is basically a combination of both the electrical answer board and the electric teaching machine previously described. Its main difference is that provision was made for a wide variety of material to be presented to students, through the use of interchangeable paper software sheets. In addition, the information presented by each sheet was arranged to minimize the chance that a student could memorize the circuit combinations exposed on the face of the ERIB unit.

SUMMARY

Learning has been described as a hierarchy based on stimulus-response learning. Many authors agree that machine like devices are well suited to provide stimulus-response learning situations, and that such devices free the teacher

from repetitive, rote-like teaching activities. Evidence has been presented to show that multiple choice or matching programs are effective, despite the fact that the learner may make several errors before selecting the right answer. This is due to the fact that the last response is always correct, and is reinforced, while incorrect responses are not.

The electrical answer board, of similar format to the ERIB unit, had been used before, but no case was unearthed where such a device had been used specifically to teach information to school students, as part of the normal educational program.

ORGANIZATION OF THE REMAINDER OF THE STUDY

Chapter 2 deals with the planning and organization of the study, and details the evolution of the ERIB material.

Chapter 3 lists the conduct of the research, with emphasis on the selection of the participating classes, administration of the study, and data collection methods used.

Chapter 4 lists the findings of the study and summarizes the results of the item analysis and analysis of variance tests performed.

Chapter 5 summarizes the conduct of the study and lists the conclusions. The findings are discussed and problems for further study listed.

CHAPTER 2

PLAN AND ORGANIZATION OF THE STUDY

PILOT STUDY

The original material used during the pilot study was developed in conjunction with two experienced Junior High School Industrial Arts teachers in Edmonton. It was therefore felt to be representative of the basic knowledge required by Junior High School Industrial Arts students in the field of Electronics Technology.

The research design used for the pilot study was

$$O_1 \quad X \quad O_2$$

$$O_1 \qquad\; O_2$$

Where O_1 was the pretest,

X was the ERIB learning process,

O_2 was the post test.

Identical pre and post tests were used. Each consisted of thirty-five multiple choice questions based on the ERIB material.

The ERIB material consisted of four pages, each containing eight or nine basic electronic facts plus matching responses, a total of thirty-five items.

Twelve students, selected randomly from one Grade 8 Industrial Arts class in Edmonton, formed the sample for the

pilot study.

After a common pretest, six students were randomly assigned to be the experimental group, while the control group was formed by the remaining six students. The experimental group were shown how to operate the software sheets in the ERIB unit in order to verify the correctness of responses made. As the function of the control group was to determine whether learning occurred because of exposure to the pre and post tests, they resumed normal Industrial Arts activities, while the experimental group proceeded with the ERIB material.

The results of the study indicated that the experimental group learned some electronic material, while the control group did not. Consequently, it was decided to make several changes in the research methodology. They were:

i. eliminate the pretest because random sampling ensured that both the experimental and control groups were homogeneous sub-samples of the same population.

ii. revise the format of the ERIB software so that each sheet contained related material.

iii. use flash cards, containing the same facts as the ERIB sheets, with the control group in order to compare the learning effectiveness of the ERIB system to another stimulus response means of instruction.

iv. introduce a common retention test.

v. randomize the format of both the post test and the retention test.

POPULATION

The population for this study consisted of students from all the Grade 8 Industrial Arts classes in both the City of Edmonton Public and Separate School Systems, a total of 290 classes, in fifty-two Junior High Schools.

SAMPLE

The sample consisted of students from twenty-five Grade 8 Industrial Arts classes, drawn from fifteen randomly selected schools within the above population.

The experimental group consisted of 100 students, being four students randomly assigned from each of the twenty-five classes. The control group consisted of 100 students similarly assigned from the same twenty-five classes. The total sample was therefore 200 students.

RESEARCH DESIGN

The research design was

$$R \quad X_1 \quad O_1 \quad O_2$$

$$R \quad X_2 \quad O_1 \quad O_2$$

Where R was the random selection,

X_1 was the ERIB process,

X_2 was the flash card process,

O_1 was the post test,

O_2 was the retention test.

The major variable between the groups was the method of instruction. Therefore any difference in results was attributed to the type of instructional program used.

DEVELOPMENT OF THE RESEARCH MATERIAL

The ERIB material was revised after completion of the pilot study. The program used in the final study consisted of four sheets. Sheet one contained information relative to the basics of electrical units such as Volt, Ohm, Ampere. Sheet two covered the relationship of the units to each other and Ohm's Law. Sheet three introduced various types of simple circuits, while sheet four was concerned with electronic terms such as modulation. The four sheets contained a total of thirty-five statements and matching responses, related to basic electronic facts.

The material for the control group consisted of thirty-five flash cards. Each card contained one basic electronic statement plus four possible responses. The correct answer was placed on the back of each card in order that it would be self checking. The cards were not sorted into any special order before student use.

The revised post test contained thirty-five multiple choice type questions, each based on the ERIB program. The retention test was similarly constructed, but the order of both the questions and the multiple choice responses were randomized.

A one week retention period was selected because most Industrial Arts classes meet on at least a weekly basis. Therefore new knowledge should be retained for (at least) that length of time in order that fresh learning experiences can occur, based on knowledge previously acquired.

SUMMARY

The pilot study provided feedback information which caused several changes to be made in the format of the research methodology.

They were:

i. eliminate the pre test.

ii. revise the ERIB software into related areas.

iii. introduce flash cards for the control group.

iv. introduce a retention test.

v. randomize the format of both the post and retention tests.

The population for the study was the students of the Grade 8 Industrial Arts classes in the City of Edmonton's fifty-two Junior High Schools.

The sample was 200 students randomly selected from twenty-five Grade 8 Industrial Arts classes drawn from fifteen randomly selected schools, within the above population.

The research design was:

$R \quad X_1 \quad O_1 \quad O_2$

$R \quad X_2 \quad O_1 \quad O_2$

The research material was developed to cover basic information required by Junior High School Electronics Industrial Arts students. The flash cards contained identical information. Two Junior High School Industrial Arts teachers assisted with the compilation of the material used in the program.

Tests used in the study were developed by the researcher, and based on the ERIB material.

CHAPTER 3

CONDUCT OF THE RESEARCH

SELECTION OF THE CLASSES IN THE STUDY

Each of the fifty-two Junior High Schools in Edmonton that comprised the population for the study had at least two separate Grade 8 Industrial Arts Classes per week. For convenience, it was decided to randomly select fifteen schools, and then schedule visitations in such a manner that the field research could be undertaken, within the fifteen schools, during twelve and one half consecutive school days.

Grade 8 Industrial Arts timetables were obtained from each of the selected schools. This information was used to construct the researcher's personal timetable, the major consideration at that time being to ensure that two Grade 8 classes could be scheduled for each school day. That is, twenty-five class visits were arranged for the twelve and a half day period allotted for this part of the study.

The final timetable included all fifteen selected schools. However, of necessity, five of the schools were visited on just one occasion, which meant that only one class from each of them was included in the study. The ten schools remaining were visited twice, which made the total of twenty-five classes that participated in the study.

The researcher had no prior knowledge of the collective ability of the selected classes.

ADMINISTRATION OF THE STUDY

The program was administered during regular lesson periods, in the Industrial Arts laboratories of the schools concerned with the study. The only requirement was that the researcher had access to a power outlet and several feet of bench or table space, on which the ERIB units and flash cards were placed.

Eight members of each class were randomly selected by the use of random number tables which were compared to the students' alphabetic class listing. The eight students thus selected drew lots to determine their placement as either members of the experimental group or of the control group. That is, four of the eight students were placed in the experimental group and four in the control group.

Each member of the experimental group was placed at an ERIB unit and told that the four software sheets provided contained thirty-five basic electronic facts. It was demonstrated how the sheets fitted into the ERIB unit and stated that the matching of a specific question to its correct response, through the use of external probes, would cause the indicator bulb to light. The light therefore, could confirm the correctness of any response selected.

Each member of the control group was provided with a set of flash cards containing the same basic material as the ERIB sheets. It was explained that each card had a choice of

four responses listed, and that the correct answer was also on the back of each card. The students were shown how to operate the cards, and how to confirm the correctness of their responses.

Both groups were allowed twenty-five minutes with their respective learning materials, as the pilot study conducted previously had indicated that student interest appeared to wane if longer periods of time were allowed for that part of the program. At the conclusion of that time, both groups completed a common multiple choice post test. They then resumed normal class activities.

A common retention test was given to the participants one week later, by the class teacher, who was provided with the test material by the researcher. The test material package contained eight copies of the retention test, eight answer blanks, eight pencils and a stamped, self-addressed envelope in which the answer sheets were mailed back to the researcher. The class teacher was requested to administer the retention test to the participating students one week later. Fifteen minutes were allowed for the completion of the test.

The same administrative procedure was followed with each of the twenty-five classes that participated in the study.

STATISTICAL METHOD

It was expected that the data to be analyzed would consist of 100 sets of post and retention tests from the

experimental group, and 100 sets of similar test results from the control group. However, due to student absences when the retention test was administered, the study finally yielded ninety-five sets of data from the experimental group and ninety-eight sets from the control group.

The University of Alberta's Division of Educational Research: Test 04 (DERS:TEST04) item analysis program was used to determine the reliability of both the post test and the retention tests used in the study.

The University's Division of Educational Research: Analysis of Variance 23 (DERS:ANOV23) program was used to check the null hypotheses. It employs a two factor analysis of variance with repeated measures on one factor.

SUMMARY

Fifteen schools were randomly selected for the study from the fifty-two schools which contained all of the 290 Grade 8 Industrial Arts classes in Edmonton. For convenience, twenty-five classes from the fifteen schools selected, were assigned to provide randomly selected students, who became the sample population.

The study was conducted in the Industrial Arts laboratories of the schools during twelve and one half consecutive school days. Class teachers administered the retention test to student participants one week later.

The study yielded ninety-five sets of test scores for the experimental group and ninety-eight sets of results for

the control group, as some participants were absent when the retention test was given. The data was processed by the University of Alberta's computer system, using the DERS:TEST 04 program to obtain a measure of the reliability of the tests used in the study, and the DERS:ANOV23 program to test the null hypotheses.

CHAPTER 4

FINDINGS OF THE STUDY

ANALYSIS OF THE POST AND RETENTION TESTS

The post test was administered after the sample had been treated, while the retention test was administered one week later. Both tests contained thirty-five multiple choice items, each having four distractors. All items were based directly on the material presented to the participating student groups, via the ERIB program.

The DERS:TEST04 item analysis provided the information which may be seen in table 1.

The test mean was 19.79 for the post test, and 18.30 for the retention test.

Test reliability is calculated with the Kuder Richardson 20 formula, and may range from 0.00 to 1.00. A high value indicates greater reliability than does a low value. The reliability of the tests was found to be 0.7792 for the post test and 0.7910 for the retention test.

Item difficulty is expressed as the percentage of students answering an item correctly, and may range from 0.00 to 1.00. A high value indicates that a large percentage of students correctly answered a specific test item. The item difficulty of the post test ranged from 0.31 to 0.90, with a mean difficulty of 0.56. Fourteen percent, or five of the items, had a difficulty less than the chance level of

TABLE 1

ANALYSIS OF POST AND RETENTION TESTS, MEANS, TEST RELIABILITY, BISERIAL CORRELATION AND ITEM RELIABILITY

Source	Test Scores			Item Difficulty		Biserial Correlation		Item Reliability	
	Mean	Range	KR20	Mean	Range	Mean	Range	Mean	Range
Post Test	19.79	6-33	.7792	0.56	0.31 to 0.90	0.48	0.14 to 0.78	0.22	0.07 to 0.34
Retention Test	18.30	5-31	.7910	0.52	0.14 to 0.85	0.49	0.14 to 0.87	0.23	0.06 to 0.36

0.75. The item difficulty of the retention test ranged from 0.14 to 0.85, with a mean difficulty of 0.52. Eleven percent or four items had a difficulty less than the chance level of 0.75.

The biserial correlation measured the relationship between student performance on a specific item and performance on the test as a whole. This value may range from -1.00 to +1.00. A high positive correlation is desirable, as it indicates that a particular test item is able to discriminate between high and low student achievers. Of the biserial correlations calculated for the post test items, fifty-seven percent or twenty items were between 0.14 and 0.50, with forty-three percent or fifteen items between 0.50 and 0.78. The mean value was 0.48.

For the retention test, the biserial correlations calculated showed that forty-eight percent or seventeen items, were between 0.14 and 0.50, while fifty-two percent or eighteen items were between 0.50 and 0.87. The mean value was 0.49.

The item reliability index determines the effectiveness of an item, when considering the item difficulty and the biserial correlation. Its value may range from -0.50 to +0.50. A high positive value is desirable. Reliability indices of the post test items ranged from 0.07 to 0.34, with a mean of 0.22. Reliability indices for the retention test ranged from 0.06 to 0.36, with a mean of 0.23.

The item analysis for the post and retention tests appears in Appendix F, Tables 4 and 5, page 75.

ANALYSIS OF VARIANCE

The DERS:ANOV23 computer program provided the following information, which also appears in Tables 2 and 3.

The X_1 group scored a mean of 18.69 items correct on the post test and a mean of 17.36 items correct on the retention test.

The X_2 group scored a mean of 20.68 items correct on the post test and a mean of 19.20 items correct on the retention test.

The 'A' main effects indicated the variation between the X_1 and X_2 groups as a whole. This was done by considering the X_1 group's post and retention tests; and comparing them to the X_2 group's post and retention tests. The consequent variation between the X_1 and X_2 groups gave an F ratio of 5.821 and a probability which was significant beyond the 0.05 level.

The 'A*B' interaction indicated the interaction between the X_1 and X_2 groups. The F ratio was 0.046 and the probability 0.83. No significant interaction occurred between the X_1 and X_2 groups. Therefore, both null hypotheses were rejected.

The 'B' main effects indicated the variation between the post and retention tests. The consequent variation between the tests gave an F ratio of 23.377 and a probability which was significant beyond the 0.05 level. The 'B' main effects were not relevant in this study.

TABLE 2

MEANS OF ACHIEVEMENT SCORES AND STANDARD DEVIATIONS FOR POST AND RETENTION TESTS.

	POST TEST		RETENTION TEST	
	Cell Means	Standard Deviation	Cell Means	Standard Deviation
Experimental Group. N =95	18.69	5.29	17.36	5.70
Control Group N = 98	20.68	6.25	19.20	6.21

TABLE 3

SUMMARY OF ANALYSIS OF VARIANCE

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F Ratio	Probability
'A' Main Effects	345.815	1	345.815	5.821	0.0167807**
'B' Main Effects	191.399	1	191.3999	23.377	0.0000062**
'A*B' Interaction	0.377	1	0.377	0.046	0.8303548

** Significant at the 0.05 level.

SUMMARY

Item analysis data were obtained for both the post test and the retention test. The reliability of the post test was 0.7792, while the reliability of the retention test was 0.7910.

The analysis of variance program provided data which led to the rejection of both the null hypotheses at the 0.05 level.

Significant differences in achievement were found between the groups tested.

CHAPTER 5

SUMMARY, CONCLUSIONS, DISCUSSION AND PROBLEMS FOR FURTHER STUDY

The purpose of the study was to compare the effectiveness of two self-instructional methods of teaching electronic facts to Junior High School Industrial Arts students.

The ERIB system was selected because it had been developed by the researcher, who had no reliable indication of its educational merit. Flash cards were used as the control because support had been found for their use in teaching electronic material to Industrial Arts students (Bjorkquist and Lease, 1965). In addition, flash cards were similar to ERIB as they were a stimulus-response self-teaching means; provided immediate indication as to the correctness of a response; and reinforced correct responses.

The study was designed to answer the following research questions.

1. Is the ERIB system a self-instructional tool which is of value in the Junior High School Industrial Arts laboratory?
2. Is ERIB as effective as another stimulus-response means in teaching electronic material to Junior High School Industrial Arts students?

The following research hypotheses were developed.

1. There will be no significant difference in achievement between those students who learn basic

electronic facts via ERIB and those who learn via flash cards.

2. There will be no significant difference in retention between those students who learn basic electronic facts via ERIB and those who learn via flash cards.

SUMMARY

The study compared the effectiveness of two self-instructional stimulus-response methods of teaching basic electronic facts to Junior High School Industrial Arts students.

The population for the study was the Grade 8 Industrial Arts students in the City of Edmonton. The sample consisted of 200 randomly selected students split into equal halves, and drawn from the defined population.

The experimental group worked with the ERIB program while the control group worked with flash cards for a period of twenty-five minutes. Both groups then completed a common multiple choice post test which was followed, one week later, by a common retention test.

A pilot study was conducted which provided information that led to a revision of both the research design and the material used in the study. The material used was developed by the researcher in conjunction with two experienced Junior High School Industrial Arts teachers.

Due to student absences when the retention test was administered, complete data were only available for ninety-five members of the experimental group and ninety-eight members of the control group.

The test data were processed by the University of Alberta's IBM 360/67 computer. Program DERS:TEST04 was used to determine the reliability of the post and retention tests. It was found that the mean score for the post test was 19.79 items answered correctly. The reliability was 0.7792, while the item difficulty ranged from 0.31 to 0.90, with a mean of 0.56. Biserial correlation ranged from 0.10 to 0.78, with a mean of 0.48. Item reliability ranged from 0.07 to 0.34, with a mean of 0.22.

For the retention test, the mean was 18.30 items correct. The reliability was 0.7910, while the item difficulty ranged from 0.14 to 0.85, with a mean of 0.52. Biserial correlation varied from 0.14 to 0.87, with a mean of 0.49. Item reliability ranged from 0.06 to 0.36, with a mean of 0.23.

Program DERS:ANOV23 was used to test the null hypotheses. The variation between the experimental and control group scores yielded an F ratio of 5.82 and a probability of 0.016. The variation of interaction between the groups yielded an F ratio of 0.046 and a probability of 0.83. Both hypotheses were therefore rejected at the 0.05 level.

CONCLUSIONS

Null Hypotheses 1 and 2 were both rejected.

There was a significant difference between the X_1 and X_2 groups as a whole, while no significant interaction occurred between the groups.

The means of the X_1 and X_2 groups after the post test, (18.69 and 20.68) indicated that the X_2 group achieved the higher score. The flash cards were more effective than ERIB in teaching basic electronic facts. Therefore, Null Hypothesis 1 was rejected.

The means of the X_1 and X_2 groups after the retention test, (17.36 and 19.20) indicated that the X_2 group achieved the higher score. The flash card learning resulted in greater student retention than did ERIB. Therefore, Null Hypothesis 2 was rejected.

DISCUSSION

Some evidence relative to the educational merit of the ERIB device was obtained. Students using the ERIB method were able to learn and retain almost as much factual information as did students using flash cards. It therefore appears that the ERIB system is able to provide the Junior High School Industrial Arts teacher with an educatioally sound, self-instructional means.

As none of the classes participating in the study appeared to normally use flash cards, it seems likely that flash cards too, are able to provide another effective

self-teaching method.

Although an attitude test was not administered, the researcher's observations suggest that the ERIB system may have a higher motivational effect on students than do flash cards. Several instances were observed where students using flash cards appeared to lose some interest prior to the expiration of the study time allotted. In contrast, students using the ERIB process appeared to be interested for the entire time period.

Several factors could account for this occurrence. They are:

1. The response listed on a flash card may allow the 'correct' response to be more easily distinguished from the four provided. This situation was permitted when the flash card responses were constructed, as it was felt that the inclusion of more difficult response choices would lead to a duplication of many of the distractors which were used in both the post test and the retention test. This in turn, could result in an undesirable situation where a student would have prior knowledge of the structure of the tests.

ERIB, however, has material grouped into related areas, on four separate software sheets. This arrangement may cause a student greater difficulty in locating the correct response. Therefore, due to their format, it appears that flash cards can allow a student to match the

statement-response sets more quickly than can the ERIB format.

2. The use of multiple choice items in both the post test and retention test may not have been appropriate, considering the instructional means used. Students using flash cards were provided with a situation whereby they had practice in selecting the correct response from four distractors. ERIB students, however, had to select a correct response from up to nine distractors. As the criterion exams which were used to indicate student progress were of similar format to the flash cards, it is possible that flash card students would find a multiple choice form of test less difficult than would ERIB students.

3. Flash cards indicate the correct answer immediately when a response is being verified, while ERIB may require up to eight responses to be made before the correct answer is located. In such a case, flash cards are able to transmit information more quickly. It follows that a student using flash cards could match the thirty-five facts and responses more quickly than a student using ERIB. Therefore, loss of student interest in flash cards may occur because of boredom, as an excessive length of time may have been allowed for their use.

4. The fact that the researcher was present and observing the students during the learning process may have created an artificial situation where students using flash cards may have worked more diligently than would occur in

a normal Industrial Arts laboratory. In a normal laboratory situation, the teacher would most likely be occupied with another class group, while some students may be using self-instructional material to increase their knowledge. In such a case, it is suggested that student motivation to use flash cards efficiently may decrease. Conversely, the researcher's observations indicate that ERIB would be more likely to motivate students, and therefore permit more effective self-instruction to occur. It is recognized that the apparent increase in student motivation when using ERIB may be due to a novelty effect. Nevertheless, it is felt that the ERIB system could be used to advantage in Industrial Arts laboratories to motivate students to learn factual material with a minimum of teacher direction.

Both the post and retention tests which were developed, were found to have high reliability. It therefore seems likely that these tests could be gainfully employed to measure student achievement in the Electronics area of Industrial Arts education.

PROBLEMS FOR FURTHER STUDY

As both instructional systems achieved similar results, further research could be initiated to evaluate other self-instructional methods used in Industrial Arts education.

Since both methods are inexpensive, teachers should be encouraged to use either means in their laboratories.

The study revealed several realated problems worthy of further investigation. They are:

1. There is a need for a study to determine the educational parameters of the ERIB system, such as;

   i. What is the optimum time that a student should use ERIB in one session?

   ii. What is the optimum amount of information that should be presented to a student in one session?

   iii. What is the optimum number of items that should be accommodated on one page of ERIB software?

2. There is a need for a similar study to determine the parameters of flash cards, as a self-instructional means in Industrial Arts.

3. There is a need for a study to compare the learning effectiveness of both ERIB and flash cards, to other self-instructional methods, in the Industrial Arts field.

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APPENDIX A

The ERIB System

THE ERIB SYSTEM

The ERIB unit was constructed as shown in Illustration 1. The terminal face was a 9" by 14" piece of plywood, with fifteen small bolts vertically positioned near the right and left hand edges.

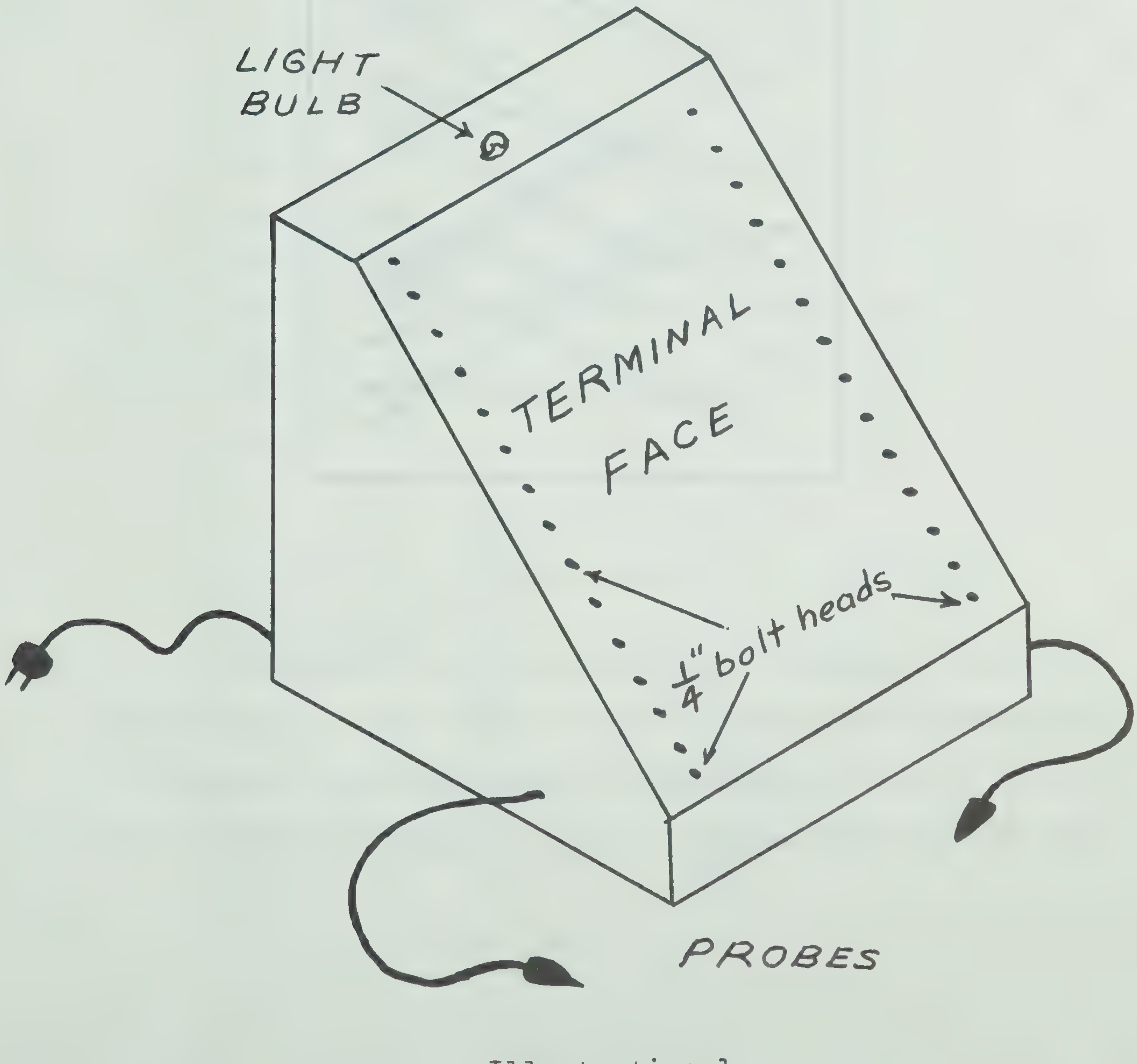


Illustration 1.

The bolts were wired in pairs, as shown by Illustration 2. The wires were placed under the terminal face.

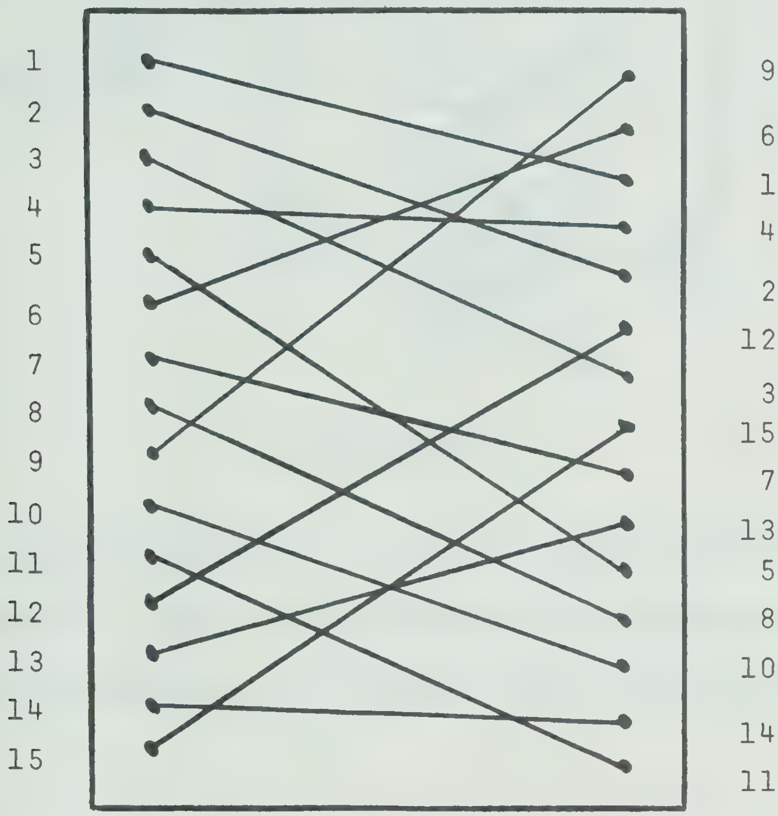


Illustration 2.

A schematic of the electrical circuit is shown in Illustration 3. The 110 volt mains current was reduced to 6.3 volts by the transformer. Completion of any of the fifteen circuits, through the probes, caused the bulb to light.

[illegible]

[illegible]

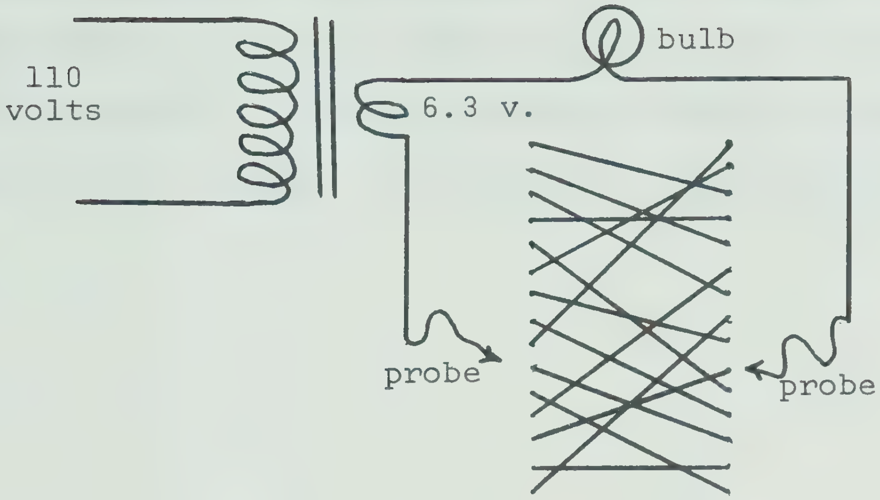


Illustration 3.

Each software sheet had holes punched, as shown by Illustration 4. Selected terminals were exposed when the sheet was placed over the terminal face of the ERIB unit.

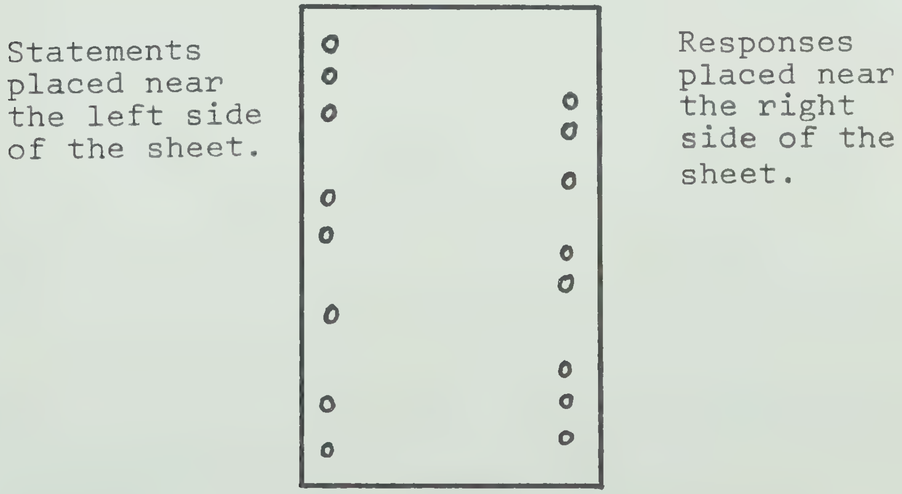


Illustration 4.

Many hole combinations could be punched, which permitted statements and responses to be arranged in a variety of combinations. Each of the four sheets used in this study had a different set of holes punched in order to present information to the learner in a variety of combinations.

APPENDIX B

Facsimile of Revised ERIB Software

Volt is the unit of measurement of

Examples of insulators are

Example of conductors are

A positive area will attract

Direct current is

An ohm is the unit of measurement of

The amp is the unit of measurement of

A resistor will

A conductor will

rate of electron flow (current)

electrons..........

air, glass, rubber plastic............

electrical pressure

electron flow in one direction

gold, silver, brass copper

resistance

reduce electron flow

A material which will

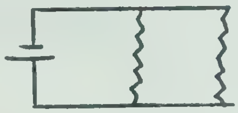
allow the free flow of electrons

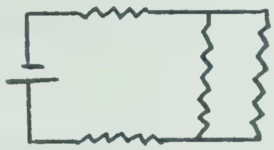
SHEET B

○ An insulator is	
○ An ammeter is	Ohm............. ○
○ A voltmeter is	any material which totall opposes electron flow ○
○ An ohmmeter is	test instrument to measure electrical pressure ○
○ The relationship between resistance, electrical pressure and current was established by	test instrument to measure rate of current flow ○
○ Current is	Power (wattage) ○
	Ohm's law .... ○
	test instrument to measure resistance ○
○ Voltage equals current multiplied by resistance, is	the movement of free electrons along a conductor ○
○ Multiplying voltage by current results in	

SHEET C

This is 

This is 

This is 

A combination of capacitors and inductors that will only oscillate at one frequency, is a

A capacitor is

Inductance is

Frequency is

An antenna is

Amplification is obtained by

resonant circuit

series-parallel circuit

series circuit ....

applying a small varying current to the input of a transistor in order to obtain a larger current variation..........

parallel circuit...........

a device that is capable of holding a charge of electrons

The property of a circuit to oppose a change in current flow

an indication that current changes direction several times a second

a high metal rod or cable, used to assist transmission or reception of radio waves

Alternating current is	varying the carrier radio frequency so that audio frequency can be superimposed on it
Rectification is	
A diode will	only allow electrons to flow in one direction
Modulation is	electron flow first in one direction, then the other
Frequency modulation is	transfer electrical energy from one circuit to another, without direct electrical connection
Demodulation is	changing alternating current into direct current
A signal generator is	visually shows characteristics of electrical wave forms
	separating audio frequency from radio frequency current
	mixing audio and radio frequency currents together
A transformer can	a test instrument that can produce any alternating current frequency
An oscilloscope can	

ERIB KEY

1.	9.
2.	6.
3.	1.
4.	4.
5.	2.
6.	12.
7.	3.
8.	15.
9.	7.
10.	13.
11.	5.
12.	8.
13.	10.
14.	14.
15.	11.

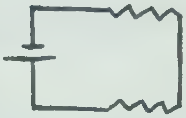
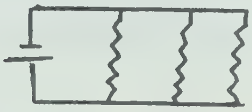
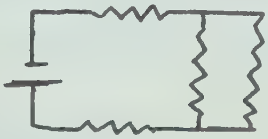
APPENDIX C

Facsimile of Flash Cards

FACE	REVERSE
The unit of electrical pressure is the volt amp antenna ohm	volt
Air, glass, rubber, plastic are conductors ohms insulators capacitors	insulators
Gold, silver, copper, brass are conductors positive resistors inductance	conductors
Electrons flow to a negative point positive point conductor resistor	positive point
Electron flow in only one direction is rectification amps direct current modulation	direct current

Resistance is measured by ammeter ohms diode series parallel circuit	ohms
Rate of electron flow is measured by amps E = IxR direct current volts	amps
Electron flow is reduced by amplification resistor oscilloscope positive point	resistor
Free flow of electrons is permitted by conductor series circuit insulator resistor	conductor
Total opposition to electron flow is provided by capacitor ohm series circuit insulator	insulator

Electrical pressure is measured by voltmeter capacitor conductor ohm	voltmeter
Current flow is measured by demodulation resistance ohm ammeter	ammeter
Ohmmeters measure current resistance series parallel circuit diode	resistance
The relationship between volts, ohms and amps was established by voltmeter Ohm insulator capacitor	Ohm
Electrical pressure multiplied by current flow, is alternating current power ohms series circuit	power

Ohm's law states the relationship between ohms(R) volts(E) and amps(I) as I = ExR R = IxE E = IxR	E = IxR
Movement of free electrons along a conductor is resistance demodulation current ammeter	current
This is a  ohm series circuit conductor resistor	series circuit
This is a  rectification antenna direct current parallel circuit	parallel circuit
This is a  ammeter resistance resonant circuit series parallel circuit	series parallel circuit

Applying a small current to the input of a transistor, in order to obtain a larger current change, is frequency modulation amplification resistor	amplification
Electron flow, first in one direction, then the other, is power capacitor series circuit alternating current	alternating current
Changing alternating current into direct current is parallel circuit signal generator rectification direct current	rectification
Current flow in only one direction is permitted by diode resonance series parallel circuit resistance	diode
Mixing audio and radio frequency currents is frequency inductance amplification modulation	modulation

A circuit of capacitors and inductors that will oscillate at one frequency, is series parallel circuit resonant circuit frequency modulation antenna	resonant circuit
A device that can hold a charge of electrons, is conductor capacitor power series circuit	capacitor
The property of a circuit to oppose any change in current flow is inductance frequency amplification modulation	inductance
The term used to indicate how often current flow changes direction is inductance frequency amplification modulation	frequency
A high metal rod or cable, used to improve transmission and reception of radio currents, is rectification resistor transistor antenna	antenna

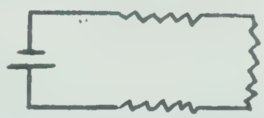
Varying a radio frequency signal in order to mix in an audio frequency, is demodulation resistance frequency modulation current	frequency modulation
Separating audio frequency from radio frequency, is resistance current diode demodulation	demodulation
Any frequency alternating current can be made by rectification antenna signal generator parallel circuit	signal generator
Electrical energy can be transferred from one circuit to another, without direct connection, by frequency amplification oscilloscope transformer	transformer
Visual characteristics of electrical wave forms are shown by oscilloscope inductance amplification modulation	oscilloscope

APPENDIX D

Revised Post Test

DO NOT WRITE IN THIS BOOKLET-USE ANSWER SHEET PROVIDED

1. This is a



a. direct circuit
b. series-parallel circuit
c. parallel circuit
d. series circuit

2. An ohmmeter measures

a. wattage
b. amperage
c. resistance
d. voltage

3. A material which totally opposes electron flow is called

a. conductor
b. insulator
c. resistor
d. inductor

4. Electron flow, first in one direction, then the other is

a. alternating current
b. amplitude modulation
c. direct current
d. electromotive force

5. Which of these components will allow electron flow in only one direction?

a. inductor
b. diode
c. conductor
d. resistor

6. A test instrument that visually shows the characteristics of an electrical wave form, is

a. ammeter
b. ohmmeter
c. voltmyter
d. oscilloscope

7. This is a

a. series parallel circuit
b. resonant circuit
c. parallel circuit
d. series circuit

8. The term used to indicate how often current changes direction, per second, is

a. rectification
b. resonance
c. modulation
d. frequency

9. A circuit of capacitors and inductors that will only oscillate at one frequency, is

a. series parallel circuit
b. parallel circuit
c. series circuit
d. resonant circuit

10. The movement of free electrons along a conductor is
a. wattage
b. amperage
c. current
d. voltage

11. Applying a small varying current to the input of a transistor, in order to obtain a larger current variation, is
a. amplification
b. demodulation
c. inductance
d. resonance

12. A material which reduces electron flow is called
a. inductor
b. resistor
c. conductor
d. insulator

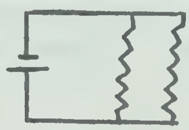
13. The relationship between Ohms(R) Volts(E) and Amps(I), is best expressed as
a. E = RxI
b. R = IxE
c. E = I÷R
d. I = ExR

14. A test instrument that can produce any alternating frequency current is a
a. voltmeter
b. signal generator
c. ammeter
d. oscilloscope

15. The test instrument which measures rate of current flow is a
a. wattmeter
b. ammeter
c. voltmeter
d. ohmmeter

16. A material that permits the free flow of electrons is called a
a. insulator
b. resistor
c. capacitor
d. conductor

17. This is a



a. parallel circuit
b. series circuit
c. resonant circuit
d. series parallel circuit

18. Electrons tend to flow to a
a. negative point
b. positive point
c. either of these
d. neither of these

19. The test instrument that measures electrical pressure is
    a. ammeter
    b. wattmeter
    c. voltmeter
    d. ohmmeter

20. The property of a circuit to oppose any current variation is
    a. resistance
    b. resonance
    c. capacitance
    d. inductance

21. Mixing together audio and radio frequency currents, is
    a. modulation
    b. rectification
    c. demodulation
    d. resonance

22. Electron flow in only one direction is called
    a. rectification
    b. alternating current
    c. inductance
    d. direct current

23. Two metal plates, separated by an insulator, and able to hold a charge of electrons, is a
    a. transistor
    b. capacitor
    c. transformer
    d. inductor

24. The unit of measurement of resistance is called a
    a. ohm
    b. watt
    c. amp
    d. volt

25. Multiplying electrical pressure by current flow, results in
    a. amperage
    b. resistance
    c. power
    d. voltage

26. A high metal rod or cable, used to assist transmission or reception of radio frequency waves, is called
    a. capacitor
    b. antenna
    c. transformer
    d. inductor

27. The rate of electron flow is measured in
    a. watts
    b. volts
    c. amps
    d. ohms

28. Separating audio from radio frequency current is called
    a. modulation
    b. inductance
    c. demodulation
    d. resonance

29. Changing alternating current into direct current is called
    a. demodulation
    b. transformation
    c. rectification
    d. amplification

30. The unit of electrical pressure is the
    a. ohm
    b. watt
    c. amp
    d. volt

31. Varying a carrier radio frequency current, in order to superimpose an audio frequency is called
    a. amplitude modulation
    b. resonance
    c. frequency modulation
    d. rectification

32. The relationship between voltage, resistance and current was established by
    a. Ohm
    b. Watt
    c. Ampere
    d. Volta

33. A component that can transfer electrical energy from one circuit to another, without direct electrical connection, is
    a. transformer
    b. insulator
    c. transistor
    d. resistor

34. Air, glass, plastic and rubber are examples of
    a. capacitors
    b. conductors
    c. resistors
    d. insulators

35. Gold, silver, copper and brass are examples of
    a. insulators
    b. conductors
    c. inductors
    d. resistors

APPENDIX E

Retention Test

DO NOT WRITE IN THIS BOOKLET..USE ANSWER SHEET PROVIDED.

1. A material which totally opposes electron flow is called a
   a. inductor
   b. resistor
   c. insulator
   d. conductor

2. Separating audio frequency from a radio frequency carrier, is
   a. resonance
   b. demodulation
   c. inductance
   d. modulation

3. Applying a small, varying current to the input of a transistor, in order to obtain a larger current variation, is called
   a. rectification
   b. modulation
   c. demodulation
   d. amplification

4. Electron flow in only one direction is called
   a. direct current
   b. inductance
   c. alternating current
   d. rectification

5. An ohmmeter measures
   a. voltage
   b. wattage
   c. amperage
   d. resistance

6. A material which permits the free flow of electrons is a
   a. conductor
   b. capacitor
   c. resistor
   d. insulator

7. The property of a circuit to oppose any change in current flow is called
   a. inductance
   b. capacitance
   c. resonance
   d. resistance

8. The rate of electron flow is measured in
   a. ohms
   b. amps
   c. volts
   d. watts

9. Electrons will tend to flow to a
   a. negative point
   b. positive point
   c. either of these
   d. neither of these

10. Which of these components will allow electron flow in only one direction?
   a. resistor
   b. conductor
   c. diode
   d. inductor

11. This is a schematic of a

   a. series circuit
   b. parallel circuit
   c. series parallel circuit
   d. direct circuit

12. Multiplying electrical pressure by current flow, results in
   a. voltage
   b. resistance
   c. amperage
   d. power

13. The relationship between voltage, resistance and current was established by
   a. Volta
   b. Ampere
   c. Watt
   d. Ohm

14. A circuit of capacitors and inductors that will oscillate at only one frequency, is a
   a. resonant circuit
   b. series circuit
   c. parallel circuit
   d. series parallel circuit

15. Gold, silver, copper and brass are examples of
   a. resistors
   b. inductors
   c. conductors
   d. insulators

16. The relationship between Ohms(R), Volts(E) and AMPS(I) is best expressed as
   a. I = ExR
   b. E = I÷R
   c. R = IxE
   d. E = RxI

17. This is a

   a. series circuit
   b. parallel circuit
   c. resonant circuit
   d. series parallel circuit

18. A high metal rod or cable, used to assist the transmission or reception of radio frequency currents, is a
   a. inductor
   b. transformer
   c. antenna
   d. capacitor

19. A test instrument that visually shows the characteristics of electrical wave forms, is a
    a. oscilloscope
    b. voltmeter
    c. ohmmeter
    d. ammeter

20. A device, usually two metal plates separated by an insulator, and able to hold an electron charge, is a
    a. inductor
    b. transformer
    c. capacitor
    d. transistor

21. The unit of electrical pressure is the
    a. volt
    b. watt
    c. amp
    d. ohm

22. Electron flow, first in one direction, then the other is called
    a. electromotive force
    b. direct current
    c. amplitude modulation
    d. alternating current

23. The test instrument which measures current flow rate, is called a
    a. ohmmeter
    b. voltmeter
    c. ammeter
    d. wattmeter

24. Mixing audio and radio frequency currents together is called
    a. resonance
    b. demodulation
    c. rectification
    d. modulation

25. Air, glass, rubber and plastic are examples of
    a. insulators
    b. resistors
    c. conductors
    d. capacitors

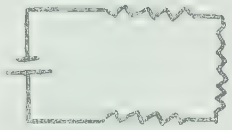
26. A test instrument that can produce any desired alternating current frequency is called
    a. oscilloscope
    b. ammeter
    c. signal generator
    d. voltmeter

27. The movement of free electrons along a conductor, is
    a. voltage
    b. current
    c. amperage
    d. wattage

28. A material which reduces electron flow is called
    a. insulator
    b. conductor
    c. resistor
    d. inductor

29. Changing alternating current into direct current is called
    a. rectification
    b. amplification
    c. transformation
    d. demodulation

30. The unit of measurement of resistance is the
    a. volt
    b. amp
    c. watt
    d. ohm

31. This is a 
    a. series parallel circuit
    b. resonant circuit
    c. series circuit
    d. parallel circuit

32. Which component can transfer electrical energy from one circuit to another, without direct electrical connection?
    a. resistor
    b. transistor
    c. insulator
    d. transformet

33. The test instrument which measures electrical pressure, is a
    a. ohmmeter
    b. voltmeter
    c. wattmeter
    d. ammeter

34. The term used to indicate how often current changes direction, per second, is
    a. frequency
    b. modulation
    c. resonance
    d. rectification

35. Varying a carrier radio frequency, in order to superimpose an audio frequency current, is called
    a. rectification
    b. frequency modulation
    c. resonance
    d. amplitude modulation

APPENDIX F

Tables 4 and 5

Item Analysis of Post and Retention Tests

TABLE 4

ITEM ANALYSIS OF POST TEST

Item No.	Difficulty	Correlation	Reliability
1	0.35	0.43	0.20
2	0.60	0.51	0.25
3	0.53	0.32	0.16
4	0.85	0.78	0.28
5	0.55	0.44	0.22
6	0.66	0.72	0.34
7	0.51	0.34	0.17
8	0.48	0.40	0.20
9	0.78	0.65	0.27
10	0.59	0.52	0.26
11	0.71	0.60	0.27
12	0.56	0.36	0.18
13	0.35	0.42	0.20
14	0.46	0.59	0.29
15	0.31	0.42	0.20
16	0.67	0.62	0.29
17	0.34	0.14	0.07
18	0.75	0.37	0.16
19	0.39	0.36	0.18
20	0.31	0.24	0.11
21	0.55	0.55	0.27
22	0.84	0.72	0.26
23	0.42	0.52	0.26
24	0.65	0.49	0.23
25	0.54	0.41	0.21
26	0.91	0.67	0.19
27	0.41	0.42	0.21
28	0.59	0.43	0.21
29	0.37	0.41	0.20
30	0.34	0.52	0.24
31	0.55	0.31	0.15
32	0.65	0.56	0.27
33	0.59	0.59	0.29
34	0.69	0.49	0.23
35	0.83	0.54	0.20

TABLE 5

ITEM ANALYSIS OF RETENTION TEST

Item	Difficulty	Correlation	Reliability
1	0.47	0.41	0.21
2	0.50	0.44	0.22
3	0.67	0.64	0.30
4	0.85	0.73	0.26
5	0.43	0.57	0.28
6	0.65	0.76	0.36
7	0.14	0.29	0.10
8	0.24	0.14	0.06
9	0.70	0.32	0.14
10	0.54	0.40	0.20
11	0.39	0.24	0.12
12	0.52	0.56	0.28
13	0.59	0.46	0.22
14	0.54	0.62	0.31
15	0.74	0.70	0.31
16	0.38	0.51	0.25
17	0.42	0.41	0.20
18	0.83	0.67	0.25
19	0.68	0.63	0.29
20	0.39	0.25	0.12
21	0.40	0.45	0.22
22	0.81	0.83	0.32
23	0.30	0.17	0.08
24	0.52	0.56	0.28
25	0.69	0.68	0.31
26	0.64	0.56	0.27
27	0.76	0.64	0.27
28	0.55	0.61	0.31
29	0.30	0.48	0.22
30	0.47	0.56	0.28
31	0.31	0.21	0.10
32	0.47	0.48	0.24
33	0.31	0.21	0.10
34	0.59	0.53	0.26
35	0.47	0.30	0.15