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AUTHOR Taber, Margaret R.
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ABSTRACT

Electric Circuits 540-125 is the first course of a three-course sequence taken in the first year of the two-year program in Electrical-Electronic Engineering Technology at Cuyahoga Community College (Ohio). The conventional lecture method of instruction includes textbook and other reading assignments, lectures based on the readings and homework problems, two or three tests, and a final exam. The individualized instruction method utilizes a modified Personalized System of Instruction (PSI) format including eight modules, audio tapes, a study guide, one 50-minute lecture per module, a test about every two weeks, and a final exam. This study was conducted to determine if this individualized instruction method decreases student attrition rates and provides the student with comparable preparation for Electric Circuits 540-126 as the 540-125 course taught conventionally. Compared to students enrolled in conventional sections, a higher percentage of students enrolled in the individualized instruction sections passed the course; they also had significantly higher grades on the final exam and performed as well in 540-126. Letter grade distribution in 540-125 was independent of the teaching method used and 90.2 percent of those enrolled in the individualized instruction sections of 540-125 said they would choose the method for 540-126. (DC)

A COMPARISON OF USING INDIVIDUALIZED INSTRUCTION AND CONVENTIONAL LECTURE TECHNIQUES IN THE LECTURE SECTION OF ELECTRIC CIRCUITS 540-125

by

Margaret R. Taber, M. S. Engr.

Cuyahoga Community College

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A Comparison of Using Individualized Instruction and Conventional Lecture Techniques in the Lecture Section of Electric Circuits 540-125

Margaret R. Taber
Cuyahoga Community College

Abstract - The purpose of this research study was to compare individualized instruction and conventional lecture techniques in the lecture section of Electric Circuits 540-125. Electric Circuits 540-125 is a course with no prerequisites taken in the first quarter of the two-year program in Electrical-Electronic Engineering Technology at Cuyahoga Community College. Individualized instruction using a modified PSI format has been used in one day section each quarter since the Fall of 1972. Individualized instruction and conventional lecture techniques were compared in the following five areas: percentage of students who passed, percentage of marginal students who passed, mean final examination grades, frequency of grades in 540-125 and frequency of grades in the second circuits course, Electric Circuits 540-126, It was found that the percentage of students who passed the individualized instruction sections was significantly higher than the conventional lecture section. There was no significant difference in the percentage of marginal students who passed these sections. The final examination results of all the individualized instruction sections were significantly higher than the conventional lecture control group. The frequency of grades received in 540-125 were independent of the method of instruction used. During the Winter 1974 quarter it was found that the grades received in the next sequential circuits course, 540-126, were independent of the method of instruction used in 540-125.

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Does individualized instruction in the lecture section of Electric Circuits 540-125 aid students in successfully completing Electric Circuits 540-125? Do a higher percentage of students pass the Electric Circuits 540-125 course in which individualized instruction was used? Do a higher percentage of marginal students pass Electric Circuits 540-125 in which individualized instruction was used? Is there a significant difference in the mean Electric Circuits 540-125 final exam grade of the students who had individualized instruction and the mean Electric Circuits 540-125 final exam grade of the students who were taught by conventional lecture techniques? Is there a significant difference in the grades obtained in Electric Circuits 540-125 by the students who had individualized instruction and those who were taught by the conventional lecture techniques? Is there a significant difference in the grades obtained in Electric Circuits 540-126 by the students who had individualized instruction and those who were taught by the conventional lecture techniques in Electric Circuits 540-125?

III. THE HYPOTHESIS

1. There is a higher percentage of students who pass the Electric Circuits 540-125 course in which individualized instruction was used than the Electric Circuits 540-125 course in which conventional lecture techniques were used.

2. There is a higher percentage of marginal students who pass the Electric Circuits 540-125 course in which individualized instruction was used than the Electric Circuits 540-125 course in which conventional lecture techniques were used.
3. There is a significant difference in the mean Electric Circuits 540-125 final exam grade of the students who had individualized instruction and the mean Electric Circuits 540-125 final exam grade of the students who had conventional instruction.
4. There is a significant difference in the frequency of grades obtained in Electric Circuits 540-125 by the students who had individualized instruction and those who were taught by the conventional lecture techniques.
5. There is no significant difference in the frequency of grades obtained in Electric Circuits 540-126 by the students who had individualized instruction and those who were taught by the conventional lecture techniques in Electric Circuits 540-125.

IV. BACKGROUND AND SIGNIFICANCE OF THE STUDY

Many schools are using some forms of individualized instruction, such as Personalized or Proctorial System of Instruction - Keller Plan (PSI), Self-Paced Instruction (SPI), Individually Prescribed Instruction (IPI), Audio-Tutorial (A-T), Audio-Visual Tutorial (AVT), Contract Grading, Programmed Instruction (PI), Learning Machines, Computer Aided Instruction (CAI) and others.

Most authors agree that individualized instruction is better than the conventional or traditional instruction because most individualized instruction programs follow the fundamental learning

principles as given by Durney which he adapted from Erickson and Gagne. (1, pp. 406 & 407):

"1. The learner must be active.
2. Feedback and a second try are essential.
3. The learner must know the learning objectives.
4. The learner must be committed and he must be motivated to learn.
5. Each person learns at a different rate and in his own way."
6. Types of learning most important for engineering: learning concepts, learning to apply principles and how to solve problems.
7. To use concepts and apply principles to solve problems and practice solving problems.
8. The learning experiences should be organized in a learning hierarchy depending upon prerequisite skills required.

Fred Keller, founder of the Keller Plan currently known as PSI, reports that the type individualized instruction he used worked so well in the General Psychology classes at Arizona State that an upside down grade distribution was received. (2) The figures shown in Table 1 are estimated from the bar graphs given in the paper (2, p25):

Table 1

The Percent Relative Frequency of Grades Received in General Psychology at Arizona State University

Year	A	B	C	D	E.	Inc	W.	Total of E, Inc & W
1967	44	14	0	1	3	20	18	41
1968 (208 students)	47	19	4	1	9	7	13	29

He did not discuss attrition rate only to say that when he discouraged the use of the incomplete and increased the number of testing hours the numbers of incompletes and failures (category E) decreased, see 1968 data compared with 1967 data. However examination of the data

given does indicate that the actual attrition rate both semesters was high. Another set of data given in the paper compares a PSI course in Psychology at Queens College, N. Y., (N 25) with the achievement of 46 students in the same course taught by a very good instructor the conventional way. The figures shown in Table 2 are estimated from the bar graphs given in the paper. (2, p. 25)

Table 2

Percent Relative Frequency of Grades Received in Psychology at Queens College

Grades	PSI Course	Conventional Course
A	56	21
B	28	35
C	4	33
D	4	11
F	8	0

Fred Keller's area of instruction is in psychology, which is considerably different from engineering. However others have used PSI in the lecture sections of Physics and various engineering courses with good results. At Michigan State University a PSI section and a control section was run in Physics 292. (3) This course is the second course in a five-quarter sequence for students who are first quarter sophomores majoring in physics, mathematics or other sciences. Austin and Gilbert compared grades on the final exam and grades on a retest taken about two months agter the completion of the course. They found that the students in the PSI section did 10 to 15% better on a common final exam than those in the control section. On the retest the PSI section did 15 to 20% better. They did not record the grades given in both sections or a mean grade point average of

the sections, however they did correct the final exam and retake test scores for overall grade point average. They found that the lower ability students benefited more from the PSI format. The only discussion of attrition rates was that 2 out of 28 actually dropped the PSI section which was essentially the same as the 4 out of 58 in the control section.

In General Physics Ph 201 - 203 at Portland State University Philippas and Sommerfeldt found somewhat different results. (4) General Physics is a three-term noncalculus course for applied science, physical science and preprofessional students. There were 99 students in the Keller Plan section and 100 students in the control section. The Keller Plan was used only in the lecture sections, not in the laboratory. Table 3 shows the grade distribution obtained for both sections. (4, p. 1302)

Table 3

Distribution of Passing Grades (P), Withdrawals (W), and Incompletes (I) for the Keller and Control Groups

	Fall Ph 201		Winter Ph 202		Spring Ph 203	
Grade	Keller	Control	Keller	Control	Keller	Control
P	41	74	50	62	48	64
I	16	3	4	0	0	0
W	42	23	15	12	5	2
Total	99	100	69	74	53	66

On graded examinations for all three terms they found no significant difference between the performance of the Keller and control groups. However as shown in the table they had about 25% attrition rate from the control group, which they say is normal for General Physics. But the number in the Keller Group who did not pass was about 60%. Ten of the incompletes did eventually complete the course, this still leaves a 50% attrition rate. However the students who completed the experimental program liked it. Ninety percent said they preferred the Keller Plan over lectures for General Physics, that they learned more but had to work harder than the lecture or control section.

At the University of Texas at Austin four engineering courses were taught using PSI and these results were compared with results of the same course taught previously by the same instructor using the same text book by conventional methods. (5) The four courses were:

Nuclear Reactor Theory I - under Nuclear Engineering
A senior level elective course taught over a fourteen week term. N 21

Kinematics and Dynamics of Machinery - under Mechanical Engineering A junior level required course taught over a six week summer term. N 12.

Digital Systems Engineering I - under Electrical Engineering
A junior level required course taught over a fourteen week term. N 40

Applied Statistics - under Operations Research
A graduate level course taught over a fourteen week term. N 25

A comparison of grade distribution obtained in the courses for both the PSI sections and the conventional sections is shown in Table 4. The figures are estimated from the bar graphs given in the paper. (5, p. 27) There were some inconsistencies in the

data for Nuclear Engineering.

Table 4

Percent Relative Frequency of Grades Received in Four Engineering Courses

Grades		Nuclear Engineering	Mechanical Engineering	Electrical Engineering	Operations Research
A	PSI	74	82	68	89
	Control	20	20	25	50
B	PSI	8	0	20	3
	Control	27	40	31	29
C	PSI	6	9	2	0
	Control	33	20	34	7
D	PSI	0	0	0	0
	Control	6	3	10	7
F	PSI	0	0	0	0
	Control	6	0	0	0
W	PSI	5	9	10	8
	Control	14	17	0	7

Many times when something new is tried in a course the "Hawthorne effect" is observed. So when the PSI system is used repeatedly in a course, the mean grade point average may return to what it was when the course was taught by conventional methods. However at the University of Texas at Austin the course in Digital Systems Engineering I has been taught using PSI for four consecutive semesters and one summer session with good results. (6) The fifth time the PSI version of the course was offered, a comparison study of the PSI so ion with a concurrent lecture section was made. Both sections covered the same material, used the same text and ran the

same lab project. The conventional lecture section used the same study guides that were prepared for the PSI section. A common final exam was given to both sections, the results are given in Table 5. (6, p. 448)

Table 5

Comparison of Lecture and PSI Groups

	Lecture	PSI
Number of Students	21	63
Final Exam:		
range of scores	29-85	47-94
mean score	62.1	71.7
standard deviation	16.8	10.7
coeff. of variation	27.1%	14.9%
Mean GPA of Previous Courses	2.96	2.81
Reported Hours/Week Spent on Course	6.7	8.1

Roth reported that the first time the PSI course was taught a similar comparison was made of final exam performance between both sections with the PSI students achieving a mean score about 10 points higher than the conventional lecture students. Therefore he concluded that the relative effectiveness of the PSI course was about the same the fifth time as it was the first time.

The students in the Digital Systems Engineering I course were junior and senior electrical engineering students with relatively high GPA as shown in Table 5. The percentage of students who dropped the course was relatively low as shown in Table 6 along with a comparison of units completed in one semester when the PSI course was offered the second and fifth time. (6, p. 448)

Table 6

Comparison of Units Completed in
Digital Systems Engineering I

Units completed	Percentage of Students 2nd time	5th time
20	73	76
19	8	11
18	2	2
17	7*	6*
dropped course	10	5

*not including drops

At Cuyahoga Community College students enrolled in the beginning course in the Electrical-Electronic Engineering Technology program, Electric Circuits 540-125, have always comprised a very heterogeneous group. One of the major contributing factors to this is that this course has no stated prerequisites. Some of the students have prior exposure to the principles of electricity through high school courses, military service training, commercial institutes or correspondence courses. Some of the students have strong high school science and math backgrounds. Some of the students have no high school science background and only shop math. Some students test out at a fourth or fifth grade reading ability rate. Another contributing factor that makes this course difficult to handle is that there are usually 48 students in one lecture section.

Some form of individualized instruction seemed to be the only way to accommodate the diverse backgrounds of the students entering this beginning course. With instructional materials in modular form, the students can proceed at their own pace in the satisfaction of

the objectives of the particular module. Additional work such as arithmetic or equations can be provided to make up for deficiencies. Also enrichment materials can be provided for the student with previous experience. Since many students have reading difficulties, it was decided to use audio tapes in addition to the written study guides.

The writer took the initiative to prepare instructional materials for 540-125 on her own time during the Summer of 1972 and the 1972-73 school year. The school is supporting development of instructional material for the second quarter course, 540-126 during the 1973-74 school year.

The individualized instruction material is based on a modified PSI or Keller Plan, see definition of terms section. The individualized instruction is currently only being tried in the lecture portion of the courses. The laboratory section of each course, which is two hours per week, is run the conventional way. Laboratory reports are required, the number of reports is determined by the instructor.

The developed instructional materials have been used by the writer in one lecture section of 540-125 each quarter of the 1972-73 school year. During the 1973-74 school year the individualized instruction material is being tried in one lecture section in both 540-125 and 126 Electric Circuits. The writer is using the material in the 126 course, and another instructor is using the material

in the 125 course. It is the objective of this study to determine if the system of individualized instruction currently being tried decreases the student attrition rate and provides the student with at least the same background for 540-126 as does the 540-125 course taught by the conventional method. The results of this study will determine the direction of the future work in the Electric Circuits 540-125, -126 and -127 courses. The results will provide information to answer such questions as is the current system of individualized instruction fulfilling the objectives, should the current system be modified or is the conventional lecture method still the best? Some insight to the answers to the following two questions may be gained by examining the results: Should individualized instruction be developed for the laboratory sections? Should the Electric Circuits 540-127 course be taught by individualized instruction methods similar to those used in 540-125 and 126?

V. DEFINITION OF TERMS

The following terms are used repeatedly in this paper. They may be unique to Cuyahoga Community College, so they are defined as follows:

Electric Circuits 540-125: A three quarter credit hour course with two hours lecture and two hours laboratory per week offered at Cuyahoga Community College. There is no prerequisite required for this course. The 1973-74 Cuyahoga Community College Catalogue description is as follows: "Direct current circuit fundamentals with emphasis on electron theory or current flow, electrical quantities and their units of measurement, sources of EMF, Ohm's law, electrical energy and power relationships. Series, parallel and series-parallel circuits, voltage dividers. Kirchhoff's laws, Thevenin's and Norton's theorems. Practical laboratory experience in the construction of working circuits and the evaluation of their performance." This course is required in the Electrical-Electronic Engineering Technology and Mechanical Engineering Technology two year Associate Degree Programs. It may be taken by anyone in the college.

Electric Circuits 540-126: A three quarter credit hour course with two hours lecture and two hours laboratory per week offered at Cuyahoga Community College. The only prerequisite for this course is Electric Circuits 540-125. The 1973-74 Cuyahoga Community College Catalogue description is as follows: "Fundamentals of alternating current circuits with emphasis on capacitance, inductance, sinusoidal voltage and current, reactance, vectors and phasors, impedance. Practical laboratory experience

with A.C. instruments including oscilloscopes, capacitance testing and the evaluation of reactive circuits." This course is required in the Electrical-Electronic Engineering Technology and is an elective in the Mechanical Engineering Technology two year Associate Degree Programs. It may be taken by anyone in the college as long as they have the prerequisite.

Grade Point Average (GPA): A student's grade based upon a four-point system.

Marginal Student in 540-125: A student who has scored 21 or less on the first three sections of a prerequisite test given in Electric Circuits 540-125 the first class session. The first three sections have ten questions each on the following:

basic arithmetic
basic algebra
units of measurement

A copy of this test will be provided if requested.

To Pass Electric Circuits 540-125: Any student who receives a letter grade of A, B, C, or D in Electric Circuits 540-125. Other grades that are possible to receive are:

incomplete (I) this must be removed by the fifth week of the next quarter or it becomes an F.

withdraw (W) either a student may withdraw from a course or an instructor may withdraw a student through the eighth week of a quarter.

no grade (X) A few no grades were given during the 1969-71 school years. The X can no longer be used.

failure (F)

Conventional Lecture Method: Students are assigned to read certain material and to work various problems from the text book. The instructor lectures on the reading material and/or problems for two 50 minute periods each week of the quarter. During the quarter there are usually two or three one hour tests and a final exam. The number of tests and homework problems required are determined by the instructor.

Individualized Instruction: The required work for the quarter is broken down into units, also called modules or minicourses. There are eight required units in 540-125 and ten units in 540-126. The instructional material is based on a modified PSI or Keller Plan, see references 2 and 7 for a description of the Keller Plan. Audio tapes are available for all but two of the required units in the 540-125 course, but the main source of direction through the unit or minicourse is the very thoroughly written study guide. The study guides are so complete that little use is made of the text book. It is called modified because lectures are still given on each unit, about 50 minutes per unit, and problem/help sessions are held during other scheduled lecture time. Testing occurs in the 540-125 course about every two weeks, with no tutors used for testing. Tests are given at a rate of once per week in the 540-126 course, with tutors giving the mastery part and the instructor giving the bonus part. The lectures are still considered motivational, because if a student completes the unit before the scheduled lecture he is excused from it.

VI. LIMITATIONS OF THE STUDY

The following limitations may affect the general use of the results of this study:

(1) The number of prerequisite test and common final exam results for the conventional lecture sections may prevent a generalization of the findings.

(2) The findings may only be important to Cuyahoga Community College and may be significant only to the Electrical-Electronic Engineering Technology Department of the College.

(3) There was no provision made to hold constant the variable of instructors; therefore some instructors may have different backgrounds, teaching techniques and use different grading systems.

(4) No provision was made to include motivational factors as a controlled variable.

(5) No provision was made to obtain a typical control group.

(6) With the exception of the prerequisite test no provision was made to analyze the data according to high school background, previous math courses, previous electronics experience, previous military service, number of credit hours carried or number of hours spent working either full or part-time on a job outside of class.

VII. BASIC ASSUMPTIONS

The following basic assumptions were made for this research project:

(1) The conventional lecture and individualized instruction sections were considered homogeneous.

(2) All the instructors of Electric Circuits 540-125 and 540-126 were equally competent.

(3) All the instructors of Electric Circuits 540-125 and 540-126 used equivalent grading procedures.

(4) The prerequisite test given in Electric Circuits 540-125 was a valid predictor of success in Electric Circuits 540-125.

(5) The final exam results obtained in the conventional lecture section of Electric Circuits 540-125 held during the Spring 1972 quarter were representative of a typical conventional lecture class section.

(6) Successful completion of Electric Circuits 540-125 meant a student should be able to successfully complete Electric Circuits 540-126.

VIII. PROCEDURES FOR COLLECTING DATA

The following procedures were used to collect data for this research project:

(1) To determine the percentage of students who passed the day sections of Electric Circuits 540-125 using the conventional lecture method for the lecture section, computer grade print out sheets and instructor's grade books for the school years 1970-71, 1971-72 and the Fall 1972 and Fall 1973 quarters were used.

(2) To determine the percentage of students who passed the Electric Circuits 540-125 course in which individualized instruction was used, computer grade print out sheets and instructor's grade books for the Fall, Winter and Spring quarters of the 1972-73 school year and the Fall quarter of the 1973-74 school year were used.

(3) To determine the percentage of marginal students who passed the Electric Circuits 540-125 course using the conventional lecture method, computer grade print out sheets, prerequisite test results and the instructor's grade books for the Spring quarter 1972 (day), Summer quarter 1972 (day and night), Fall quarter 1972 (day), Summer quarter 1973 (night) and Fall quarter 1973 (night) were used.

(4) To determine the percentage of marginal students who passed the Electric Circuits 540-125 course in which individualized instruction was used, computer grade print out sheets, prerequisite test results and instructor's grade books for Fall, Winter and Spring quarters of the 1972-73 school year and the Fall quarter of the 1973-74 school year were used.

(5) To determine the mean final exam grades of the conventional and individualized instruction sections of Electric Circuits 540-125 common final examination results of the conventional section of Spring quarter 1972 and individualized instruction sections of Fall, Winter, Spring quarters of the 1972-73 school year and Fall 1973 quarter were used.

(6) To determine if there was a significant difference in the frequency of grades obtained in the conventional and individualized instruction sections of Electric Circuits 540-125, computer grade print out sheets for the conventional day sections of Fall 1972 and Fall 1973 and individualized instruction sections of the Fall, Winter, Spring quarters of the 1972-73 and Fall 1973 quarter were used.

(7) To determine if there was a significant difference in the frequency of grades obtained by the students who had and did not have individualized instruction in 540-125, computer grade print out sheets were physically viewed, compared and traced for the Fall 1972 and Fall 1973 quarters for both conventional and individualized instruction sections of 540-125 and the Winter 1973 and Winter 1974 sections of 540-126. The Winter 1973 section of 540-126 was taught using conventional lecture techniques. The Winter 1974 section of 540-126 was taught using individualized instruction techniques.

IX. PROCEDURES FOR TREATING DATA

The following procedures were used to treat the data for this research project:

Hypothesis 1

The difference between the percentage of students who passed the individualized instruction and conventional lecture sections is zero.

$$H_o: P_I = P_C$$
$$H_a: P_I > P_C$$
$$\alpha = 0.05$$

I(individualized instruction)
C(conventional lecture)

The z-Test was used to determine if the percentage in the individualized instruction sections was significantly higher. The classes were considered homogeneous. The critical z value (one-tailed test) is 1.645, therefore if $z > +1.645$ the H_o would be rejected and H_a accepted.

Hypothesis 2

The difference between the percentage of marginal students who passed the individualized instruction and conventional sections of 540-125 is zero.

$$H_o: P_I = P_C$$
$$H_a: P_I > P_C$$
$$\alpha = 0.05$$

The z-Test was used to determine if the percentage in the individualized instruction sections was significantly higher. The classes were considered homogeneous. The critical z value (one-tailed test) is 1.645, therefore if $z > +1.645$ the H_o would be rejected and H_a accepted.

Hypothesis 3

The final exam means of the individualized instruction and conventional lecture sections do not differ significantly.

$$H_o: \bar{X}_I = \bar{X}_C$$
$$H_a: \bar{X}_I > \bar{X}_C$$
$$\alpha = 0.05$$

The z table was used for the t-Test because the degrees of freedom were larger than 30. The test scores were interval data and were normally distributed. The critical z value (one-tailed test) is 1.645, therefore if $z > +1.645$ the H_o would be rejected and H_a accepted.

Hypothesis 4

There is no significant difference in the frequency of grades obtained in Electric Circuits 540-125 by the students who had individualized instruction and those who had the conventional method of instruction.

$$H_o: G_I = G_C$$
$$H_a: G_I \neq G_C$$
$$\alpha = 0.05$$

The letter grades could be considered interval data, however they were not normally distributed therefore the grades were treated as ordinal data as frequency of grades. They were arranged in the order A, B, C, D and no pass. The Chi Square (X^2) Test was used to determine if there was a significant difference. For a contingency table of five rows and two columns, there are four degrees of freedom. The critical X^2 value is 9.49, therefore if $X^2 > 9.49$ the H_o would be rejected and H_a accepted.

Hypothesis 5

There is no significant difference in the frequency of grades obtained in Electric Circuits 540-126 by the students who had individualized instruction and those who were taught by the conventional lecture techniques in 540-125.

$$H_o: G_I = G_C$$

$$H_a: G_I \neq G_C$$

$$\alpha = 0.05$$

The letter grades could be considered interval data, however they were not normally distributed therefore the grades were treated as ordinal data as frequency of grades as in hypothesis 4. The Chi Square (X^2) Test was used to determine if there was a significant difference. The critical X^2 value for four degrees of freedom is 9.49, therefore if $X^2 > 9.49$ the H_o would be rejected and H_a accepted. The 540-126 grades of the students from both the individualized instruction and conventional sections of 540-125 were compared. There were two comparisons made. The two Fall 1972, 540-125 sections went into one Winter 1973, 540-126 section using the conventional lecture techniques. The two Fall 1973, 540-125 sections went into one Winter 1974, 540-126 section using individualized instruction. The Winter 1973 and Spring 1973 quarter sections of Electric Circuits 540-125 were not considered in this analysis because there was only one section each quarter and it was taught using individualized instruction; there was no control group.

X. RESULTS

The results of each hypothesis are listed separately.

Hypothesis 1

Table 7 lists the number and percent of students who have passed the day conventional lecture sections of Electric Circuits 540-125 since the Fall quarter of 1970. No figures are given for the Winter 1973 and Spring 1973 quarters, because the day classes used individualized instruction. Examination of the percentage of students

Table 7

The Number and Percentage of Students Who Passed the Day Sections of Electric Circuits 540-125 Using Conventional Lecture Techniques

Quarter	No. of Students who Passed	Total in Class	% who Passed
Fall 1970	53	92	57.6
Winter 1971	29	52	55.8
Spring 1971	20	38	52.6
Fall 1971	63	126	50.0
Winter 1972	25	54	46.3
Spring 1972	23	37	62.1
Fall 1972	22	45	48.9
Fall 1973	25	54	46.3
Total F'72 & F'73	47	99	47.47

who passed column shows generally a decrease. The only big exception to this is the Spring 1972 quarter. However the Instructor who taught this class gave a higher percentage of D's (16%) when compared

with the number of D's given during the Fall 1971 quarter (7%) and the Winter 1972 quarter (0%).

Table 8

The Number and Percentage of Students Who Passed the Day Sections of Electric Circuits 540-125 Using Individualized Instruction

Quarter	No. of Students who Passed	Total in Class	% who Passed
Fall 1972	28	47	59.6
Winter 1973	34	49	69.4
Spring 1973	24	43	55.8
Fall 1973	28	48	58.3
Totals	114	187	60.96
School year '72-73 and F'73	$z = 2.188$*		

* Significant at the 0.05 level.

Table 8 lists the number and percentage of students who have passed the day sections of Electric Circuits 540-125 using individualized instruction. Individualized instruction was also used during the Winter 1974 quarter, but time did not permit tabulation of these figures.

Using the percentage figures from Table 7 and Table 8 for the 1972-73 school year and the Fall 1973 quarter and testing at the 0.05 significance level, it was found that the percentage of students who passed the section in which individualized instruction was used was significantly higher than the percentage of students who passed the sections in which the conventional lecture methods were used.

Hypothesis 2

Table 9 lists the number of marginal students who passed Electric Circuits 540-125. Of the identified 51 marginal students who took the course with instructors using the conventional lecture method during Spring 1972 through Fall 1973, 19 passed. Of the identified 66 marginal students who took the course using individualized instruction during the same time period, 29 passed.

Table 9

The Number of Marginal Students who Passed Electric Circuits 540-125

Quarter	No. of Marginal Students	No. of Marginal Students who Passed	
	Conventional Lecture		
Spring 1972 (Day)	18	10	
Summer 1972 (Day)	9	1	
Summer 1972 (Night)	6	2	
Fall 1972 (Day)	9	4	
Summer 1973 (Night)	5	0	
Fall 1973 (Night)	4	2	
Total	51	19	37.2%
	Individualized Instruction		
Fall 1972	17	7	
Winter 1973	19	11	
Spring 1973	15	6	
Fall 1973	15	5	
Total	66	29	43.9%
			z = 0.7296

The percentage of marginal students who passed the individualized instruction sections is higher, however it is not significantly higher (0.05 level). Therefore the number of marginal students

who passed were independent of the method of instruction used in Electric Circuits 540-125.

Hypothesis 3

Table 10 compares the final examination grades of the individualized instruction sections with the conventional lecture section of the Spring 1972 quarter. The conventional lecture section was considered the control group. The final examination was a problem solving type examination with a maximum possible total of 200 points. During the Spring 1973 quarter the examination was changed to a four multiple choice answer format.

Table 10

Comparison of the Final Examination Grades of Electric Circuits 540-125 of the Individualized Instruction Sections with the Conventional Lecture Section of Spring 1972

Quarter	Mean	Standard Deviation	No. of Students	z
		Conventional Lecture		
Spring 1972	132.26	47.78	23	
		Individualized Instruction		
Fall 1972	150.57	26.37	28	1.645*
Winter 1973	155.34	26.10	32	2.102*
Spring 1973	160.75	27.20	24	2.498*
Fall 1973	167.33	22.69	30	3.250*

*Significant at the 0.05 level.

Each individualized instruction class was compared with the control class using the t-Test and testing at the 0.05 significance level. The final examination results of all the individualized

instruction sections were significantly higher than the convention lecture section of the Spring 1972 quarter.

Hypothesis 4

Table 11 shows the observed frequency of grades obtained in both the conventional lecture and individualized instruction sections for the Fall 1972 and Fall 1973 quarters.

Table 11

The Observed Frequency of Grades for Conventional Lecture and Individualized Instruction Sections of Electric Circuits 540-125

Grades	Conventional Lecture	Individualized Instruction	Totals
		Fall 1972 Quarter	
A	6	9	15
B	9	16	25
C	6	1	7
D	1	2	3
No Pass	23	19	42
	45	47	92
			$X^2 = 6.846$
		Fall 1973 Quarter	
A	13	12	25
B	6	11	17
C	5	5	10
D	1	0	1
No Pass	29	20	49
	54	48	102
			$X^2 = 3.904$

Using the Chi Square (X^2) Test and testing at the 0.05 significance level, it was found that during the Fall 1972 and Fall 1973 quarters the grades received in Electric Circuits 540-125 were

independent of the method of instruction used.

Table 12 compares the combined observed frequency of grades received in the Fall 1972 and Fall 1973 conventional lecture classes to the frequency of grades received in the four individualized instruction classes held during the 1972-73 school year and the Fall quarter of the 1973-74 school year.

Table 12

The Observed Frequency of the Grades Received in the Two Conventional Lecture Day Classes and Four Individualized Instruction Classes Held During the 1972-73 School Year and the Fall Quarter of the 1973-74 School Year

Grades	Conventional Lecture	Individualized Instruction	Totals
A	19	44	63
B	15	49	64
C	11	16	27
D	2	5	7
No Pass	52	73	125
	99	187	286
			$X^2 = 7.375$

Using the Chi Square (X^2) Test and testing at the 0.05 significance level, it was found that the grades received in Electric Circuits 540-125 were independent of the method of instruction used.

Hypothesis 5

Table 13 shows the observed frequency of grades received in the Winter 1973 quarter Electric Circuits 540-126 conventional lecture class of those students who had conventional and individualized instruction during the Fall 1972 quarter Electric Circuits 540-125 day courses.

Table 13

The Observed Frequency of Grades in the Winter 1973 Quarter Electric Circuits 540-126 Conventional Lecture Class of those Students who had Conventional and Individualized Instruction during the Fall 1972 Quarter Electric Circuits 540-125 Day Courses

Grades in 540-126	540-125 Conventional Lecture	540-125 Individualized Instruction	Totals
A	6	3	9
B	1	2	3
C	5	2	7
D	0	0	0
No Pass	0	11	11
	12	18	30
			$X^2 = 12.936$*

*Significant at the 0.05 level.

Using the Chi Square (X^2) Test and testing at the 0.05 significance level, it was found that during the Winter 1973 quarter the frequency of grades received in the next sequential circuits course, Electric Circuits 540-126, were dependent upon the method of instruction used in the lecture section of circuits 540-125. All of the 12 students from the conventional lecture section passed. Many, 11 of 18, of the students from the individualized instruction section did not pass the second circuits course during the Winter

quarter. Variables which were not controlled during the Fall 1972 and Winter 1973 quarters affected these results. The instructor who taught the second circuits course, 540-126, during the Winter quarter using conventional lecture methods was the same instructor that taught the 12 students in the conventional lecture section during the Fall quarter 540-125 course. For these 12 students the Winter quarter was just a continuation of the Fall quarter -- same instructor, same text book and same methods. Whereas for the 18 students from the Fall individualized instruction section of 540-125 everything was different -- different instructor, actually using a text book instead of study guides and different method of instruction. Of the 11 of 18 students from the individualized instruction section that did not pass 540-126 during the Winter quarter, six students took the 540-126 course during the Spring 1973 quarter and four students passed.

During the Fall 1973 and Winter 1974 quarters the instructor as a moderator variable was more controlled. For this variable to be controlled the same instructor should teach both sections of 540-125 and the 540-126 class. The instructor who taught the second course, 540-126, during the Winter quarter using individualized instruction was not the same instructor that either the conventional lecture section or the individualized instruction section had during the Fall quarter. During the Fall quarter each section of the 540-125 course had a different instructor.

Table 14 shows the observed frequency of grades received in the Winter 1974 quarter Electric Circuits 540-126 individualized instruction class of those students who had conventional and individualized

instruction during the Fall 1973 quarter Electric Circuits 540-125 day courses.

Table 14.

The Observed Frequency of Grades in the Winter 1974 Quarter Electric Circuits 540-126 Individualized Instruction Class of those Students who had the Conventional or Individualized Instruction during the Fall 1973 Quarter Electric Circuits 540-125 Day Courses

Grades in 540-126	540-125 Conventional Lecture	540-125 Individualized Instruction	Totals
A	8	5	13
B	6	8	14
C	0	1	1
D	0	1	1
No Pass	2	3	5
	16	18	34
			$X^2 = 3.29$

Using the Chi Square (X^2) Test and testing at the 0.05 significance level, it was found that the grades received in the next sequential circuits course, 540-126, were independent of the method of instruction used in the lecture section of circuits 540-125.

XI. CONCLUSIONS AND SIGNIFICANCE

Conclusions

The major objectives of the individualized instruction program for the 540-125 course were to decrease the student attrition rate and to provide the student with at least the same background for the 540-126 course as did the 540-125 course taught by the conventional lecture method. The results found under Hypothesis 1 showed that the percentage of students who passed the sections in which individualized instruction was used was significantly higher than the percentage of students who passed the section in which conventional lecture methods were used. Therefore the first objective has been achieved.

The results under Hypotheses 3, 4 and 5 were used to determine if the second objective has been achieved. The results under Hypothesis 3 showed that the final examination results of all the individualized instruction sections were significantly higher than the conventional lecture section of the Spring 1972 quarter. The results under Hypothesis 4 showed the grades received in Electric Circuits 540-125 were independent of the method of instruction used. The results under Hypothesis 5 showed that when the moderator variable (instructors) was more controlled, that grades received in the 540-126 course were independent of the method of instruction used in 540-125. Therefore the second objective has been achieved. However there are still areas that must have further study. See Further Studies section.

During the Spring 1974 quarter both the day sections of 540-125 and 540-126 will continue to use individualized instruction. There will be very little revision of material for the 540-125 class,

however an attempt will be made to provide the marginal or weak student with more tutoring help. Additional tapes and study guides will be developed for the 540-126 class. During the Spring quarter the individualized instruction program will be further evaluated to determine if it will be continued into the next school year 1974-75. Also at this time a departmental decision will be made regarding whether individualized instruction should be extended into the third circuits course, Electric Circuits 540-127.

Residual Findings

The students in the individualized instruction sections of 540-125 complete a questionnaire at the end of the quarter. One of the questions is:

> "For the next Circuits course, if there were two sections available, one taught the conventional lecture method and the other section taught using Minicourses, which would you take? Conventional method ( ) Minicourses ( )"

A total of 101 of the 112 students (90.2%) who completed the questionnaire answered Minicourses.

Further Studies

This study only examined the comparison of using individualized instruction and conventional lecture techniques in the lecture section of 540-125. This school year 1973-74 individualized instruction is being tried in the lecture section of 540-126. A similar study should be made for this second circuits course. The results of a study of 540-126 along with the results of this study on 540-125 would provide a better answer to the question: Should the third circuits course, 540-127, be taught by individualized

instruction methods similar to those used in 540-125 and 126?

Further study should be made into the problem found in the results section of Hypothesis 5, of what happens to a student in a course that runs sequential quarters if he is in an individualized instruction section one quarter and a conventional lecture section the next. Even though individualized instruction helps the student to pass the first course, does it make him a weaker student in the following course?

The results listed under Hypothesis 2 showed that there was no significant difference in the percentage of marginal students who passed the individualized instruction or conventional lecture sections of 540-125. One of the reasons for trying individualized instruction was to help the marginal student. Further study should be made in this area. Should the individualized instruction material be improved? Should the methods of using the materials be changed? Is the test used to determine the marginal students a valid one?

The attrition rate has significantly decreased in the individualized instruction sections of 540-125, however it is still high (40%). Further study should be made about the students who do not pass the course. For example, if it is found that most of the students that do not pass 540-125 also do not pass their other courses, then further improvement of 540-125 may be just a waste of time and money. The whole program or something else must be changed.

There has been no experimenting in the night sections of Electric Circuits. Some problems are common between both day and night, so individualized instruction may help. However trying to use individualized instruction at night would present many problems also. This is an

area that requires further study.

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APPENDIX -- Formulas and Computations of Research Results

Hypothesis 1

H_o: $P_I = P_C$

H_a: $P_I > P_C$

$\alpha = 0.05$ critical z value is 1.645

$$P_I = \frac{114}{187} = 0.6096$$

$$P_C = \frac{47}{99} = 0.4747$$

$$\bar{p} = \frac{114 + 47}{187 + 99} = 0.5629$$

$$\bar{q} = 1 - \bar{p} = 1 - 0.5629 = 0.4371$$

$n_I = 187$

$n_C = 99$

$$z = \frac{P_I - P_C}{\sqrt{\frac{\bar{p}\bar{q}}{n_I} + \frac{\bar{p}\bar{q}}{n_C}}}$$

$$z = \frac{0.6096 - 0.4747}{\sqrt{\frac{(0.5629)(0.4371)}{187} + \frac{0.2460}{99}}}$$

$$= 2.188$$

Hypothesis 2

H_o: $P_I = P_C$

H_a: $P_I > P_C$

$\alpha = 0.05$ critical z value is 1.645

$$P_I = \frac{29}{66} = 0.4394$$

$$P_C = \frac{19}{51} = 0.3725$$

$$\bar{p} = \frac{29 + 19}{66 + 51} = 0.4103$$

$$\bar{q} = 1 - \bar{p} = 0.5897$$

$n_I = 66$ $n_C = 51$

$$z = \frac{P_I - P_C}{\sqrt{\frac{\bar{p}\bar{q}}{n_I} + \frac{\bar{p}\bar{q}}{n_C}}}$$

$$z = \frac{0.4394 - 0.3725}{\sqrt{\frac{(0.4103)(0.5897)}{66} + \frac{0.2419}{51}}} = 0.7296$$

Hypothesis 3

$H_o: \bar{X}_I = \bar{X}_C$

$H_a: \bar{X}_I > \bar{X}_C$

$\alpha = 0.05$ critical z value is 1.645

$df = n_I + n_C - 2 > 30$
use z table

$$z = t = \frac{\bar{X}_I - \bar{X}_C}{\sqrt{\frac{s_I^2}{n_I} + \frac{s_C^2}{n_C}}}$$

Fall 1972 $$z = \frac{150.57 - 132.26}{\sqrt{\frac{(26.37)^2}{28} + \frac{(47.78)^2}{23}}} = 1.645$$

Winter 1973 $$z = \frac{155.34 - 132.26}{\sqrt{\frac{(26.10)^2}{32} + 99.258}} = 2.102$$

Spring 1973 $$z = \frac{160.75 - 132.26}{\sqrt{\frac{(27.20)^2}{24} + 99.258}} = 2.498$$

Fall 1973 $$z = \frac{167.33 - 132.26}{\sqrt{\frac{(22.69)^2}{30} + 99.258}} = 3.250$$

Hypothesis 4

H_o: $G_I = G_C$

H_a: $G_I \neq G_C$

$\alpha = 0.05$

$df = (5 - 1)(2 - 1)$
$= 4$

critical X^2 value is 9.49

Fall 1972

f_o see Table 11

f_e:

Grades	Conv.	Indiv.	Total
A	7.3	7.7	15
B	12.2	12.8	25
C	3.4	3.6	7
D	1.5	1.5	3
No Pass	20.6	21.4	42
	45	47	92

Calculation of X^2:

Cell		f_o	f_e	(f_o-f_e)	$\frac{(f_o-f_e)^2}{f_e}$
A	Conv.	6	7.3	-1.3	0.231
	Indiv.	9	7.7	1.3	0.219
B	Conv.	9	12.2	-3.2	0.839
	Indiv.	16	12.8	3.2	0.808
C	Conv.	6	3.4	2.6	1.988
	Indiv.	1	3.6	-2.6	1.878
D	Conv.	1	1.5	-0.5	0.167
	Indiv.	2	1.5	0.5	0.167
No Pass	Conv.	23	20.6	2.4	0.280
	Indiv.	19	21.4	-2.4	0.269
				Σ	6.846

Fall 1973

f_o see Table 11

f_e:

Grades	Conv.	Indiv.	Total
A	13.2	11.8	25
B	9	8	17
C	5.3	4.7	10
D	0.5	0.5	1
No-Pass	26	23	49
	54	48	102

Calculation of X^2:

Cell		f_o	f_e	(f_o-f_e)	$\frac{(f_o-f_e)^2}{f_e}$
A	Conv.	13	13.2	-0.2	0.003
	Indiv.	12	11.8	0.2	0.0034
B	Conv.	6	9	-3.0	1.000
	Indiv.	11	8	3.0	1.125
C	Conv.	5	5.3	-0.3	0.0169
	Indiv.	5	4.7	0.3	0.0191
D	Conv.	1	0.5	0.5	0.50
	Indiv.	0	0.5	-0.5	0.50
No Pass	Conv.	29	26	3	0.346
	Indiv.	20	23	-3	0.391
				Σ	3.904

Comparison of the frequency of grades for the total conventional lecture and individualized instruction day classes for the 1972-73 school year and the Fall 1973 quarter:

f_o see Table 12 f_e:

Grades	Conv.	Indiv.	Total
A	21.8	41.2	63
B	22.2	41.8	64
C	9.3	17.7	27
D	2.4	4.6	7
No Pass	43.3	81.7	125
	99	187	286

Calculation of X^2:

Cell		f_o	f_e	(f_o-f_e)	$\frac{(f_o-f_e)^2}{f_e}$
A	Conv.	19	21.8	-2.8	0.360
	Indiv.	44	41.2	2.8	0.190
B	Conv.	15	22.2	-7.2	2.335
	Indiv.	49	41.8	7.2	1.240
C	Conv.	11	9.3	1.7	0.311
	Indiv.	16	17.7	-1.7	0.163
D	Conv.	2	2.4	-0.4	0.067
	Indiv.	5	4.6	0.4	0.035
No Pass	Conv.	52	43.3	8.7	1.748
	Indiv.	73	81.7	-8.7	0.926
					Σ 7.375

<u>Hypothesis 5</u> H_o: $G_I = G_C$

H_a: $G_I \neq G_C$

$\alpha = 0.05$

df = 4
critical X^2 value is 9.49

Winter 1973 540-126

f_o see Table 13 f_e:

Grades	Conv.	Indiv.	Total
A	3.6	5.4	9
B	1.2	1.8	3
C	2.8	4.2	7
D	0	0	0
No Pass	4.4	6.6	11
	12	18	30

Calculation of X^2:

Cell		f_o	f_e	(f_o-f_e)	$\frac{(f_o-f_e)^2}{f_e}$
A	Conv.	6	3.6	2.4	1.600
	Indiv.	3	5.4	-2.4	1.067
B	Conv.	1	1.2	-0.2	0.033
	Indiv.	2	1.8	0.2	0.022
C	Conv.	5	2.8	2.2	1.729
	Indiv.	2	4.2	-2.2	1.152
D	Conv.	0	0	0	0
	Indiv.	0	0	0	0
No Pass	Conv.	0	4.4	-4.4	4.400
	Indiv.	11	6.6	4.4	2.933
				Σ	12.936

Winter 1974 540-126

f_o see Table 14

f_e:

Grades	Conv.	Indiv.	Total
A	6.1	6.9	13
B	6.6	7.4	14
C	0.5	0.5	1
D	0.5	0.5	1
No Pass	2.3	2.7	5
	16	18	34

Calculation of X^2:

Cell		f_o	f_e	(f_o-f_e)	$\frac{(f_o-f_e)^2}{f_e}$
A	Conv.	8	6.1	1.9	0.592
	Indiv.	5	6.9	-1.9	0.523
B	Conv.	6	6.6	-0.6	0.0545
	Indiv.	8	7.4	0.6	0.0486
C	Conv.	0	0.5	-0.5	0.500
	Indiv.	1	0.5	0.5	0.500
D	Conv.	0	0.5	-0.5	0.500
	Indiv.	1	0.5	0.5	0.500
No Pass	Conv.	2	2.3	-0.3	0.0391
	Indiv.	3	2.7	0.3	0.0333
				Σ	3.2905