INTEGRATION OF MICROCOMPUTER USAGE
IN AN ENTRY-LEVEL COURSE
IN ENGINEERING
TECHNOLOGY

By

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CHAPTER I

INTRODUCTION

Background Information

Today, it is not remarkable to see students in college classrooms and laboratories using their own hand-held electronic calculators. Non-programmable calculators, however, are limited in their application. They are well adapted to immediate numerical solution of mathematical formulae, but cannot provide a hard copy of the results of several consecutive computations, and cannot store resident programs for later recall and use.

Many students in science, engineering, and engineering technology have begun to purchase and use the newer and more sophisticated programmable hand-held calculators. The programmables have a significant advantage over the non-programmables in that some have both program storage and printing capabilities. Students who own these machines, and who take the time to learn how to utilize them in their course work, can be expected to have a distinct advantage over their peers who do not. Students who utilize these machines to eliminate the tedious and repetitive computational aspects of preparing their assignments should have more time to concentrate on the concepts, applications, and procedures pertinent to their particular area of study.

Since the introduction of microcomputer systems in 1977 an increasing number of students in science, engineering, and engineering technology have begun to purchase their own computer (1). Computers are of course much more powerful computational tools than are the hand-held calculators, but the cost of the microcomputer is presently much greater than that of the most powerful hand-held calculators.

A still more recent development in hardware technology has been the introduction of the hand-held computer. These machines are much simpler to program than the calculators and presently cost about the same as the most powerful of the hand-held calculators.

It is expected that in the near future, advances in hardware technology will be such that the cost-to-performance ratio of these computers will drop to the point where students can be required to own one (1).

Students in engineering technology are required to acquire a strong background in mathematics, and electrical and electronics technology is one of the most mathematically demanding branches of engineering technology. In the past, students in electrical and electronics technology spent an inordinate amount of time performing computations in order to obtain solutions to problems. The advent of the electronics hand-held calculators, particularly the programmable ones, has significantly reduced computational time for those students who have mastered the use of these machines.

Computers are far superior to calculators as computational tools because programming techniques are more straightforward and logical and the visual display of computational results is far superior. Also, programming language varies widely among different calculator manufacturers, whereas language among various computer manufacturers is nearly standardized.

Projected trends in employment indicate an ever increasing interrelationship between the technical expertise in electrical and electronic circuits and systems on the one hand, and the ability of the electrical engineer and the technologist to readily use the computer in design, analysis and diagnostics of these circuits and systems on the other. The use of conversational or so called "interactive" computer programs in design, analysis and diagnostic problems is today one of the most powerful tools available to scientists, engineers, and technologists. The question is not whether students in these technical disciplines should learn to use the computer as a tool, but rather at what point in their education should these students be exposed to computer utilization.

Statement of the Problem

Students in Electrical and Electronics Technology at OSU take a computer programming course (COMSC 2113) in the second semester of their freshman year. In this course they learn to program the IBM-370 system using Fortran IV language.

The skills they learn in this course lay unused, in most instances, until the first semester of their junior year, at which time they take a course in advanced circuit analysis (EET 3113). In this course, the students use "on-line" programs in the IBM-370 system as tools in the analysis of fairly complex electrical and electronic circuits and systems. The problem here is that EET-3113 concentrates on application of the computer as a computational tool using existing programs and there is very little emphasis on programming. In COMSC-2113 the emphasis is on the development of programming skills with little or no application in solving the types of problems encountered by the electrical and electronics student in his or her major area of study.

Very few, if any, freshman students, upon completion of COMSC 2113, have any notion of how they might be able to use the computer in solving system analysis, diagnostic, and design problems in electrical and electronics technology. Also, students who have difficulty in mastering the programming skills in COMSC quite often become discouraged with computers, and may develop a negative attitude about using computers.

The salient problem which this research shall address then, is how can we create a positive association between student and computer early in the academic career, and maintain this positive association throughout all courses of study which involve computer usage? The study has considered the implementation of microcomputer-assisted laboratory procedures in an entry-level circuit analysis course as a possible solution to the problem.

Need for the Study

Educators in science, engineering, and engineering technology are today very much aware of the fact that computers are widely if not universally used as the "state-of-the-art" in analysis, design, and diagnostics of modern technological hardware systems. It therefore becomes imperative that students in the technical disciplines be exposed to using the computer as a tool early in the academic career, and that this exposure be at a level and under circumstances which allow the students to readily see and appreciate the value of the computer as a tool. This should ensure that students will develop positive associations and positive attitudes toward computers in their work.

What is needed then is a model which could give technical educators some insight into how to provide their students with meaningful, applicable and stimulating exposure to computer usage as applied to their major area of study. The need for such a model suggests the need for this study.

Purpose of the Study

The purpose of this study is to answer three questions which are felt to be important to an educator who is considering the integration of computer usage in an existing engineering technology curriculum.

Research Questions

This research attempts to answer the following questions:

1. Is it desirable and feasible to introduce freshman students in electrical and electronics technology to computer usage in an entry-level circuit analysis course?

2. Will the lack of prior formal exposure to computer programming, computer hardware, and computer usage be an impediment to the student in the application of the computer as a computational tool?

3. Will there be a significant difference in the performance of students who are using the computer and those who are not, within the same class and in the same course?

CHAPTER II

REVIEW OF LITERATURE

Identification of the Need for the Study

At the present time, writers of journal articles on technical education are advocating the applications of the digital computer and in particular the microcomputer in established curricula for science, engineering and engineering technology. It seems reasonable to expect that students in the technical disciplines should learn to use the computer as a tool just as they were expected to learn to use a slide rule not so many years ago. In addition, the early appearance in technical curricula of a course which introduces the student to computer usage directly applicable to his or her discipline should be deemed desirable and appropriate. Such a course will provide the necessary background that will be needed as higher level courses are upgraded to include computer usage. This study will attempt to demonstrate a method for integrating computer usage into an entry-level course without the necessity of performing major "surgery" on existing curricula.

Results of Previous Research

A review of current literature in technical education, although by no means exhaustive, has indicated that technical and especially engineering educators are predominantly in favor of the integration of the computer into the engineering curriculum. The results, findings, and conclusions of some of the recent studies that have been reviewed are presented below.

According to Neu (1) the teaching of circuit analysis to students in the electrical engineering discipline should proceed on the assumption that students own or have ready access to a computer or microcomputer. The professor will then be in a position to assign more meaningful and complex problems without having the student become inordinately burdened with computations. The student in turn will be able to concentrate on concepts and procedure techniques and use the computer to check and diagnose computations. On the design level, ready access to computers by students should greatly facilitate the verification and modification of design.

Since the work of the engineering technologist closely parallels that of the engineer with respect to the analysis and diagnosis of modern electrical and electronics hardware systems, Neu's statement also has implications for the technologist.

In March of 1980, the Institute of Electrical and Electronics Engineers (IEEE) conducted a survey of 250 educational institutions to determine the status of microcomputer education at those schools (2). The survey yielded a 50 percent mailing return. The response indicated that nearly every student in the engineering disciplines had access to microcomputers and microcomputer education. The IEEE determined from this survey that the microcomputer has been readily and rapidly accepted by the engineering educators and that schools which have not implemented the use of these machines are somewhat "out of step".

Many of the respondents to the IEEE survey felt that early exposure to computer or microcomputer usage and also the freedom of the faculty to assign more meaningful and complex "real world" problems were important. An open lab facility where the students could have nearly continuous access to the computers as well as integration of computers into the overall curriculum was cited as being particularly desirable. The most often cited problems in instituting the computer and microcomputer into existing curricula were budget, manpower, laboratory facilities and space, and faculty support or interest.

Klafter (3), in his research, has observed that engineering students, even at the freshman level, are well aware of the importance of computers and microcomputers in modern technology and that they want to learn about them as soon as possible. These students also realize that by acquiring knowledge of computers early in their academic career, they will be more attractive to prospective coop and/or summer job employers.

Fitzpatrick and Howard (4), in their research, identify two trends in the application of computers and microcomputers to teaching and learning activities. They are: (A) the development of computer-based laboratories; and (B) the creation of a research and teaching environment which allows the computer itself to be studied and utilized as an educational system. They tested the concept of a digital systems laboratory and concluded that the concept was successful in supporting electrical engineering curriculum at their respective institutions.

Trutt (5) in his papers states that supplementary use of microcomputers in electrical engineering education can provide an effective learning environment for introductory as well as advanced studies. In addition, sufficient exposure to microcomputers as a design and analysis tool is consistent with the ever expanding industrial application of these devices. In his research, Trutt (5) shows that a low-cost microcomputer may be used in the computer-aided instruction of extremely complex concepts dealing with electric power protection systems.

Townsend and Hale (6) present strategies for coping with opposition to using microcomputers on the part of students, faculty, and administration. According to these researchers, opposition may be specific to microcomputers, or more likely may be simply a general resistance to any kind of change or innovation in educational practices. They contend that the opposition may be overcome if one is aware of its existence and uses appropriate strategies for dealing with it.

Summary

After reviewing the literature in this area, one suggestion that is common in many of the studies is that computers should be integrated into existing engineering curricula and that exposure to the computer should occur early in the student's academic career. This allows the student to learn the basic concepts of computer applications early and then broaden his or her skills and expertise with more advanced applications in later courses. Furthermore, Sheets (7) concluded that it has become increasingly clear that the electrical/electronics graduate who has developed computer skills in school will enhance his or her ability to acquire and maintain employment in industry.

Considering the findings of this literature review, it appears that the integration of the computer into the electrical/electronics curriculum in engineering technology at OSU is indicated. Furthermore, it seems appropriate to investigate the questions previously stated in Chapter I.

CHAPTER III

METHODOLOGY

Definitions

The following definitions were used in this study:

EET: Electrical and Electronics Technology.

DCALP: Digital computer-assisted laboratory procedures.

Microcomputers: A relatively small and low-cost stand-alone digital computer system with keyboard input and video output display which utilizes modern integrated electronics circuitry for memory and processor functions. (The basic machines can generally be expanded with peripheral hardware to allow tape and/or disk input and line printer or other digital to analog output functions.)

OSU: Oklahoma State University.

Assumptions

The students who participated in the DCALP study were freshman students, male and female, enrolled in EET 1104, an entry-level course in circuit analysis required of all EET majors at OSU. The assumptions made for this study are:

1. The students who participated in this study are representative of all students who are currently enrolled in EET or who will subsequently enroll in the EET curriculum at OSU.

2. If DCALP is feasible and desirable for students in EET 1104, then DCALP should be feasible and desirable for other EET courses at OSU and for other similar curricula at other institutions.

3. There is no significant difference in the ability, attitude, or background of the students in the two laboratory sections who were exposed to DCALP and the students in the two laboratory sections who were not exposed to DCALP.

4. The factors selected for evaluation in this study are among the major items which would reflect the attitude of the students toward using the computer and the effectiveness of the computer as a teaching/learning system.

5. Enrollment of students into the four laboratory sections of EET 1104 is assumed to be a purely random process and therefore there is no correlation between data taken in the two lab sections which were exposed to DCALP and the two lab sections which were not.

Selection of the Subjects

EET 1104 is an entry-level fall semester offering for freshman students in basic electric circuit theory and circuit analysis. Historically, this course has the largest enrollment of any course in the EET curriculum at OSU. There are two lecture or theory sections and four laboratory sections. Two professors from the EET department are assigned responsibility for the course. Each professor has one theory section and two laboratory sections. Students in laboratory section I under Professor Burton and students in laboratory section II under Professor Jones served as subjects for DCALP with sections III and IV serving as a data control group. No attempt was made to inform the students that they were involved in a formal research activity. There were 32 students participating in DCALP and 30 students in the control group.

Development of the Instruments

The study involved the development and utilization of three instruments. Each is described below:

1. A technique for integrating the microcomputer into the existing laboratory activities for the course. This included:

   A. The development of software (computer programs) for those laboratory procedures in which computer assistance was deemed meaningful and appropriate.

   B. Logistical considerations with respect to class size, time, and availability of facilities.

   C. Instructional consideration with respect to operator procedures on the computers.

   D. Effective observation and documentation with respect to student interaction with the computer.

2. Documentation of grades on laboratory reports for both the DCALP group and the control group.

3. A questionnaire was developed for distribution to the DCALP group at the final laboratory session. The purpose of the questionnaire was mainly to glean information in the following areas:

   A. Personal information.

   B. Educational background.

   C. Industrial and/or military experience.

   D. Previous computer experience.

E. Attitude of the DCALP subjects about having utilized the computer in the course.

A copy of the questionnaire is exhibited in Appendix A. A sample laboratory procedure and computer program are included in Appendix C.

Study Procedure and Data Collection

The procedure for implementing the DCALP study and the method of data collection are presented below:

1. Nine of 14 previously developed laboratory procedures were selected for use in the DCALP study. Conversational or "interactive" computer programs were written to provide computer-assisted design and/or analysis functions. The programs were stored on cassette tapes. The machine selected for use in the DCALP study was the Commodore PET microcomputer system. (The OSU EET department had recently purchased seven of these machines and they were readily available for student use.)

At the beginning of each laboratory session in which a procedure calling for DCALP was to be performed, the students reported first to the computer facility. (The OSU EET computer facility is a 400 square foot room containing seven PET microcomputers, two DEC, PDP-11 mini-computers, and one DEC printing terminal which can be linked by tele-phone to the on-campus IBM 370 system on a time-share basis.) Here, each student's laboratory preparation assignment was checked for accuracy and completeness. Next, the students were allowed to be seated at a microcomputer station. At the first DCALP session students were given instructions on loading the programs from the cassette tapes into the microcomputer system and taught the necessary keyboard commands to execute the program. Since the programs were conversational, no further instructions other than from the computer were necessary. However, the researcher remained throughout each session to observe the proceedings and to answer questions from the students.

Upon completion of the computer session each student reported to the EET laboratory to perform the actual hardware experimentation as outlined in the laboratory procedure. His or her results could then be compared with the theoretical analysis obtained from the computer session. (Note--it should be pointed out that great care was taken not to allow the students to become overly dependent on the computer for analytical support. Each laboratory procedure calls for an outside preparation which requires the students to demonstrate a knowledge of the analytical and quantitative aspects of the procedure. The computer must not be allowed to compromise the theoretical, analytical and quantitative integrity of the learning process.)

2. Students in this course are required to write and submit a formal report on each laboratory procedure performed. The reports are graded by the instructor on the basis of compliance with acceptable form and format, completeness, accuracy, and professionalism in reporting results and conclusions. Grades for both the study group and the control group were documented and submitted to the researcher for later comparison and analysis.

3. At the last laboratory session calling for DCALP the questionnaire was distributed and the students were required to complete the questionnaire and return it to the researcher before leaving the laboratory. This phase of the study was completed on December 15, 1981.

Analysis of Observations and Data

The observations and data collection used for this study were performed during the fall semester of 1981 on the OSU campus in Stillwater, Oklahoma. The major thrust of the observations made and the data collected was to provide the information necessary to answer the research questions stated in Chapter I. The information required to answer research questions 1 and 2 was gleaned mainly by integrating the microcomputer into the course, observing the reaction of the students to the computer as well as documenting problems and/or events which occurred that would have an effect on future projects similar in nature. Finally, the students were polled by questionnaire with respect to their attitudes, opinions, and perceptions about the use of the computer in the course, as well as the desirability of using the computer in future courses.

While it appeared that research questions 1 and 2 could be answered adequately by objective observation on the part of an experienced educator along with some qualitative data input from the students, question 3 needed a more quantitative approach. It was decided that question 3 could best be answered by comparing the mean grades of the DCALP group with those of the control group using a statistical procedure. It was also decided that grades on the laboratory reports rather than test scores or final course grade would be the best indicator of any performance difference which might be attributed to the use of the computer.

A review of Popham (8) and Freund (9) was performed and the results of this review indicated that either a t-test or a single-classification analysis of variance procedure would be appropriate for the data involved. Since both the t-test and the single-classification analysis of variance procedures are available in the OSU IBM 370 computer program library, both of the procedures were executed. The computer programs utilized were "TTEST" and "ONEWAY" for the t-test and the single classification analysis of variance respectively.

The data used in the analysis of this study are couched in tabular format and presented in Appendix B.

Limitations

The major limitation of this study is that entry-level students in Electrical and Electronics Technology at OSU may not be altogether representative of entry-level EET students at other institutions. Therefore, the results of this study are not necessarily applicable to a general population of entry-level EET students.

CHAPTER IV

RESULTS

Return Rates

The 32 students in the two lab sections in which DCALP was implemented were present when the questionnaire was distributed. All 32 students completed the questionnaire and returned same to the lab instructors. The lab instructors, in turn, delivered the questionnaire to the researcher. Also, all 32 students participating in the DCALP study were present for all nine laboratory procedures in which the computer was utilized, and each submitted a report for all nine procedures. Therefore, the mean grade for laboratory procedures for the DCALP group is based on nine reports for all 32 students. For the two laboratory sections serving as the control group, there were two of the 30 students who were absent for one of the lab procedures and one student who was absent for two lab procedures. The mean grade for lab procedures for these students are based on eight reports and seven reports respectively.

The mean grade for the nine lab procedures in which computers were utilized are tabulated in Appendix B. Responses to selected questions from the questionnaire are also exhibited in Appendix B. A tabulation of central tendencies with respect to mean scores on laboratory procedure reports is presented in Table I.

TABLE I

CENTRAL TENDENCIES OF MEAN SCORES ON LABORATORY PROCEDURE REPORTS

Statistic	DECALP Group	Control Group
Range of Means*	9.6 to 6.0	8.6 to 6.4
Mean of Means	8.2375	7.75999
Median of Means	8.10	7.90
Mode of Means	7.90	8.20
Variance of Means	0.61983	0.39696
Standard Deviation of Means	0.78729	0.63004

*Maximum mean score is 10.

Results of Analysis

The research questions which were investigated by this study were stated in Chapter I. Each of the three questions are listed again in this section, and the analysis procedures employed to answer each question are presented.

Research Question Number 1

Research question number 1 asks if it is desirable and feasible to introduce freshman students in electrical and electronics technology to computer usage in an entry-level circuit analysis course.

The research used to answer this question proceeded in several steps as listed below. The researcher:

1. Identified those laboratory procedures which best lent themselves

to meaningful support by the computer.

2. Wrote the computer programs for those laboratory procedures and stored them on cassette tapes.

3. Planned the logistics with respect to time, availability of facilities and computers, and sequence of procedures.

4. Provided necessary instruction to the students in operation of the computers such as loading programs from tape and entering keyboard commands.

5. Observed the students during their computer sessions with particular attention to attitude, enthusiasm or lack of enthusiasm, remarks positive and negative, and specific problems encountered by the students in interacting with the computer.

6. Polled the students by questionnaire as to their attitudes and opinions about having used the computer in this course.

Because of the positive attitude and support of other EET department faculty with respect to this project and because of the availability of facilities and computer hardware, the feasibility of this undertaking was an a priori known. The question of feasibility of this type of project is answered simply on the basis of whether or not the faculty is willing to take the time and make the effort, and the administration is supportive in making whatever budgetary arrangements are necessary to provide facilities and hardware. With respect to this particular undertaking, no problems were encountered in either faculty or administrative support.

The question of desirability was answered basically by determining if DCALP had a positive impact on the students. Attitude and performance were the primary parameters of concern. The students were carefully and continuously observed during the time they were working with the computers. Several cases of acute frustration were noted during the first encounter with the computer, mainly because of unfamiliarity with the machines and especially with the keyboards. The programs, however, were written to be very "forgiving" with respect to erroneous keyboard commands and as the students became aware that mistakes at the keyboard during data entry were not catastrophic, the level of frustration declined, and the level of confidence and competence increased with each procedure.

Remarkably, there were no chronic problems with either the software or the hardware during any of the sessions with the computer. Each program was checked by the researcher and several faculty members before it was used by the students and there were no cases of equipment failure with the computers themselves.

Several items on the questionnaire were pointed at gleaning information which would indicate the attitude of the students toward having been exposed to computer usage in a course in their major. When asked if they thought that the computer had helped them to better understand the technical concepts of the laboratory procedures; 35 percent said "definitely yes;" 59 percent said "yes, to some extent;" and 3 percent said "no." When asked if they thought that the computer helped in the preparation of laboratory procedure reports, 47 percent said "definitely yes;" 50 percent said "yes, to some extent;" and 3 percent said "no." When asked if they thought that the computer helped in the actual performance of the laboratory procedures at the bench, 38 percent said "definitely yes;" 62 percent said "yes, to some extent;" and there were no negative responses. When asked if they had enjoyed using the computer in the courses, 72 percent said "definitely yes;" 28 percent said "yes to some extent;" and there were no negative responses.

Based on the observations made during the computer sessions and the responses of the students to the above questions, the following statements seem appropriate:

1. DCALP was well received by the students as demonstrated by the positive attitude and high level of enthusiasm observed.

2. DCALP did help the students in understanding concepts, writing technical reports, and performing the actual hardware procedures in the laboratory.

3. The students definitely enjoyed working with the computers.

4. The project was supported by both the faculty and administration of the EET department, the logistical aspects of the project went very smoothly, and the hardware and software performed remarkably well.

Research Question Number 2

Research question number 2 asks if the lack of prior formal exposure to computer programming, computer hardware, and computer usage will be an impediment to the student in the application of the computer as a computational tool.

To answer this question it was first necessary to establish whether or not the students involved in the study were in fact novices in working with computers. This information was obtained through the questionnaire. The following information was taken from the questionnaire.

1. None of the 32 students in the DCALP group had taken a course (other than a programming course) in which the computer was utilized as a tool.

2. Only 22 percent of the students had taken a college-level course in computer programming.

3. Only 28 percent of the students claimed to know how to program a computer.

This information indicates that none of the students had any experience in applying the computer as a tool in their work, and that the large majority had no knowledge of computer programming.

The next step in answering this research question was to attempt to establish whether or not this evident lack of exposure to computers had any negative effects on using the computer as a tool in the course. One item on the questionnaire asked the students if they thought that the computer could be used effectively as a tool without prior knowledge of computer usage or computer programming. In response, 69 percent said "definitely yes;" and 28 percent said "yes, to some extent." When asked if they thought that the computer should be used as a tool in other courses in their major, 75 percent said "definitely yes" and 25 percent said "it might be useful."

The above responses indicate that the students were able to apply the computer as a tool in their work even though the majority had limited or no past exposure to working with computers. These responses to the questionnaire items were consistent with the observations made during the computer sessions. None of the students seemed to have any great difficulty in following instructions from the computer programs, entering the data, and interpreting the results of computations. Another interesting observation was that in performing the laboratory procedures, if students obtained results which were significantly different from those predicted by the computer, they would take great care to check instrument readings, circuit configurations, and computations. This behavior indicates that the students had come to trust the computer as a reliable tool.

In view of the observations and the responses of the students to the questionnire, the following remarks seem appropriate:

1. The students who were using the computer in the DCALP study had limited, if any, previous exposure to using computers as computational tools and to computer programming.

2. The students were able to use the computer effectively as a tool in their laboratory work in this course.

3. The majority of the students indicated an interest in using the computer in other courses in their major area of study.

Research Question Number 3

Research question number 3 asks if there will be any significant difference in the performance of students who are using the computer and those who are not, within the same class and in the same course.

The mean grades of laboratory procedure reports on computer-assisted procedures for the DCALP group were compared with the mean grades of the corresponding reports for the control group to determine if there was a significant difference in performance between the two groups. First, a statistical procedure was used to prove that the variances of the two groups were statistically equal. Equal variance is an *a priori* criterion for both of the statistical test procedures which were performed.

The results of the test to prove statistically equal variance are shown in Table II. The results of the t-test and the single classification analysis of variance are shown in Table III and Table IV respectively.

TABLE II

TEST FOR HOMOGENEITY OF GROUPS (EQUAL VARIANCES)

S_1	S_2	$F_{calc} = S_1/S_2$	F_{table}	D.F.*	Significance
0.61983	0.39696	1.56144	1.84	31 and 29	0.02

$F_{calc} < F_{table} \therefore S_1 = S_2$ @ 0.02

*D.F. - degrees of freedom

TABLE III

RESULTS OF T-TEST

T_{calc}	T_{table}	D.F.*	Significance
2.62564	2.000	60	0.05

$T_{calc} > T_{table} \therefore \Delta\overline{X} \neq 0$ @ 0.05

*D.F. - degrees of freedom

TABLE IV

RESULTS OF SINGLE CLASSIFICATION ANALYSIS OF VARIANCE

F_{calc}	F_{table}	D.F.*	Significance
6.897	4.00	1 and 60	0.05

$F_{calc} > F_{table} \therefore \Delta \overline{X} \neq 0$ @ 0.05

*D.F. - degrees of freedom

At the 0.05 level of significance, both the t-test and the single classification analysis of variance indicate that there is a significant difference in the mean scores of the two groups. Based on the analysis then, it is appropriate to claim that the performance of the DCALP group was significantly better than the performance of the control group when the computer was used to support the laboratory procedures.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this research was to provide a model for the integration of the computer as a tool in an existing curriculum in Electrical and Electronics Technology at Oklahoma State University and at institutions with similar programs; and, to study the impact on students who use the computer as a tool in an entry-level course in circuit analysis.

The course selected for the implementation of digital computer-assisted laboratory procedures (DCALP) was EET 1104, a freshman offering in electric circuit theory and circuit analysis. Two laboratory sections comprising 32 students were exposed to DCALP and two sections comprising 30 students were not exposed to DCALP but were used as a data control group. The study was performed during the fall semester, 1981 on the OSU campus in Stillwater, Oklahoma.

Besides designing the procedures for integrating the computer into the existing curriculum, the DCALP study sought to answer three research questions, which are listed below.

1. Is it desirable and feasible to introduce freshman students in electrical and electronic technology to computer usage in an entry-level circuit analysis course?

2. Will the lack of prior formal exposure to computer programming,

computer hardware, and computer usage be an impediment to the student in the application of the computer as a computational tool?

3. Will there be a significant difference in the performance of students who are using the computer and those who are not, within the same class and in the same course?

Data were collected by direct observation and by questionnaire. The analysis of the data as applied to the research questions indicated that introduction to computer usage to freshman students in an entry-level course in their major area of study is both feasible and desirable. Lack of prior formal exposure to computers is not an impediment to the student in learning to apply the computer as a tool. Students exposed to computer usage in support of laboratory procedures performed significantly better, as revealed by their laboratory reports, than did their classmates who were not so exposed.

Conclusions

This section is devoted to reporting the conclusions indicated by the data analysis performed in this study. These conclusions are listed below.

1. The digital computer, and in particular, the microcomputer, should be integrated into the existing curriculum in electrical and electronics technology as a support tool in design, analysis and diagnostic functions. This statement is applicable to the EET curriculum at OSU and may also apply at other institutions with similar programs where faculty and administration have the interest and budgetary resources to accomplish the undertaking. For those who meet opposition in their endeavors to implement computer usage, Townsend and Hale (6) present strategies for coping with such opposition.

2. A commonality of opinion among other researchers, as revealed in the review of literature, was that exposure should take place early in the academic career. The results of this study definitely support that opinion. Freshman students in electrical and electronics technology are interested in computers. They are interested in using computers in their work as well as being interested in how computers work and how they are built. This study has demonstrated that lack of experience in working with computers does not prevent the freshman student from eagerly learning to apply the computer as a tool in his work. Where good planning and meaningful computer application on the part of the faculty has preceeded, no cases of chronic student opposition to computer usage should be expected or encountered.

3. Using the computer stimulates interest and generates enthusiasm in the majority of students. The performance level of the students who were exposed to computer usage in this study was superior to those who were not; and interest and enthusiasm are probably partly responsible for this performance difference. Truitt (5) states that supplementary use of microcomputers in engineering education can provide an effective learning environment for introductory and advanced studies. Where interest and enthusiasm are considered to be important elements of an effective learning environment, this study has shown that the computer can help provide such an environment.

4. Computer usage may be expected to stimulate interest in computer programming. This conclusion is reached based on questions asked by many students who were involved in the DCALP study. It was not remarkable for students to approach the researcher after a session with the computer and request a listing of the program which they had just used

or to ask specific questions about conversational programming. Some students who owned their own microcomputers and who utilized them to play recreational computer games become aware that if they could learn to program, they could find other applications for their machines.

It has long been a consensus among EET faculty at OSU that computer programming courses did not, in fact, stimulate interest in computer usage. This turn-about, as it were, where usage stimulated interest in programming, was an exciting result.

5. Because of the interest in programming, as well as using the computer as a tool, it seems appropriate to conclude that students should be exposed to computer usage in other, more advanced courses in their major area of study, and that this exposure should be continued throughout the academic tenure at all levels of course work.

Recommendations

From the standpoint of an educator, the desirability of installing any new teaching/learning device or technique must be evaluated in terms of its ability to enhance the teaching/learning environment to which it pertains.

The response of the students in this environment, his or her attitude and performance, are critical parameters of concern. Also, of concern must be the question of articulation or transferability of knowledge. Can the student, having been exposed to this device or technique, utilize the knowledge it hopefully imparts in future academic and professional endeavors? If a positive effect with respect to the above parameters can be demonstrated, then the device or technique should be deemed desirable, and its installation appropriate.

The results of this research, along with the above philosophy, have guided the researcher in making the following recommendations:

1. The utilization of computer-assisted laboratory procedures should become a permanent activity in the laboratory component of EET 1104 at OSU.

2. Other entry-level courses in the OSU EET curriculum should be considered for computer usage and where the computer can be meaningfully utilized in the laboratory or other course activities, it should be.

3. In more advanced courses where design, analysis and diagnostic procedures are the primary activities, and where the computer is not already utilized as a tool, the possibility of integrating the computer into these courses should be considered.

4. Since computer programming is a required course for all OSU EET majors, faculty should ensure that courses they teach which list computer programming as a prerequisite include some component in which programming is a required activity. The computational aspects of assignments should be rigorous, recognizing the fact that the student has the computer at his or her disposal.

5. Department planning activities, with respect to future needs in hardware and facilities, should proceed on the assumption that the present department computer facility will be inadequate once any two of the above recommendations are implemented. Assuming a flat enrollment projection, the facility should be at least doubled with respect to space and number of units over the next three years; and a technician should be hired whose major responsibility is maintenance of the computer facility and the computer hardware. Also, the necessary security arrangements should be made so that the students can have

access to the computer facility in the evenings.

6. Because of the results of this study, the above recommendations are felt to be valid as they pertain to Electrical and Electronics Technology at OSU. Because of the stated limitation of the study, the recommendations possess limitations with respect to their validity at other institutions with similar programs. However, it is recommended that other institutions with similar programs which have not begun a general program of integrating the computer into their existing curricula begin to think in terms of at least a literature review and perhaps an in-house study similar to DCALP. Also, they should consider the IEEE understated position that schools which have not implemented the use of computers in their engineering curricula are "somewhat out of step" (2).

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APPENDIXES

APPENDIX A

QUESTIONNAIRE

QUESTIONNAIRE

EET-1104 COMPUTER ASSISTED LABORATORY PROCEDURES

As you know, this semester we have implemented digital computer assisted laboratory procedures in two of four lab sections of EET-1104. The purpose of this questionnaire is to help us collect data which will allow us to measure the effects, if any, of using the computer as an analysis tool in the performance of laboratory procedures.

Your cooperation in assisting us by responding to this questionnaire will be greatly appreciated. Your responses will, of course, be confidential and will be seen only by persons involved in the performance and review of the study. None of the information provided will be used in any way which does not pertain to the study.

PERSONAL DATA

NAME ____________________ DATE OF BIRTH __________

MARITAL STATUS __________ CITIZENSHIP ______________

I. ACADEMIC BACKGROUND

A.) Present major area of study (circle one of the following):

1. EET
2. EPT
3. Other; please specify ________

B.) Number of semesters you have been a student at O.S.U. in the above major (circle one of the following):

1. one semester
2. two semesters
3. more than two semesters

C.) Have you ever, as a student at O.S.U., been enrolled in a major area of study other than the one given above?

1. yes; major area of study ___________
2. no

D.) Have you ever been enrolled as a student at a college or a University other than O.S.U?

1. yes
2. no

E.) If the answer to D.) above was yes, give the name of the universities attended, the dates attended, and the major area of study:

University	Dates attended		Major area of study
	from	to	

F.) List other training that you have had, such as military schools, vocational/technical schools, correspondance courses, or on-the-job training in industry:

Area of study	Type of program	Time in program

II. WORK EXPERIENCE

A.) Have you been employed full-time at anytime since graduating from high school or had military service?

1. yes
2. no

B.) If the answer to A.) above is yes then please complete the listing below:

Name of job and your duties	Employing firm or branch of military service	Dates	
		from	to

III. COMPUTER EXPERIENCE

A.) Have you ever taken a formal college level course in computer programing?

1. yes
2. no

B.) Do you know how to program a digital computer?

1. yes; language(s) ______________________________
2. no

C.) If the answer to B.) above is yes then circle one of the following:

1. self-taught
2. correspondance course
3. high school course
4. other; please specify ______________________

D.) Have you ever taken a course in college, secondary, or post-secondary level of instruction in which you used a digital computer in problem analysis or as an aid in design? (That is other than a programming course)

1. yes
2. no

E.) If the answer to D.) above is yes then circle one of the following:

1. programming was required
2. used 'canned' programs
3. both the above

IV. EET-1104 COMPUTER ASSISTED LAB PROCEDURES

A.) Do you feel that using the computer in this course helped you to better understand the concepts of the laboratory procedures performed? (circle one of the following):

1. definitely yes
2. yes, to some extent
3. definitely no
4. not sure

B.) Do you feel that using the computer in this course helped you to do a better job of reporting your lab procedures? (circle one of the folling):

1. definitely yes
2. yes to some extent
3. definitely no
4. not sure

C.) Do you feel that using the computer in this course helped you in the actual performance of the lab procedures at the bench? (circle one of the following):

1. definitely yes
2. yes to some extent
3. definitely no
4. not sure

D.) Did you enjoy using the computer in this course? (circle one of the following):

1. definitely yes
2. yes to some extent
3. definitely no
4. not sure

E.) Do you feel that the digital computer should be used as a design and/or analysis tool in other EET/EPT courses? (circle one of the following):

1. definitely yes
2. might be useful
3. definitely no
4. not sure

F.) Even without prior knowledge of computer usage or computer programming, do you feel that you can use the computer as a tool in your studies if interactive programs such as the ones used in this course are available?

1. definitely yes
2. yes, to some extent
3. definitely no
4. not sure

APPENDIX B

RAW DATA

TABLE V

TABULATION OF MEAN SCORES ON LABORATORY PROCEDURE REPORTS SUBMITTED BY STUDENTS IN EET 1104 FALL SEMESTER, 1981*

DCALP GROUP		CONTROL GROUP	
Student	Lab Reports Mean Scores	Student	Lab Reports Mean Scores
1	9.6	1	8.6
2	9.5	2	8.5
3	9.4	3	8.5
4	9.2	4	8.5
5	9.2	5	8.4
6	9.0	6	8.3
7	9.0	7	8.3
8	8.9	8	8.2
9	8.8	9	8.2
10	8.7	10	8.2
11	8.7	11	8.2
12	8.4	12	8.1
13	8.4	13	8.1
14	8.4	14	7.9
15	8.3	15	7.9
16	8.1	16	7.9
17	8.1	17	7.8
18	8.0	18	7.8
19	8.0	19	7.7
20	8.0	20	7.6
21	7.9	21	7.5
22	7.9	22	7.4
23	7.9	23	7.4
24	7.9	24	7.2
25	7.7	25	7.2
26	7.7	26	7.1
27	7.6	27	6.7
28	7.5	28	6.7
29	7.4	29	6.5
30	7.4	30	6.4
31	7.0		
32	6.0		

*Maximum possible score on any report is 10 points. Mean score was computed using the nine procedures in which the DCALP group utilized the computer and the corresponding nine reports from the control group.

Summary of responses to selected items on the questionnaire. (Thirty-two of the DCALP group are the respondents to the questionnaire which was implemented in the Fall semester, 1981.)

1. Had taken courses previously in which they had used a digital computer. (Other than a programming course):

   yes 0 no 32 (100%)

2. Knew how to program a digital computer:

   yes 9 (28%) no 23 (72%)

3. Had taken a college-level course in computer programming:

   yes 7 (22%) no 25 (78%)

4. Thought that using the computer in this course helped in understanding concepts of the lab procedures performed:

   definitely yes 11 (34%)
   yes, to some extent 19 (59%)
   no 1 (3%)
   not sure 1 (3%)

5. Thought that the computer helped in the preparation of lab procedure reports:

   definitely yes 15 (49%)
   yes, to some extent 16 (50%)
   no 1 (3%)
   not sure 0

6. Thought that the computer helped in the actual performance of the lab procedure at the bench:

   definitely yes 12 (38%)
   yes to some extent 20 (62%)
   no 0
   not sure 0

7. Enjoyed using the computer in EET 1104:

   definitely yes 23 (72%)
   yes, to some extent 9 (28%)
   no 0
   not sure 0

8. Thought that the computer should be used as a tool in other courses in their major:

definitely yes 24 (75%)
might be useful 8 (25%)
no 0
not sure 0

9. Thought that the computer could be used effectively as a tool without prior knowledge of computer usage or computer programming:

definitely yes 22 (69%)
yes, to some extent 9 (28%)
no 0
not sure 1 (3%)

APPENDIX C

SAMPLE LABORATORY PROCEDURE AND

SAMPLE COMPUTER PROGRAM

EXPERIMENT NO. 10

THEVENIN'S THEOREM

OBJECTIVE

The objective of this experiment is to experimentally verify Thevenin's theorem and to investigate its usefulness as an analytical tool.

DISCUSSION

Thevenin's theorem is a very useful tool for analyzing electrical circuits. The theorem states that any two-terminal network containing only linear resistances and sources may be represented by a single constant voltage source in series with a single linear resistor.

To apply Thevenin's theorem to a circuit the load must first be disconnected and the voltage across the output terminals computed. This is Thevenin's equivalent voltage. Thevenin's equivalent resistance is determined by replacing all sources with a short circuit and computing the resistance seen looking back into the circuit from the output terminals. Thevenin's equivalent circuit is then represented as a series circuit consisting of Thevenin's equivalent voltage and resistance.

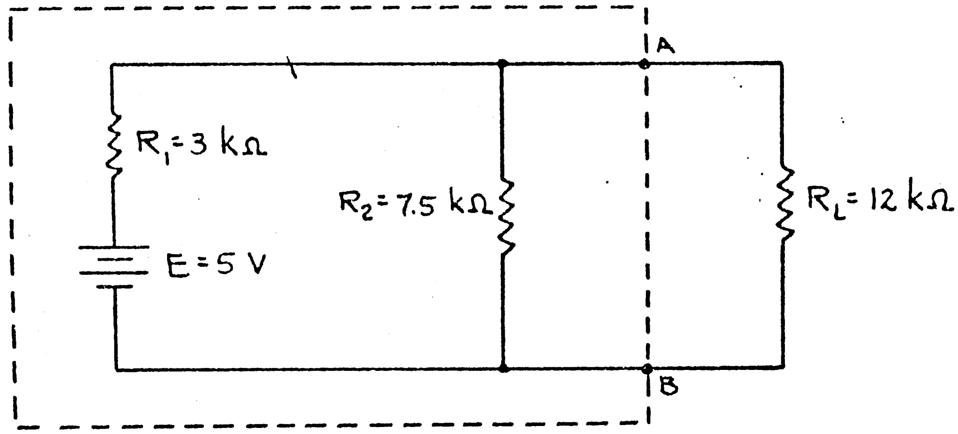
EQUIPMENT

1 dc power supply

1 VOM

3 resistors, 3kΩ, 7.5kΩ, 12kΩ

EXPERIMENTAL CIRCUIT



PROCEDURE

1. Construct the circuit shown.
2. Measure the current I_L.
3. Measure the open circuit voltage (V_{AB} with no load).
4. Measure the short circuit current (shorting AB).
5. Now remove the 5V power supply and replace with a short and measure R_{THEV}.
6. Draw the Thevenin equivalent circuits for the above circuit. Compare the measured values with calculated values.
7. Build the Thevenin equivalent circuit, attach the load and measure I_L and compare with the previously measured value.

DATA TABLE

Original Circuit I_L ______________________________

No Load Voltage V_{AB} ______________________________

Short Circuit Current I_{SC} ______________________________

Measured Thevenin's Res. R_{THEV} ______________________________

Calculated Thevenin's Res. R_{TH} ______________________________

Calculated Thevenin's Voltage V_{TH} ______________________________

Calculated Load Current (from V_{TH}, R_{TH}) I'_L ______________________________

Measured Load Current I_{L_1} ______________________________

% Error between I'_L and I_{L_1} ______________________________

(use I'_L as reference)

```
 10 PRINT
 20 PRINT"PROGRAM THEVNS"
 30 PRINT"--------------"
 40 PRINT
 50 PRINT"ENTER VALUE OF R1 (KILOHMS):"
 60 INPUT R1
 70 PRINT
 80 PRINT"ENTER VALUE OF R2 (KILOHMS):"
 90 INPUT R2
 100 PRINT
 110 PRINT"ENTER VALUE OF RL (KILOHMS):"
 120 INPUT R3
 130 PRINT
 140 PRINT"ENTER VALUE OF E (VOLTS):"
 150 INPUT E
 160 PRINT
 161 PRINT"LIST OF INPUT DATA FOLLOWS:"
 162 PRINT
 163 PRINT"R1="R1"KILOHM."
 164 PRINT"R2="R2"KILOHM."
 165 PRINT"RL="R3"KILOHM."
 166 PRINT"E="E"VOLTS."
 167 PRINT
 170 PRINT"ANY CORRECTIONS?"
 180 PRINT"(ENTER YES OR NO):"
 190 INPUT T$
 200 IF T$="YES" THEN 40
 210 PRINT
 220 R=R1*R2/(R1+R2)
 221 R=(INT(R*100))/100
 230 V=R2*E/(R1+R2)
 231 V=(INT(V*100))/100
 240 PRINT
 250 PRINT"THEVENIN EQUIVALENT FOLLOWS:"
 290 PRINT
 300 PRINT"    ___________/\/\/\/\/\____________. A"
 310 PRINT"    |"
 320 PRINT"    |           "R"KILOHM"
 330 PRINT"    |"
 340 PRINT"  ______"
 350 PRINT"    __"
 360 PRINT"  ______" V"VOLT"
 370 PRINT"    __"
 380 PRINT"    |"
 390 PRINT"    |"
 400 PRINT"    |"
 410 PRINT"    ___________________________________. B"
 420 PRINT
 450 PRINT
 460 I=V/(R+R3)
 470 PRINT"THE CURRENT THROUGH THE"R3"KILOHM"
 480 PRINT"LOAD RESISTOR IS:"
 490 I=(INT(I*100))/100
 500 PRINT"IL="I"MILLIAMP."
 501 PRINT"         -------------------------"
 510 PRINT"░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░"
 520 PRINT"DO YOU WISH TO RUN AGAIN?"
 530 PRINT"(ENTER YES OR NO):"
 540 INPUT T$
 550 IF T$="YES" THEN 10
 560 END
READY.
```

VITA

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