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OF ENGINEERING GRAPHICS

Dissertation
Presented in Partial Fulfillment of the
Requirements for Doctorate of Philosophy

By
William Edwin Brown, B.S., M.S.

**************

The Ohio State University
1964

Approved by
Robert W. Haws, Adviser
Department of Education
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CONTENTS

Chapter Page

1 INTRODUCTION ........................................................... 1
Statement of the Problem
Importance of the Research Project
Definition of Terms
Statement of Hypothesis
Sub-Problems
Dissertation Organization
Summary of the Chapter

II REVIEW OF RELATED LITERATURE. ......... 7
Introduction
Historical Development
Related Research in Engineering Graphics

III THE METHOD OF PROCEDURE ................. 16
The Experimental Techniques Used
Testing Group Equivalence
Convenience Selection Method
Summary of the Chapter

IV DESCRIPTION OF THE EXPERIMENT .......... 30
Administering the Pre-Test
Equipment and Materials
Program Development
Instructional Procedure
Post-Testing
Gathering Data
Summary of the Chapter

V RESULTS AND THEIR INTERPRETATION ........ 43
Test of Major Hypothesis
Test of Sub-Problems
General Discussion
VI SUMMARY AND CONCLUSIONS. ....... 50

Experimental Design
Subjects Used in the Experiment
Equipment and Materials
Program Development
Instructional Procedure
Testing
Findings
Conclusions
Limitations
Implications for Future Research
Educational Implications

BIBLIOGRAPHY. ................. 58

APPENDIX A Teacher-Constructed Pre-Test ............... 61
APPENDIX B Personal Data Record Sheet ............... 66
APPENDIX C Specifications for Equipment ............... 68
APPENDIX D Programmed Illustrations Used for Film Striping. ............... 71
APPENDIX E Transcript That Accompanied Programmed Illustrations. ............... 97
APPENDIX F Partially Completed Problem Sheets for Note Taking. ............... 106
APPENDIX G Student Instruction for Engineering Drawing 440. ............... 111
APPENDIX H Teacher-Constructed Post-Test ............... 118
APPENDIX I Raw Scores and Difference Scores ............... 124
APPENDIX J Sample Laboratory Exercises. ............... 127
LIST OF TABLES

Table                                                                 Page

1. Arithmetic Means, Median, Standard Deviations and Standard Error of the Means of OSPE Scores Used to Test for Equivalence of the Two Groups .................................................. 21
2. Standard Deviations and Standard Error of the Means of the Mathematics Placement Used to Test for Equivalence of the Groups .................................................... 27
4. Analysis of Difference Scores Obtained by Using the Pre and Post Criterion Tests .................................................. 45
5. Analysis of Different Credits Received on Laboratory Sheets for the Two Groups .................................................. 46

LIST OF FIGURES

Figure

1. Distribution of OSPE Scores for the Two Groups .................................................. 22
2. Distribution of the Mathematics Placement of the Two Groups .................................................. 25
3. Distribution of the English Placement for the Two Groups .................................................. 26
Chapter I

INTRODUCTION

The research studies conducted in the area of engineering graphics have either been curricular studies or visual aids usage studies. Many researchers have been concerned with what has been taught and what should be taught, but little work has been done concerned with the development of new knowledge directly applicable to the teaching of engineering graphics.

Until recently the methodology of teaching engineering graphics has remained static. In recent years, however, individual classroom instructors have tried to find better methods of teaching by utilizing overhead projectors, slides, film strips, movies and the use of television in the engineering graphics classroom. The writer believes that there is a need for research to test different methods of presentation of subject matter in engineering graphics. This research project was undertaken to gain some evidence in the use of an automated teaching device in engineering graphics.

Statement of the Problem

In recent years experimental psychologists through research have shown evidence that different kinds of subject matter can be presented by means of an automated teaching device. This research project was
designed to evaluate the educational significance of an automated teaching device used to supplement the instructor in the teaching of engineering graphics.

A survey of research literature indicated that little work has been done in experimenting with the automated teaching device in engineering graphics.

**Importance of the Research Project**

The results of this research project will provide engineering graphics instructors with some experimental evidence concerned with the development of new knowledge directly applicable to the teaching of engineering graphics through the use of an automated teaching device. It is believed that decisions can best be made by using experimental data as opposed to empirical data as a basis for judgment on the use of the merits of an automated teaching device. This project should be of importance to all educational institutions as well as industry and governmental agencies which are involved in the training of teachers, engineers, and technicians.

Time is an important element in any learning atmosphere. Through the use of the automated teaching device it is believed that more time will be available for the instructor to cover more material, to give more individual help and to do some evaluation of the student's work during laboratory time.
The implication of the automated teaching device for individual student and group use is the most important. The use of this device for review purposes during laboratory time or at any other time the student wishes to use it should produce more rapid student progress and a better understanding of subject matter.

**Definition of Terms**

**Engineering Graphics.** An accurate method of writing the language of the engineer and solving engineering problems, graphically, by the use of mathematical descriptive geometry principles as instruments. "... the graphic language in which are expressed and recorded the ideas and information necessary for the building of machines and structures." (9, p. 1).

**Control Group.** (Group A) This group in the research project received the traditional type lecture by the instructor the first period then reported to the laboratory the second period to work under the direction of a laboratory supervisor.

**Experimental Group.** (Group B) This is the name given to the group which received all new subject matter coverage from the automated teaching device in a combined laboratory-lecture room.

**Statement of Hypothesis**

The null hypothesis to be tested in this experiment follows:

There is no difference in achievement, as measured by the criterion
test, between subjects taught by the traditional method in the control group and subjects taught by the experimental method in the experimental group.

Differently stated, the mean of the difference scores between the pre-test and the post-test on principles of descriptive geometry for subjects taught in Group A will be equal to the mean of the difference scores between the pre-test and the post-test on principles of descriptive geometry for subjects taught in Group B.

\( \left( M_{\text{diff}}_A - M_{\text{diff}}_B \text{ or } M_{\text{diff}}_A - M_{\text{diff}}_B = 0 \right) \)

**Sub-Problems**

The principal hypothesis has been stated above; however, there will also be some sub-problems under consideration in this study. They are expressed in the following questions:

1. Will there be any difference in individual progress as observed by the instructor in the time taken for completion of a problem between the traditional group and the experimental group which had the availability of the automated teaching device for review?

2. Will there be any difference in individual grades on laboratory sheets between the control group and the experimental group?
**Dissertation Organization**

After careful examination of research literature, it was ascertained that no previous research projects had been done in the specific area in the use of automated teaching devices in engineering graphics. With no previous experiments to analyze for strengths and weaknesses in procedure, this research was undertaken as one original in scope and development. A survey of related literature was made as stated in Chapter II which revealed that no experiments dealt with this specific problem; however, there were a few similar experiments that were helpful in designing this research project.

A review of the related literature is discussed in Chapter II. A description of the procedure and experimental techniques are covered in Chapter III. Chapter IV is concerned with program development, instructional procedure and the collection of data and Chapter V deals with the statistical interpretation. Chapter VI deals with what are the implications derived from the research for the teaching of engineering graphics in an engineering program, industrial arts and related fields. The summary, recommendations and conclusions are presented in Chapter VI.

**Summary**

The teaching profession to avoid becoming static in presentation of subject matter must always be willing to experiment with new methods. It has been pointed out in this Chapter that engineering graphics has
undergone little change in becoming more effective and more efficient in subject matter presentation. Most of the research done in this area has been concerned with curriculum studies and visual aids usage. The lack of research studies available in engineering graphics dealing with the use of an automated teaching device shows a need for this type of research project.

This research project is designed to provide experimental evidence in the use of an automated teaching device in engineering graphics. The results of this research project should be of interest to engineering graphics teachers, industrial arts teachers and related technical fields in industry.

The null hypothesis to be tested in this experiment is that the means of the difference scores between the pre-test and the post-test on principles of descriptive geometry for subjects taught in Group A will be equal to the mean of the difference scores between the pre-test and the post-test on principles of descriptive geometry for subjects taught in Group B.

Chapter II is concerned with a survey of related literature dealing with experiments and programmed instruction that have been done in the field of engineering graphics.
Chapter II
REVIEW OF RELATED LITERATURE

Introduction

One of the first steps in this research project was to make an extensive review of literature concerning automated teaching devices. At the time of the conception of this research project comparatively little writing of significance had been done in this field.

In addition to review of the literature on the subject under consideration, it was necessary to take a careful look at a cross section of the types of equipment that were available and being used in programmed learning situations.

Historical Development

The concept of programmed instruction either through the use of a "teaching machine" or without it is not a new one (14). Early Greek teachers promoted the tutorial method of teaching. That is, they presented the individual student with programs of problems to be solved, questions and answers, or exercises to be performed. In a tutorial situation the teacher always provided some type of feedback or correction to the student so that he was immediately informed of his progress at each step and then given a basis for correcting his errors. This has come to be known as the Socratic method of teaching.
The present concept of the automated teaching device is an outgrowth of Pressey's self-instructional, test scoring devices that he developed in 1924 at The Ohio State University (17). The machine was a simple drum type arrangement that allowed the student to respond to multiple-choice test questions. A score was automatically kept on the number of choices the student made before answering the question correctly.

Remarks made by the students using this testing program indicated that they learned much of the subject matter from the tests. This led Pressey to change his original machine into a teaching device.

Even though Pressey conducted controlled experiments that showed the value of the machine as a self-tutor, it created little interest among the educators and psychologists. Peterson, a former student of Pressey, did some work in the 1930's on a device for use in teaching, testing, and research in learning (16). This device employed a quick-scoring punch card device.

Briggs, working with the United States Air Force in the 1950's, developed a self-instructional device which was used initially for military training and research purposes but which could be used for educational purposes also (4).

This machine, known as the Subject Matter Trainer, presented stimulus items one at a time in a small window on the left; the subject could select his answer from among 20 response items continuously
present to be viewed on the righthand side. Adjacent to each of the 20 response alternatives was a response button to be pressed when the subject had chosen an item as his answer. If he had chosen correctly, a green light next to the answer glowed; if he had chosen a wrong answer, a buzzer sounded. A series of 20 stimulus items were presented repeatedly until mastery was achieved.

This effort, with the results it produced, was responsible for much of the interest shown in the automated teaching devices by educators and psychologists at the present time. However, the interest shown in teaching devices was sporadic from the time of Pressey's first experiments until 1954. The studies that were done were conducted by psychologists whose primary interest lay in understanding the human learning process rather than in the applications of the machine for classroom use.

The above mentioned teaching device, called the Subject Matter Trainer, represented a further evolution of some of the simpler devices which were developed and studied earlier by Pressey and some of his students at The Ohio State University. Several of these machines were constructed and tried out experimentally in the instruction of technical specialists in the Air Force.

Skinner of Harvard University published an article in 1954 which advocated the possibility of a more direct educational application of concepts he had developed in the experimental laboratory (22). He
proposed that his extensive work on the experimental analysis of behavior had direct implications for the teaching process and that its application could be effectively implemented by appropriate instrumentation. Basically, he postulated that small stimulus response steps with immediate reenforcement would lead to the quickest learning.

Several machines with these required characteristics were built and tested (21). Sets of separate presentations of visual material were stored on disks, cards, or tapes. One frame was presented at a time, adjacent frames being out of sight. In one type of machine the subject composed a response by moving printed figures or letters. His setting was composed by the machine with a coded response. If the two corresponded, the machine automatically presented the next frame. If they did not, the response was cleared and another was composed. The student could not proceed to a second step until the first had been taken.

Pressey, in his original experiments, and Crowder in automatic tutoring by intrinsic programming, set forth in his scrambled text book, are the chief proponents of the multiple-choice response while Skinner and his followers require the student to write in his answer (7).

It was the work of Skinner and his associates that caught the imagination of educators and psychologists throughout the country. From this has sprung much of the interest and development of automated teaching devices.
Related Research in Engineering Graphics

After a careful review of the research literature it was found that no experiment dealing with the specific problem had been done. Although there were no experiments which dealt directly with the use of an automated teaching device in engineering graphics, a few of the more recent studies in this area were helpful in designing some of the procedure in this research project.

Schroeder conducted an experimental study of junior high school students to compare the relative effectiveness of two methods of teaching industrial arts mechanical drawing (18). They were divided into two groups by Schroeder, the experimental group and the control group. The groups were equated by using "intelligence grade placement" as the prime determinant. Other factors of secondary possibilities considered were chronological age, an algebra aptitude test and a pre-test in drawing given by the instructor at the beginning of the course.

This experimental study was conducted over a period of one semester. A teacher-made pre-test was given in the form of a post-test at the end of this time to determine the effectiveness of the two methods. One conclusion drawn from the study was that there was little difference in the amount of factual knowledge gained between the two groups. However, in the experimental group, student interest was much higher.

Allison conducted an experimental study which dealt with the teaching methods in mechanical drawing (1). The purpose of this
experiment was to determine the effectiveness of teaching mechanical drawing by the use of projection planes as opposed to the method of non-use of projection planes. The equivalent-groups method was used. The groups were equated on the basis of previous mechanical drawing, age, I.Q. and spatial ability. The groups were taught during two different semesters, one group by the use of projection planes and the other group without the use of projection planes. A teacher-constructed pre-test was given at the start of the semester to measure pupil achievement.

An experimental study on the teaching of multi-view drawing with pictorial sketching as the experimental variable was conducted by Hoskins (11). The purpose of this study was to provide experimental research evidence concerning the effects pictorial drawing (sketching) knowledge had on the acquisition of knowledge pertaining to multi-view drawing. The groups were equated on the basis of their I.Q. scores. The students were divided into two groups, the control group and an experimental group. Pre- and post-teacher-constructed tests were analyzed to test the major hypothesis. The .05 level of significance was used for testing the hypothesis. The data offered sufficient evidence against the null hypothesis \( M_{\text{diff}_A} = M_{\text{diff}_B} \), \( M = \) arithmetic mean, \( \text{diff}_A \) and \( \text{diff}_B = \) difference in the two groups. The null hypothesis was not tenable and at the .05 level of confidence it was rejected.
DuPont, under the direction of Keluche, developed a series of programmed instructions for teaching the reading of engineering drawings (12). This program was designed to be used in on-the-job training of DuPont personnel.

The material to be taught was broken down into a series of small steps carefully arranged so that each step builds on those preceding. Each instructional step or "frame" teaches something new and asks the student to use what he has just learned by completing a diagram or phrase, solving a problem or summarizing a concept. After responding to each frame, the student could immediately check his answer usually by turning the page. Thus the student could proceed with confidence and avoid building false understanding or incorrect information.

A representative sample of trainees was selected to compare the effectiveness of the programmed instruction course with the same subject matter taught by a skilled instructor using conventional classroom techniques. Both groups were equated as to formal education, experience and mechanical aptitude scores.

Comparative evaluation demonstrated that the programmed instruction could deliver higher uniform performance in approximately 25 percent less time than could an experienced instructor using ordinary classroom techniques.
DuPont estimated that a savings of $30 per trained man could be realized through the reduction of trainee time and the elimination of a need for a qualified instructor.

The type of programmed instruction was presented in book form similar to the scrambled text books developed by Crowder.

A research project in the application of a teaching machine to engineering graphics is under way by Basel and Knoblock at the University of Wisconsin in Milwaukee (3). The program is based on classroom lectures given by their engineering drawing staff. The lectures are broken down into logical self-contained units. The program consists of taped lectures accompanied by illustrations presented on slides. The program is designed for the student who is having difficulty with the course and who will use the machine for review purposes.

The machine used is a prototype developed by the Lectron Corp. of America. It consists of a four channel tape playback unit that is connected to a 36 slide automatically controlled projector. One channel of the tape is used for controlling the slide changer; the other three channels are used for presenting the material and reinforcing the student's answers.

The three channels which presents the material are controlled by three buttons -- A, B and C. The student by pressing one of the buttons hears the presentation through his earphones because the presentation is taped on all three channels. After the presentation a question appears
on a slide. Since the tape continues to run, the student is given a predetermined length of time to answer. He responds by pressing the button conforming to the choice he has made. This changes the pick up of his earphones to channel 2, 3 or 4 where after the timed interval is up, he is told whether his response is correct or not and why his choice is right or wrong. The next question appears on a slide and the sequence repeats until the program is completed. The advantage of this machine is that it is multi-sensory. The student hears and sees the material being presented. There were no available results of this research project at the time of this writing.

After reviewing the literature, the next step was to survey the problem and decide upon the equipment and procedure to use in the research project experiment. The following chapter deals with these problems.
Chapter III

THE METHOD OF PROCEDURE

This experiment was conducted in the Department of Engineering Drawing at The Ohio State University. The curriculum, as prescribed by the College of Engineering, consists of three three-quarter hour courses -- 440, 441 and 442. All engineering students are required to take these three courses. Most engineering students schedule the three courses in the first year of their pre-engineering curriculum. Exceptions to this rule are transfer students to the College of Engineering either from within the University or from other schools.

The engineering graphics courses used in this research project were taught in double class periods of one hour and forty-eight minutes duration meeting three days a week. The first class period was a lecture followed by a laboratory period.

The Experimental Techniques Used

This research project had as its goal one function, namely, to evaluate the use of an automated teaching device in the instruction of engineering graphics. The specific purpose was to determine the effectiveness of an automated teaching device as opposed to the traditional lecture-laboratory method used in teaching engineering graphics.
The convenience method of student selection was used in this experiment. Approximately one-hundred students assembled the first day of the quarter at each scheduled class time. From this group students were divided into separate class groups for each instructor. The size of each group was determined by the laboratory room capacity assigned to the instructor.

The most appropriate time for scheduling this experiment was the autumn quarter; this is the beginning of the engineering drawing sequence with the largest population of students. Engineering Drawing 440 is offered every quarter, but in the off-quarter offering there are many additional variables that would require consideration -- repeat students, greater number of transfer students, and a small population from which to select subjects just to mention a few.

The Ohio State Psychological Examination (OSPE) scores were used in this study to test for equivalency of groups. These scores were not obtainable until winter quarter, therefore, it was not possible to use the scores as a tool in equating the two groups at the beginning of the autumn quarter.

The standards set by the College of Engineering for accepting students into the engineering curricula are high. As a result over 75 percent of the beginning freshmen in the College of Engineering graduated in the upper ten percent of their high school class. All freshmen are required to have had high school chemistry, physics, and
advanced mathematics including plane geometry. Little consideration is given to a student's high school engineering drawing. There is no established standard in Ohio for a high school engineering drawing curricula, therefore, no emphasis is placed on the engineering drawing background of the student.

As indicated by the high standards for admission into the College of Engineering, a grouping of students by a convenience selection should be similar in structure to a group of students selected by the equivalent-groups method. The test for equivalency of groups was used in this project.

During the experiment, there were many known factors that affected the students. Most students participating in the experiment were first-quarter freshmen, away from home for the first time. Environment, social maturity, college experiences such as developing study and sleep habits, achievement and peer standing, as well as pressures from the family, and natural ability were a few of the many influences at play.

To overcome the difficulty of controlling the involved and inherent factors that were inevitable in the experiment the law of the single variable was followed. The single variable was the use of an automated teaching device in the instruction of engineering graphics. The students were divided into two groups with the same instructor for both groups, thereby keeping the teacher variable constant. In this
situation the difference between the traditional lecture-laboratory method of teaching and use of the automated teaching device was observed, measured, and evaluated using the student's personal record card data, with achievement scores as the criterion. Students enrolled in Engineering Drawing 440 were evaluated in terms of their OSPE scores, mathematics placement, English placement, age, sex and previous experience. The OSPE score was the major criterion used in this evaluation.

This experiment was conducted over a total of thirteen classroom instructional periods. Included in this time was the administering of a teacher-made pre-test that was used to measure the student's knowledge of descriptive geometry principles at the beginning of the experiment and the administering of teacher-made post-test to evaluate student progress at the end of the experiment. The experiment was started on the first day of class autumn quarter, 1963. The following six main steps of procedure were executed:

1. Testing group equivalence
2. Pre-testing
3. Equipment and materials
4. Program development
5. Instructional procedures
6. Post-testing
7. Gathering data

The purpose of Chapter III and Chapter IV is to explain in detail each of these separate steps.
Testing Group Equivalence

In the design of any experimental research study the total change in the trait in question resulting from irrelevant factors must be negligible, or the degree of such changes must be measured and discounted by the application of a controlled experimental factor (15, p. 499). Such traits that might influence the experiment were reduced to a minimum by considering the factors listed on the following pages to equate the two groups used in this research project.

Selection of Groups: Convenience Method

In Engineering Drawing 440 at The Ohio State University all students in the autumn quarter 1963 met in a designated room the first day of the quarter at their assigned class time. From this group the students are selected, put in class sizes and assigned to instructors. The size of each class depends upon the availability of staff and room capacity at the appointed time. The selection of students for the control group and experimental group was thus made.

As a result of the allocation of lecture and laboratory space it is difficult to control the size of classes scheduled at different times. Group A had twenty-seven students enrolled compared to twenty-one students in Group B. With the advent of the use of equipment in Group B it was felt necessary to use a room that provided laboratory facilities and lecture space, thus curtailing the number of students in Group B. In both groups the rooms were filled to capacity.
OSPE Scores. The OSPE scores which were used to test for equivalence of groups were obtained from the College of Engineering office. OSPE scores were available for only those students who were first-quarter freshmen. Scores were not available for transfer students or for upper classmen. A study of the two groups revealed that the OSPE scores for Group A ranged from a 13 percentile to a 97 percentile. There were two transfer students in Group A. The OSPE scores for Group B ranged from a seven percentile to a 96 percentile. There were three transfer students in Group B. Distribution of OSPE percentile scores is presented in Figure 1. Descriptive statistics (2, 8, 15) regarding the OSPE scores are given in Table 1.

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARITHMETIC MEANS, MEDIAN, STANDARD DEVIATIONS AND STANDARD ERROR OF THE MEANS OF OSPE SCORES USED TO TEST FOR EQUIVALENCE OF THE TWO GROUPS</td>
</tr>
<tr>
<td>Groups</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Group A</td>
</tr>
<tr>
<td>Group B</td>
</tr>
</tbody>
</table>
FIGURE 1

DISTRIBUTION OF OSPE SCORES FOR THE TWO GROUPS
**Age.** Chronological age affects the maturity of individuals and it is believed that maturity affects some types of learning. The age range in each group can be expected to be relatively small because most students enrolled in Engineering Drawing 440 were first-quarter freshmen. It was found that the ages of subjects in Group A ranged from 17 years to 22 years. The age range of subjects in Group B were from 17 years to 25 years. The mean age for Group A was 17 years, six months and the mean age for Group B was 18 years. Literature indicates that there is less variance in young adults than in very young children; therefore the slight difference in age between the two groups is insignificant.

**Previous experience.** It might be argued by some that this should be an important factor to consider in this study. Most engineering drawing instructors consider high school engineering drawing experience to be of little value to the student and to his success in engineering graphics. Studies have shown that there is little correlation between one's having had engineering drawing in high school and as to one's success in engineering graphics in college (5).

The College of Engineering at Ohio State does not include high school engineering drawing as one of the entrance requirements for pre-engineering. In Ohio there are no standards at the secondary level for engineering drawing. In most schools it is an elective and may be taken either in junior or senior high.
Pre-engineering students are given the opportunity to take proficiency tests in engineering graphics. Records in the Engineering Drawing Department indicate that fewer than one-half of one percent of the students pass the engineering graphics proficiency test. As a result of the wide variance in engineering drawing programs in the state of Ohio school systems, a statistical analysis of the two groups in terms of previous experience would not be meaningful.

In Group A there were nine students with a total of 14 semesters of high school engineering drawing. In Group B there were ten students with a total of 16 semesters of high school drawing. In comparing the two groups it can be seen that they were nearly equal in previous experience with regard to number of students and number of semesters. Because of the wide variance in different high school engineering drawing programs previous drawing experience among different students may make for a source of error in this experiment, but in view of the previous discussion it is believed that this factor was of little consequence in this experiment.

**Mathematics and English placement.** In comparing the two groups for the experiment, it was believed that the subject's abilities in mathematics and English are factors that needed consideration. As a result of the high standards set by the College of Engineering the cross section of students entering the pre-engineering curricula are above the average college freshman.
FIGURE 2

DISTRIBUTION OF THE MATHEMATICS PLACEMENT OF THE TWO GROUPS
FIGURE 3

DISTRIBUTION OF THE ENGLISH PLACEMENT FOR THE TWO GROUPS
TABLE 2

STANDARD DEVIATIONS AND STANDARD ERROR OF THE MEANS OF THE MATHEMATICS PLACEMENT USED TO TEST FOR EQUIVALENCE OF THE GROUPS

<table>
<thead>
<tr>
<th>Groups</th>
<th>Standard Deviation</th>
<th>Standard Error of the Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>8.87</td>
<td>1.81</td>
</tr>
<tr>
<td>Group B</td>
<td>7.0</td>
<td>1.69</td>
</tr>
</tbody>
</table>

As indicated by the arithmetic mean of the OSPE scores of the two groups, which were chosen by convenience selection, they were close to being equivalent groups. This is also seen when a comparison is made of the mathematics and English placement scores of the two groups. Figure 3 shows the mathematics placement of the two groups and Figure 4 shows the English placement of the two groups. Descriptive statistics regarding the mathematics and English placement of the two groups are given in Table 2 and Table 3 respectively (8, pp. 52-55).
TABLE 3

STANDARD DEVIATIONS AND STANDARD ERROR OF THE MEANS OF THE ENGLISH PLACEMENT USED TO TEST FOR EQUIVALENCE OF THE GROUPS

<table>
<thead>
<tr>
<th>Groups</th>
<th>Standard Deviation</th>
<th>Standard Error of the Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>8.18</td>
<td>1.70</td>
</tr>
<tr>
<td>Group B</td>
<td>7.52</td>
<td>1.82</td>
</tr>
</tbody>
</table>

Summary

The subjects were chosen by the convenience selection method for this experiment. Engineering Drawing 440, 441 and 442 is a three-quarter sequence course. This experiment was concerned with subject matter coverage in the 440 course. The experiment was run autumn quarter with the advantage of having a large population to work with. Running the experiment autumn quarter also offset certain variables such as repeat students, transfer students and the disadvantage of a small population. It was decided that the OSPE scores would be used as a test for equivalency of groups. The groups were compared in terms of OSPE scores, age, previous experience, composition, English and mathematics placement.
In the following chapter is a complete description of testing, equipment, materials, programming and the procedure of instruction used in the control and experimental groups.
Chapter IV

DESCRIPTION OF THE EXPERIMENT

The pre-test, developed for this experiment, was used to measure the extent of knowledge of descriptive geometry at the command of the subjects prior to the beginning of this study. The pre-test and post-test were identical in subject matter coverage -- in effect, different formats of the same test. The pre-test and the post-test were used as the criterion measure of the dependent variable. There was a possible score of 100 points on each test (Appendix A). Effort was made to include adequate types of the different phases of descriptive geometry problems, keeping in mind the expected learning that was to be a result of the instruction.

Campbell indicated the possibility of interaction effects which could limit the capacity to generalize from the pre-tested experimental group to the unpretested general population (6). Pre-test may reduce the effects of a training period. To control this Campbell suggested to add to the traditional two-group experiment two unpretested groups. This would enable one to control and measure both the main and interaction effects of testing and the main effect of a composite of maturation and history.
Because of time and staff limitations the four group method could not be used in this research project. The effect that pre-testing might have had on the outcome of student progress was held to a minimum by the strict limitations of the course outline. Other effects such as history, maturation and regression were offset as a result of the short duration of the experiment.

**Administering the Pre-Test**

The students, after being assigned to an instructor on the first day of the quarter, were shown to their lecture and/or laboratory rooms. Class cards and personal data sheets were completed by each student. An example of the personal data sheet is shown in Appendix B. The pre-test was administered during the second half of the double class period. It was a timed test of one hour duration. The students were instructed to do their best and not to guess on any items. It was also stressed that the grades received on the pre-test would not influence their final grades for the course. The students were told that the pre-test was to be used in an experiment. The students, in both groups, were informed by the instructor about the research project and what their roles would be in the experiment. Each student was then given the opportunity to transfer to another section if he chose not to participate in the experiment. Another reason for explaining to both groups about their roles in the experiment was in an
effort to eliminate, to a degree, the Hawthorne effect which is usually indigenous in an experimental group.

**Equipment and Materials**

As indicated in the survey of literature in Chapter II, the field of the automated teaching machine is relatively new, particularly is this true in the area of Engineering Graphics. At the time of inception of this project there was no available literature on the use and affect of automated teaching devices in the field of Engineering Graphics.

Several criteria were established as those being desirable to have in a machine that could be used in this experiment. The machine should be portable, presentation should be both visual and audio, low maintenance, operation instructions should be simple and the cost of purchasing the machine and development of the programming would have to be within the limitations of the research budget.

Careful thought was given to the possibility of developing a machine that would meet the above requirements but cost and time ruled against the development of a machine. Interest was then directed toward the possibility of adapting a commercial machine that could fulfill the criteria. After careful consideration the Salesmate, manufactured by Charles Beseler Company, was selected. The machine could be purchased and serviced locally.

The Salesmate is a portable automatic sound slide film viewer. It has a maximum capacity of 150 frames and 18 minutes of sound. The
film strip and the magnetic tape are each contained in continuous cartridges. After the machine has completed one cycle, it shuts itself off, and by pushing the start button the machine repeats the cycle again. In addition to the start button, the machine has these controls -- volume, frame advancement, and frame hold. See Appendix C for complete specifications of the Salesmate.

The program for the machine was of two parts -- film strip and magnetic tape. The film strip consisted of black on white illustrations synchronized with the audio-magnetic tape. The film strip and magnetic tape were in continuous cartridges, thereby requiring no rewinding. To change programs, a new film strip and magnetic tape cartridge were inserted into the machine.

Program Development

In a research project of this type the bulk of the work and time was in the development of the program -- organization of subject matter coverage units and development of visual and audio program­ming for each unit.

The first four weeks of subject matter coverage for Engineering Drawing 440 was carefully examined and broken down into subject matter units of work that could be presented by the automated teaching device.
In programmed instruction planning it is important to arrange concepts to be learned in a series of small steps designed to lead the student through self instruction from what he knows to the unknown of new and more complex knowledge and principles (13, p. 2).

An outline for the automated teaching device programming was compiled from the experiences gained and lecture notes and problems used by the supervisor of the research project in his teaching of Engineering Drawing 440. The outline was checked by other instructors on the engineering drawing staff. Using the outline as a guide inked illustrations were made showing the step by step applications of the fundamental principles of descriptive geometry for the solution of a problem.

The inked illustrations format was black on white made on 8 1/2" by 11" sheets. The illustrations consisted of statement of principles, methods of procedure, application of principles in solving problems in descriptive geometry and review or summary statements. The illustrations were sent to a commercial photographer to be photographed and processed into film strips. The number of frames per film strip ranged from twenty to forty frames. A set of illustrations used in the production of the film strip for one unit of programming can be seen in Appendix D.

The production of the audio consisted of recording lectures to accompany the illustrations. This was accomplished through a series
of steps. First, the supervisor of the research project recorded the lecture using a set of illustrations as a guide; second, a transcript was made from the recording with corrections and adaptations were made on the transcript; third, with the aid of a professional radio program director, a second recording, with the supervisor reading from the revised transcript, was produced at a level equal to broadcast quality; fourth, this recording was edited and transferred to a special lubricated tape; fifth, to the lubricated tape a thousand frequency modulated signal was added -- the signal is used to activate the frames of the film strip; sixth, the lubricated tape was wound into the tape cartridge.

For the entire project a total of three-hundred illustrations and twelve tapes were used. See Appendix E for example of transcript that accompanied the illustrations of Appendix D.

In an Engineering Drawing 440 course, spring quarter, 1963, a pilot was run using the first two series of programs to determine the adequacy of illustrations and audio necessary to convey the subject matter, the correct phasing of time with regard to illustrations and audio and the required comprehension and note taking time by the student. During this time several technical difficulties in the signaling of the tape and the signaling pick up mechanism of the machine were encountered. After several weeks of delay, the signal generator was repaired and the necessary adjustments on the automated teaching device were made.
Because of this delay it was necessary to postpone the running of the experiment to autumn quarter, 1963.

In addition to the production of illustration for film strip purposes, partially completed illustrations that paralleled the subject matter coverage presented by the machine were designed for student use. These were made on 8 1/2 by 11" sheets and presented to the students each day prior to their using the automated teaching device. These sheets provided an easy means for the students to work through the problems as the automated teaching device presented the material and to take the necessary notes (see Appendix F).

**Instructional Procedures**

The research project was conducted during the first four weeks of the autumn quarter, 1963. The subject matter coverage during these four weeks dealt with the fundamental principles of descriptive geometry (Appendix G). At the end of this period the first midterm examination was administered to all Engineering Drawing 440 students. This first midterm examination was used as a post-test to evaluate the dependent variable -- the effect of the automated teaching device.

The two groups met for one hour and forty-eight minutes, three times a week -- Monday, Wednesday and Friday. The investigator gave the lectures and conducted the laboratory period for Group A and supervised Group B. Group A met at the eight o'clock hour. Group B
met at the ten o'clock hour. The ten o'clock hour was selected for
the experimental group (Group B) because the room assignment, for that
time, could be used for lecture and laboratory.

The difference in time between Group A and Group B and its
effect on the experiment were considered. A record of test scores and
final quarter grades for different times of course scheduling is kept
by the Engineering Drawing Department; an analysis of these records
indicated that there was no difference in student achievement between
the 8-10 o'clock class and the 10-12 o'clock class.

Instructor bias is an important element that could effect the
results of the study. Engineering Drawing 440 is a departmentalized
course. Each instructor must adhere to the course outline (Appendix
G). The outline spells out the subject matter coverage, assignment
of laboratory problem exercises and the time limit for each. All
testing is also departmentalized. Therefore, instructor bias was at
a minimum in this research project.

The two groups were required to have similar drawing instruments
and equipment. Some equipment was issued by the Department
(Appendix G). Each student was required to have two text books --
*Engineering Drawing* by French and Vierick (9) and *Engineering
Graphics* by Shupe and Machovina (19), and a work book *Engineering
Problems* by Shupe, Machovina, and Cooper (20). The first day of class
each student was given a set of "Student Instructions" outlining
Engineering Drawing 440 (Appendix B). The student instructions, identical for both groups, listed the study assignments, laboratory problems and due dates for each problem and examination dates.

The supervisor in charge of the research project gave the lectures and conducted the laboratory period of the control group (Group A). Group A received the traditional engineering drawing instructions -- each lecture session began with a review of the previous day's assignment when time was spent in answering students' questions and working those problems that gave the students difficulty followed by a lecture coverage of the assigned material. The students met in two separate rooms -- one for lecture and one for laboratory. In the laboratory each student was assigned a drawing table. Individual help was given during the laboratory time; for more extensive help students were urged to make appointments with the instructor for tutoring other than during the laboratory time.

The supervisor of the research project was also in charge of the experimental group (Group B). The pre-lecture review that was given in Group A was also given in Group B. A review of the preceding day's assignment -- questions were answered and problems that had given the students difficulty were worked -- was given by the instructor at the beginning of the first period.

Group B received the basic subject matter from the automated teaching device. Each day before exposure to the automated teaching
device, students were issued partially completed problems on 8 1/2" by 11" sheets for note taking. These problems paralleled the material presented by the machine. These sheets provided an easy way for the student to work through the problems as the automated teaching device presented the material. Because of the size of the viewing screen on the teaching machine, the class was divided into two groups to receive their instruction; the one group not using the machine worked at their laboratory tables.

The instructor was available during the laboratory time but gave limited help. Students with questions involving fundamental principles were referred to the automated teaching device. The teaching device was made available in the classroom for individual or group use. It was also available for student use, upon request, for review purposes outside of class scheduled time.

For students who were having extreme difficulty, provisions were made available for students to make appointments with the instructor for individual tutoring, outside of classroom time.

Both groups worked identical laboratory problems (Appendix J) that were assigned from the problems workbook (20). In both groups the preceding day's assignment of problems was collected at the beginning of the laboratory period, graded (see Appendix G for grading scale) and returned to the students at the following class meeting.
Post-Testing

At the conclusion of the experimental period the post-test was administered. These tests were given during class time as were the pre-test. After the end of the fourth week a midterm examination was administered to all Engineering Drawing 440 students to evaluate student progress. This test was teacher-constructed. In this experiment the midterm examination was used as the post-test (Appendix H).

The midterm examination was a timed exam of one hour and forty-eight minutes duration. The allocation of time was based on the bell ringing for class period termination used at the University. The examination was proficiency in nature and graded on the basis of 100 points. A grading schedule for each problem was used in the assessment of partial credit.

Gathering Data

Special data sheets were designed to gather all the necessary information regarding the individual -- name, age, sex, college, and previous experience in drawing. The sheet also contained space for recording individual laboratory progress and test scores (Appendix I). In addition the project supervisor kept a record on length of daily lecture time in Group A, length of time used in daily review of the previous assignment in both groups, the number of scheduled conferences by students from both groups and the number of times students from the experimental group requested to use the automated
teaching device outside of the regular class scheduled time. At the end of the experimental period students were asked to express in prose their "likes" and "dislikes" regarding their use of the automated teaching device.

Summary

A teacher-constructed test to measure the extent of knowledge of descriptive geometry was administered as a pre-test at the beginning of the experiment. A post-test, similar in nature, was administered at the end of the experimental period. These tests were used as the criterion measure of pupil achievement in relation to the use of the automated teaching device.

A commercially made machine, the Salesmate, manufactured by the Charles Beseler Company was used as the automated teaching device. It was an automatic sound slide film viewer with a self-contained screen, that incorporated the use of synchronized film strip and magnetic tape which were contained in individual continuous cartridges that required no rewinding.

As a result of the allocation of lecture and/or laboratory rooms it was decided that Group A, the control group, would meet at the eight o'clock period, since they used separate lecture and laboratory rooms. Group B, the experimental group met at the ten o'clock period and used a combined lecture-laboratory room.
The subject matter coverage for both groups was identical. The one variable introduced was that in the experimental group the students received all new information from the automated teaching device, whereas, the control group received the traditional engineering drawing lecture.

The results of the statistical data and their interpretation regarding the hypothesis and sub-problems are given in the following chapter.
Chapter V

RESULTS AND THEIR INTERPRETATION

A convenience method of selection of subjects was used in this experiment, likewise a test for equivalence of groups was also utilized. Difference scores were obtained by administering the teacher-constructed pre- and post-tests. Variance measurement techniques were selected because of their adequacy in relation to the data. The .05 level of significance for testing the hypothesis was used for this research project.

To answer the sub-problems concerning individual progress and individual grades on laboratory sheets between the control group and experimental group, careful analysis will be made of all data gathered by the supervisor during the experiment.

**Test of Major Hypothesis**

**Hypothesis.** There is no difference in achievement, as measured by the criterion test, between subjects taught by the traditional method in the control group and subjects taught by the experimental method in the experimental group.

Growth in knowledge as pertaining to the effect of the automated teaching device in the subjects taught in Group B was the criterion to be measured. As stated above, difference scores were employed to
measure this growth (see Appendix I for a table of raw scores and difference scores).

Upon inspection of Table 4, it can be observed that the standard deviations of difference scores for the two groups appear to be considerably different. The F test as suggested by Edwards was employed to test the hypothesis that the groups were drawn from a common variance (8, p. 138-139). It was found, by approximate interpolation, that an F score value of 2.18 would be significant at the .05 level. The F value obtained from data was 2.18, the difference in the variability of the difference scores of the group is not considered to be significant.

To test the major hypothesis by a "t" test, the standard error of the difference in means was calculated using the formula suggested by Edwards (8, p. 130-131). The results of this analysis are shown in Table 4.

It can be seen from a study of Table 4 that the group taught by the automated teaching machine showed a mean growth of six points more than the group taught by the traditional method. This difference was significant at the .05 level of confidence. Entering the "t" table with 42 degrees of freedom it was found that 2.017 is significant at the .25 level, and since the "t" value obtained from the data was 2.05, the data offered significant evidence against the null hypothesis \( M_{\text{diff}_A} = M_{\text{diff}_B} \). This null hypothesis is thus not tenable and at the .05 level of confidence it must be rejected.
TABLE 4
ANALYSIS OF DIFFERENCE SCORES OBTAINED BY USING THE PRE AND POST CRITERION TESTS

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean</th>
<th>Standard Deviations</th>
<th>Standard Error of the Mean</th>
<th>Standard Error of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>34</td>
<td>14.2</td>
<td>2.8</td>
<td>2.50</td>
</tr>
<tr>
<td>Group B</td>
<td>37</td>
<td>20.9</td>
<td>4.9</td>
<td>2.05</td>
</tr>
</tbody>
</table>

Test of Sub-Problems

Sub-problem 1. Will there be any difference in individual progress, as observed by the instructor, in the time taken for completion of a problem between the traditional group and the experimental group who had the availability of the automated teaching device for review?

In Group A the average review time was 41 minutes, the average lecture time was 40 minutes. In Group B the average review time was 39 minutes, the average lecture time required by the machine was 15 minutes. This difference in time gave the students in Group B more laboratory time to complete their problem sheets. As shown in Table 5 there was a better showing on laboratory sheets in Group B than in Group A.
TABLE 5
ANALYSIS OF DIFFERENT CREDITS RECEIVED ON LABORATORY SHEETS FOR THE TWO GROUPS

<table>
<thead>
<tr>
<th>Number of Laboratory Sheets Receiving Other Than Full Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Group A</td>
</tr>
<tr>
<td>Group B</td>
</tr>
</tbody>
</table>

In most cases the better students in Group B, after receiving the material once from the machine, were prepared to perform the problem exercise. Those students who were having difficulty sat through the lecture again before beginning their exercise. In Group A this could not be done. In a traditional lecture-laboratory method the good students are forced to wait until the material has been covered to the level of the slower student. In this method a degree of motivation is lost in the good students.

It is pointed out in the Student Instruction (Appendix G) that all sheets submitted after the due date would receive one-half credit, provided the sheet is otherwise correct. As indicated in Table 5 there was a greater percentage of one-half credit sheets in Group A.
than in Group B. There were three factors that helped contribute
toward Group B receiving fewer one-half credits. One, as mentioned
in sub-problem 1, Group B had more time in the laboratory to work on
problem exercises; second, Group B had the advantage of partially
completed problems, that were correlated with the lectures presented
by the machine, to complete, take notes on and then used as a
reference while working on the problem exercises; third, if a student
in Group B were having difficulties with the problem exercise, the
machine was available for a quick review on principles.

In answer to sub-problem 2 there appears to be some significance
in favor of the experimental method in promoting individual progress
over the traditional lecture method.

Sub-problem 2. Will there be any difference in individual
grades on laboratory sheets between the control group and the experi­
mental group? Laboratory sheets were graded as full credit, one-
half credit and zero credit, with missing sheets receiving zero credit.
Further elaboration on the grading of laboratory sheets can be found
in Appendix G.

An analysis is shown in Table 5 of the credits received on the
laboratory sheets from the two groups. In the one-half credit sheets
values are seen as an important significance between the control group
and the experimental group. There appears to be evidence in favor of
the experimental group (Group B) over the control group (Group A)
between the difference in individual laboratory grades. In the other
grade breakdown of laboratory sheets the trend is also toward the
experimental group having a better laboratory grade record.

General Discussion

The assumption that the two groups are sampled from a population
with a common variance is the basis for the significance of the difference
between the means of the difference scores by the "t" test. If
the null hypothesis \( M_{\text{diff}_A} = M_{\text{diff}_B} \) is rejected, it is implied that
the way in which the two samples differ is with regard to their means
rather than with regard to their variances. To insure that any differ-
ence obtained from the statistical analysis of the gathered data was
in fact a difference between the means and not a difference in the
variance, it seems desirable to test the hypothesis \( (O_{A}^{2} - O_{B}^{2} = 0) \).
The F test was used to determine the degree to which the assumption
of common variance was valid.

The hypothesis was rejected at the .05 level of confidence. This
means that the null hypothesis is not tenable. It is concluded that
there was a significant difference between the traditional lecture method
and the use of the automated teaching device.

In answering the sub-problems the element of time, gained by
Group B who used the teaching machine, had an effect on the
completion of laboratory sheets. Therefore part of the significant
difference between the two groups would be contributed to the teaching machine plus time.

From an analysis of the assembled data it became evident that there was a significant difference in student performance in descriptive geometry in the group which used the automated teaching device over the group which received the traditional lecture-laboratory type of instruction.

A summary of the project is given in the following chapter. Conclusions, limitations and implications for additional research are also discussed.
Chapter VI

SUMMARY AND CONCLUSIONS

This research project was designed to provide experimental evidence regarding the effect of an automated teaching device in the instruction of descriptive geometry. Sub-problems also under consideration were: (1) will there be a difference in individual progress in the time taken for completion of laboratory exercises between the two groups?; and (2) will there be any difference in individual grades on laboratory sheets between the two groups?

Experimental Design

The convenience method of selection of students was used with a test then used for equivalency of groups of the selected students. These groups were tested for equivalency by using OSPE scores. The two groups were also compared in terms of mathematics placement, English placement, college major, age, sex and previous experience in mechanical drawing. The independent variable was the method of instruction and the dependent variable was a teacher-constructed test measuring achievement in descriptive geometry.

Subjects Used in the Experiment

The 43 students selected for participation in this research project were students who scheduled Engineering Drawing 440, autumn quarter,
1963 at The Ohio State University. Through a convenience selecting procedure, 25 students were placed in the 8-10 o'clock class and 18 students were placed in the 10-12 o'clock class. The number of students per class was dependent upon the capacity of each room.

**Equipment and Materials**

A commercially produced machine, the Salesmate, made by Charles Beseler Company, was selected to be used in the experiment. The machine cost was within the limits of the project budget and met the criteria for its application in this research project. It was portable, combined audio and visual presentation that were contained in continuous cartridges, thereby requiring no rewinding and furthermore, the machine could be purchased and serviced locally.

Accompanying each program on the machine was a partially completed set of drawing problems that were issued to the students. The students completed the problems as the material was presented by the machine. The completed problems provided reenforcement to the subject matter presented by the machine and provided the students with helpful notes that were used in solving descriptive geometry problems during the laboratory time.

**Program Development**

In the programmed instruction planning it was important to arrange concepts which had been learned in a series of small steps
designed to lead the student through self-instruction from what he
knows to the unknown of new and more complex knowledge and principles.
The outline of subject matter to be programmed was compiled from
experience gained and lecture notes and problems used by the research
project supervisor in his teaching of Engineering Drawing 440. Inked
illustrations consisting of statement of principles, methods of
procedure, application of principles in solving problems in descriptive
geometry and review of summary statements were produced on 8 1/2" by 11" sheets. The illustrations were sent to a commercial
photographer for processing into film strips.

The production of the audio consisted of a series of recorded
lectures that were to parallel the film strips.

Instructional Procedures

The control group (Group A) met at the 8-10 o'clock period. The
experimental group (Group B) met at the 10-12 o'clock period. The two
groups received the same subject matter coverage and performed the
same laboratory problem exercises. The control group was taught by
the traditional engineering drawing lecture-laboratory method. The
experimental group received all their new subject matter coverage via
the automated teaching machine. The experiment was conducted over
a four weeks period.
Testing

A teacher-constructed pre-test to measure knowledge of descriptive geometry was administered at the beginning of the experiment. At the conclusion of the experiment a teacher-constructed post-test was administered to measure student growth in descriptive geometry. These test scores were used to obtain difference scores which were analyzed to determine growth.

Findings

Appropriate statistical techniques were employed to analyze the data obtained and to test the research hypothesis. Based on this analysis the investigator found:

1. with regard to student's growth in descriptive geometry there was a statistically significant difference in growth between those subjects receiving instruction between Group B and Group A, or in favor of the experimental method.

2. with regard to individual progress in time taken for completion of the laboratory problem exercises between the two groups, there appeared to be some significance in favor of the experimental group.

3. with reference toward any difference in individual grades on laboratory sheets between the two groups
there appeared to be evidence in favor of the experimental group having a better breakdown of laboratory grades.

Conclusions

On the basis of the findings obtained under the conditions of this experiment, the following conclusions seem warranted:

1. The experimental method, which used the automated teaching machine, is superior to the traditional lecture-laboratory method for teaching descriptive geometry.

2. Individual progress and individual grades on laboratory problem exercises are improved in the experimental group over the group who had the traditional method.

3. The time factor is an important element for both student and instructor. The increase in available time in the experimental group provides the student with more laboratory time for completion of problem exercises and time to review the descriptive geometry principles by using the automated teaching machine. For the instructor, the available time provides more opportunities for individual student help and time to evaluate student problem exercises.
Limitations

In generalizing from the conclusions based on the collected data in the research project, extreme caution should be exercised. Consideration should be given to several limitations of this experiment which are listed below:

1. The number of students in each group was small.
2. Teacher bias cannot be completely ruled out in this study. There is always a chance that a teacher may be biased in his observations of student motivation and progress. In this experiment great care was taken to keep this factor at a minimum.
3. There was a need for complete control of instructions.
4. The length of time for which the experiment was conducted was relatively short.

Implications for Future Research

1. A similar study should be conducted which would use equivalent groups and I.Q. as the major control variable.
2. A similar study could be conducted using a combination of intelligence and abstract reasoning as the major control variables.
3. This same experimental variable should be tested with regard to different areas of engineering drawing other than descriptive geometry.
4. This same research covering a longer period of time would provide more evidence as to the permanent effect of the methods employed in this experiment.

5. The same experimental variable should be tested with regard to a larger population.

6. Replications of this experiment are needed, perhaps with a more sophisticated machine in which the subject controls the speed of subject matter presentation.

7. Repetitions of this experiment are needed with a two or three variable design.

8. A similar study could be conducted using four groups -- two unpretested groups.

9. A similar experiment could be conducted where the time variable is controlled -- a fixed laboratory time for both groups.

**Educational Implication**

This experiment, when compared with many research projects conducted in psychology and education, must be considered practical and applied rather than one that is laboratory oriented. The learning tasks are ones that exist in a practical school situation. As a result of this, generalizations made from the learning-teaching procedures have face validity for classroom instructors and educators.
From the analysis of the data gathered in this experiment, it appears that the automated teaching device could be used effectively in engineering drawing as a supplement to the instructor's lectures and for individual review of principles and problems. With certain modifications, the automated teaching machine could conceivably be used as a programmed teaching device for individual progress.

If the experimental method and its applications are considered effective methods of instruction as a supplement to the classroom instructor, the preparation of teachers skilled in the use of this approach holds implication for teacher educators in all subject matter areas and at all levels of instruction.


APPENDIX A

TEACHER-CONSTRUCTED PRE-TEST
FIG. 4. Given the COMPLETE top and front views of the object. There are 5 right side views given, only one of which is CORRECT. Fill in the circle that is below the CORRECT right side view. Do not add or erase any lines.

FIG. 5. Fill in the circle that is below the CORRECT right side view. Do not add or erase any lines.

FIG. 6. Fill in the circle that is below the CORRECT right side view. Do not add or erase any lines.

FIG. 7. Fill in the circle that is below the CORRECT right side view. Do not add or erase any lines.
## ENGINEERING DRAWING
### ORTHOGRAPHIC PROJECTION

**GIVEN:** The above are principal views of an angle brace. Fill in the circle that is the correct answer for the following questions and statements.

**IF VIEW "G" IS THE FRONT VIEW:**

<table>
<thead>
<tr>
<th>View</th>
<th>Top</th>
<th>Front</th>
<th>R.S.</th>
<th>L.S.</th>
<th>Bottom</th>
<th>Rear</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;A&quot;</td>
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<td></td>
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<tr>
<td>&quot;B&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
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<tr>
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<td></td>
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<tr>
<td>&quot;G&quot;</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**IF VIEW "F" IS THE FRONT VIEW:**

<table>
<thead>
<tr>
<th>View</th>
<th>Top</th>
<th>Front</th>
<th>R.S.</th>
<th>L.S.</th>
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<tbody>
<tr>
<td>&quot;A&quot;</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>&quot;B&quot;</td>
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</tr>
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<tr>
<td>&quot;D&quot;</td>
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<td></td>
<td></td>
</tr>
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<td>&quot;E&quot;</td>
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**IF VIEW "E" IS THE FRONT VIEW:**

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ENGINEERING DRAWING
ORTHOGRAHIC PROJECTION

Complete, by sketching in the indicated view.

Sketch the necessary orthographic views to completely describe the object.

SCALE FULL SIZE
Given two views (Top & Front) of line AB. Project and draw a third view to show line AB true length.

Given two views (Front & Right side) of plane RST. Project and draw the necessary views to show the true size and shape of plane RST.
APPENDIX B

PERSONAL DATA RECORD SHEET
INDIVIDUAL RECORD SHEET

Name__________________________Age__Sex____

College________________________

Class Rank (circle year and quarter) ______

Engineering Drawing__________repeat - Yes ( ), No ( )

Did you have mechanical drawing in high school? Yes ( ), No ( )

If answer is "yes" how many semesters? ________Av. Grade______

Have you had mechanical drawing experience other than high school? Yes ( ), No ( )

If answer is "yes" briefly describe the type of experience____________________________________

Test Scores

OSPE__________Math Placement____

English Placement____Pre Test ________Post Test ______

Laboratory Record

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APPENDIX C

SPECIFICATIONS FOR EQUIPMENT
SALESMATE

New ATTACHE CASE

AUTOMATIC SOUND SLIDEFILM VIEWER

1 - Open the screen  2 - plug in  3 - push the red button —

For Person-to-Person Presentations

SALESMATE opens the door to the busy buyer who will listen to your story without interruption.

With SALESMATE you can show products too large to carry or too small to see. You can communicate abstract ideas. You can visualize intangibles. You can present a controlled story with emotional appeal and the ring of authority.

You can strengthen product knowledge in salesmen and customers. You can reduce costs of recruiting, sales training, and sales promotion.

SALESMATE—with your own powerful sales story—will increase your sales, increase your profits.
What is SALES MATE?

• Focus the attention of the buyer on your uninterrupted story.
• Tell the same story to every customer in the same way, every time, everywhere.
• Important sales points are never omitted.
• Show your product in use and suggest new uses.
• Simply and concisely explain ideas and products.
• Bring a conventional story with color and sound.

A COMPLETE SALES PROGRAM
For $10.00 Per WEEK

You can have a complete SALES MATE selling program for your product or service for as little as $10.00 per week per minimum of two. This includes a SALES MATE for each of your employees, plus graphs, your own custom-made sound equipment, sound accessories, and a complete service program to keep your SALES MATE program in top operating condition. Get started right now on your part for success. Ask your nearest SALES MATE Program Distributor for details today.

FEATURES
SALES MATE Model 9800

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 4800

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 2800

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 1800

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 9000

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 8000

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 7000

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 6000

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 5000

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 4000

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 3000

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 2000

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 1000

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound

SALES MATE Model 900

- Complete SALES MATE Line
- Drop Frame Action
- Depth of Field
- High-Resolution Film
- Sound
- Long-Range Signal
- Complete Program
- Easy to Use
- High-Quality Sound
APPENDIX D

PROGRAMMED ILLUSTRATIONS USED FOR FILM STRIPING.
ORTHOGRAPHIC PROJECTION OF A PLANE
GIVEN SPACE DIMENSIONS OF A PLANE
PROBLEM NUMBER 1

GIVEN: TOP AND FRONT VIEWS OF PLANE ABC.
DRAW A VIEW ADJACENT TO THE FRONT VIEW
STEP I

DEPTH MEASUREMENT IS PERPENDICULAR TO FRONTAL REFERENCE PLANE.

PROJECT A VIEW ADJACENT TO THE AUXILIARY VIEW.
MEASUREMENT X IS PERPENDICULAR TO THE FRONTAL REFERENCE PLANE
EDGE VIEW OF A PLANE
FIND ANY LINE IN THE PLANE
TRUE LENGTH
FIND A POINT VIEW OF THE TRUE LENGTH LINE THAT IS IN THE PLANE
PROBLEM NUMBER 2

GIVEN: TOP AND FRONT VIEWS OF PLANE DEF.
DRAW A VIEW OF DEF ADJACENT TO THE TOP VIEW TO SHOW
LINE DF TRUE LENGTH
STEP 1

HEIGHT MEASUREMENT IS PERPENDICULAR TO THE HORIZONTAL REFERENCE PLANE.
PROJECT A POINT VIEW OF THE TRUE LENGTH LINE.
MEASUREMENT X IS PERPENDICULAR TO THE AUXILIARY REFERENCE PLANE
REVIEW OF STEPS TO FIND EDGE VIEW OF A PLANE

1. FIND ANY LINE IN THE PLANE TRUE LENGTH

2. FIND A POINT VIEW OF THE TRUE LENGTH LINE

3. A POINT VIEW OF A LINE IN THE PLANE GIVES AN EDGE VIEW OF THAT PLANE
PROBLEM NUMBER 3

DRAW A TRUE LENGTH VIEW OF ANY LINE IN PLANE ABC
STEP I

DC IS A HORIZONTAL LINE THAT IS CO-PLANAR WITH ABC
STEP 2

FIND POINT VIEW OF TRUE LENGTH LINE $C_{T-D_T}$
GIVES EDGE VIEW OF PLANE ABC
NORMAL VIEW

OF A PLANE
STEPS TO FIND NORMAL VIEW OF A PLANE
PROBLEM NUMBER 4

GIVEN:
TOP AND FRONT VIEWS OF PLANE DEF
STEP 1

FIND TRUE LENGTH OF ANY LINE IN THE PLANE
STEP 2

FIND A POINT VIEW OF THE TRUE LENGTH LINE
HEIGHT MEASUREMENT IS PERPENDICULAR TO FRONTAL REFERENCE PLANE
STEP 3

POINT VIEW OF THE LINE GIVES
EDGE VIEW OF THE PLANE
HEIGHT MEASUREMENT IS PERPENDICULAR
TO FRONTAL REFERENCE PLANE
Look perpendicular to the edge view to find a normal view of the plane.

Measurement X is perpendicular to auxiliary reference plane.
REVIEW OF STEPS TO FIND NORMAL VIEW OF A PLANE

1. FIND ANY LINE IN THE PLANE TRUE LENGTH

2. FIND A POINT VIEW OF THE TRUE LENGTH LINE

3. A POINT VIEW OF A LINE IN THE PLANE GIVES AN EDGE VIEW OF THAT PLANE

4. OBSERVER LOOKS PERPENDICULAR TO AN EDGE VIEW OF THE PLANE TO GET A NORMAL VIEW OF THAT PLANE
APPENDIX E

TRANSCRIPT THAT ACCOMPANIED PROGRAMMED ILLUSTRATIONS
Orthographic projection of a plane. (Signal) Given the space dimensions of a plane, any number of auxiliary views may be drawn. (Signal) In this example plane ABC is positioned inside the orthographic projection box, showing the top, front and profile views of plane ABC. These are the space dimensions - height, width and depth of this plane.

(Signal) In problem number 1, we are given top and front views of plane ABC or the space dimensions - height, width and depth of plane ABC. You are asked to project a view adjacent to the front view. In the direction shown as C1. The new view is projected from the front view. The reference plane that we see as an edge takes its name from the projected view, therefore, it is a frontal reference plane.

The direction of our projectors is determined by constructing a projection line from C in the front view to C1 in this auxiliary view. The reference plane is always perpendicular to the projectors. In projecting from one view to another one dimension is brought into the new view, it is the one perpendicular to the projectors. Then one must find the measurement perpendicular to the reference plane. To take measurements, one finds another frontal reference plane. In the top view we see an edge of a frontal reference plane. This gives
us two frontal reference planes seen as edges for taking measurements. Point C is on the frontal reference plane, point B - a given depth measurement - back of the frontal reference plane. These measurements are transferred from the top view perpendicular to the FRP to the new auxiliary view perpendicular to the FRP. This completes the auxiliary view projected adjacent to the front view.

For additional practice in the projection of a plane C2 is given adjacent to auxiliary view 1. (Signal) To project for auxiliary view 2 the line of sight is determined by connecting a projector from C1 to C2. The reference plane is always perpendicular to the projectors, in this case it is constructed through C2, that the 2nd auxiliary view is adjacent to the auxiliary view #1, the edge view of the reference plane takes its name from the projected view ARP. We must find a mate to this ARP seen as an edge, for taking measurements. Note that the front view is adjacent to the auxiliary view 1, therefore, we will see an edge view of the ARP in the front view. The measurements identified as X are perpendicular to the ARP, seen as an edge in the front view and are transferred to the new auxiliary 2 view - points A and B are given X measurement back of the reference plane. These are transferred to the new auxiliary view. Point C being on the ARP is transferred to the other ARP.

In the orthographic projection of a plane it may appear as the edge view of the plane, as the flat view or normal view of the plane
or as an oblique view, in which it does not appear normal or true size in shape.

(Signal) The first one of these that we are going to consider is the edge view of a plane. The key to finding the edge view of a plane is to find any line in the plane true length. (Signal) This is the first positioning of the observer in order to find the edge view of a plane.

(Signal) The second important step is to find a point view of the true length of the line that lies in the plane. (Signal) Let's apply these two steps in problem number 2 to find the edge view of the plane. Problem number 2, given top and front views of plane DEF. You are asked to draw a view of DEF adjacent to the top view to show line DF true length. This will fulfill the first requirement of finding edge view of a plane.

(Signal) To find DF true length the observer must look perpendicularly at DF, the edge view of the reference plane is parallel to DF and perpendicular to the line of sight.

The edge view of the reference plane is constructed parallel to DF at an arbitrary distance away. In that we are projecting from the top view the reference plane takes its name from the projected view. It is an HRP. We must find a mate to the horizontal reference plane. In the front view is seen an edge view of the HRP.

For convenience the HRP seen as an edge in the front view is drawn through point E. Therefore, when we transfer the height
measurement to the new auxiliary view point E will be on the reference plane, points D and F will be given height measurement below the reference plane. This gives us true length of DF in the auxiliary view. The next step is to find a point view of line DF. To project to find a point view of the true length line, the observer must look parallel with the true length line.

(Signal) In the solution, we see the line of sight parallel with the projection which are also parallel with DF. The auxiliary view 2 is adjacent to the first auxiliary view, then the name of the edge view of the reference plane will be ARP, taking its name from the projected view. The reference plane is positioned at an arbitrary distance away perpendicular to the projectors and also to the line of sight.

A mate to the ARP is found in a view adjacent to the auxiliary view, the top view. The ARP is positioned perpendicular to the projectors in this view. The X measurement perpendicular to the ARP in the top view is transferred to the auxiliary 2 view perpendicular to the ARP. Points D and F are on the reference plane, point E - a given X measurement - back of the reference plane. This completing the problem showing the edge view of plane DEF.

(Signal) Review of the steps to find edge view of plane.

Number 1 - find any line in the plane true length.

Number 2 - find a point view of the true length line.

Number 3 - a point view of a line in the plane gives an
edge view of that plane.

Let's review these steps with another problem.

(Signal) Problem number 3. Given top and front view of plane ABC find edge view of plane ABC.

(Signal) Step number 1 - find a true length of any line in the plane. The first requirement simply states find any line in the plane true length. Then construct a line in the plane so that it will be true length. It does not necessarily have to be line AB - BC or AC, but any line in the plane. By reviewing the definition of co-planar relationships we know that if a line is constructed in the plane, it is co-planar with the given plane, and it can be projected from view to view. In this case we have constructed a very special line. In the front view line CD is constructed so that one observing it from the top view will be looking perpendicularly at the line CD. Therefore, it will be true length in the top view or a horizontal line in the top view. This fulfills the first requirement of finding the edge view of a plane.

(Signal) The second step is - find a point view of the true length line. To find a point view of the true length line the observer must look parallel with the true length line. In step #2 the line of sight is with projectors and with CD the true length line. The reference plane is perpendicular to the projectors or line of sight. The reference plane seen as an edge view here is the HRP taking its name from the
projected view, the top view. The mate to the HRP is found in the front view. In taking the height measurement you will find that C1 and the new point D will be the same height measurement below the horizontal reference plane, thereby, giving a point view of line CD which is identified by point C in the auxiliary view.

(Signal) In the last step, points B and A are projected into the new auxiliary view from the top view with height measurements transferred from the front view perpendicular to the HRP to the new auxiliary view – completing an edge view of plane ABC.

(Signal) Normal view of a plane. Steps to find normal view of a plane. (Signal) In problem #4 we will go through the four steps to find a normal view of a plane. Given top and front views of plane DEF, you are asked to find the normal view of this plane.

The first step in finding the normal view of a plane is to find the true length of any line in the plane.

(Signal) In step #1 - that in the front view line GF is constructed so that an observer looking at the top view is looking perpendicularly at GF. GF then is a horizontal line or a true length line in the top view.

(Signal) Step number 2 - find a point of view of the true length line. Point view of HF. To find the point view of GF the observer must look parallel with the true length line, the reference plane is perpendicular to the line of sight. The edge view of the
reference plane is an HRP taking its name from the projected view – the top view.

Measurements for the location of the point view are height measurements taken perpendicularly to the HRP seen as an edge in the front view and transferred to HRP in the auxiliary view giving a point view of line FG.

(Signal) In step 3 the height measurements are transferred to HRP in the front view to the HRP in the auxiliary view. The location of D and E in the (edge view of plane) auxiliary view completes the edge view of plane DEF.

(Signal) In completing the problem, to find a normal view of the plane, the observer must look perpendicularly at the edge view of the plane to see a normal view of the given plane. The line of sight is perpendicular to the edge view, the reference plane is parallel to the edge view of the plane. In that we are projecting from the auxiliary view the name of our reference plane is ARP, taking its name from the projected view. We find the mate to this ARP in the top view, seen perpendicular to the projectors for the ARP view.

To complete the normal view, measurements are perpendicular to the ARP, are transferred from the top view to the ARP to the auxiliary view to the ARP.

(Signal) A review of steps to find normal view of a plane.
Step number 1 - find any line in the plane true length.

Step number 2 - find a point view of the true length line. When a point view of the true length line in the plane is found this gives an edge view of that plane,

and

Step number 4 - the observer looks perpendicular to normal view of that plane.

If you wish a repeat of this lecture, wait until the machine has come to a complete stop, then push the red button.
APPENDIX F

PARTIALLY COMPLETED PROBLEM SHEETS FOR NOTE TAKING
DRAW A VIEW ADJACENT TO THE FRONT VIEW
DRAW A VIEW ADJACENT TO THE TOP VIEW TO SHOW LINE DF TRUE LENGTH
DRAW NORMAL VIEW OF PLANE DEF
DRAW NORMAL VIEW OF PLANE ABC
APPENDIX G

STUDENT INSTRUCTION FOR ENGINEERING DRAWING 440
STUDENT INSTRUCTIONS
Engineering Drawing 440

GENERAL
The course is scheduled for either three one-hour and forty-eight minute periods or two two-hour and forty-eight minute periods per week. A lecture will precede laboratory work each period, except on examination days. Each lecture will start with a brief review of the previous assignment. Reviews of each Midterm Examination are scheduled. No other reviews will be scheduled during the quarter. Students requiring help with specific problems of the course are invited to arrange individual meetings with their instructors.

Students desiring to enter a laboratory at a time other than during their regularly scheduled class periods must secure permission from the instructor in charge of the laboratory. It will be customary for permission to be given during the laboratory part of the period. Permission will not be granted during the lecture part of the period (in rooms used for both lecture and laboratory), not during an examination.

EQUIPMENT
The Department of Engineering Drawing will issue to each student the following items of equipment:

- Kit box
- Pencils: red, blue, green
- Scale
- Pencil leads: H, 2H, 4H, compass (2 each)
- File
- Erasers: Red, pencil tip (2)
- Drafting tape
- Dust cloth

Students may purchase pencils, erasers, drafting tape, tracing paper, etc., in Room 214A, Brown Hall.

Check in Room 218, Brown Hall, for articles lost and found in the departmental area.

LAB SHEETS
Sheets will be graded full credit, half credit, or no credit.

A sheet that is correctly solved, properly delineated, and submitted at the beginning of the period identified in the schedule as the "Collect" date will receive full credit for that sheet.

Half credit will be given for all other acceptable sheets submitted on or before the deadline date for such sheets.
Deadlines are at beginning of the laboratory periods.

Sheets with incorrect solutions will be returned to the student. Such sheets will receive half-credit if they are corrected and resubmitted by the pertinent deadlines.

Sheets of below standard delineation, and sheets requiring an excessive amount of correction, should be redrawn. They may be redrawn on a sheet of tracing paper if the resubmission is with the original sheet. Deadlines apply equally to resubmissions and original solutions.

Sheets submitted after their respective deadlines will be checked for solution. No credit will be given for such sheets except in the cases of approved absences. (Approved absences are those for which a student could secure an excuse from either his physician or the University.)

Students are to keep all of their recorded sheets in either a 3-ring notebook or a Vertical File Pocket.

**EXTRA LAB SHEETS** Extra laboratory sheets are identified in the schedule. They are scheduled for submission on the day of their respective topic lectures. These sheets will be graded either full credit or no credit; Penalties assessed on the regular sheet sequence will be offset by extra sheet credits.

**FIRE DRILL** At least one unannounced fire drill will be held during the quarter. Sustained ringing of the alarm bells will be the signal for an orderly departure from the building.

**SMOKING** Attention of all concerned is invited to the University regulations relative to smoking. Smoking in the lecture rooms, drafting rooms, hallways, and stairways of Brown Hall is prohibited.

**SUPPLEMENTARY TEXTS** A selection of reference volumes are available in Brown Hall Library.

**EXAMINATIONS** Two one-hour and forty-eight minute midterm examinations are scheduled.

Make-up examinations will be scheduled from 6:00 to 7:48 p.m. Only students with make-up examination permits will be allowed to take these examinations.
The final numerical grades will be computed according to the following percentages:

- Midterms ................. 50%
- Lab Sheets ................ 20%
- Final Exam ................ 30%

Check of the office records will be made during the last class meeting. This check will require the student to have a listing of all his lab sheet grades and the file of lab sheets with him at that time.

The following form is presented for the convenience of each student.

Name ________________________ Instr _______ Hour ______

Midterm Grades: ___________ ___________

Laboratory Sheets:

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**"Engineering Drawing". All other assignments are in "Engineering Geometry and Graphics".**
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*Chap. 3

at end of period.
APPENDIX H

TEACHER-CONSTRUCTED POST-TEST
Draw the top, front, and right-side views of the given object. Scale: 1 = 1. The surfaces of the object are planar.
The top and front views of a sheet metal hopper are shown. It is made of four plane pieces of sheet metal fastened together at the seams. The top and bottom are open. Draw views 1 and 2 of surface ABCD. View 1 is to be adjacent to the top view; view 2 is to be adjacent to view 1.
General Note: Instrument drawings are required for the solutions of all problems of this examination. Show all construction used. Letter all points specified, wherever shown. Identify all reference planes with a distinctive color or code, wherever used.

Two different objects are shown on this sheet. All surfaces of these objects are planar.

The front and right-side views of an object are given. Draw the top view of this object.

The top and front views of an object are given. Draw the right-side view of this object.
Triangle CDE lies in plane RSP. Complete, in red, the front and right-side views of triangle CDE.

Isosceles triangle ACD lies in plane ABC. One of the equal legs of the triangle lies on line CB. Complete, in red, the front and left-side views of triangle ACD.
Determine the true size of the angle between planes MNO and NOP.
Show, in red, where the measurement is made. Answer ___ degrees.
APPENDIX I

RAW SCORES AND DIFFERENCE SCORES
RAW SCORES AND DIFFERENCE SCORES FOR SUBJECTS TAUGHT BY THE TRADITIONAL METHOD

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### RAW SCORES AND DIFFERENCE SCORES FOR SUBJECTS TAUGHT BY THE AUTOMATED TEACHING DEVICE

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APPENDIX J

SAMPLE LABORATORY EXERCISES
Plane H11 is horizontal. Draw, in red, the front and right-side views of triangle H11. Mark points 4 and 8 with small crosses and letter each point.

Plane M11 is frontal. Draw, in red, the top and left-side views of triangle M11. Mark points 4 and 8 with small crosses and letter each point.

Plane G11 is profile. Draw, in red, the top and front views of triangle G11. Mark points 8 and 1 with small crosses and letter each point.

Plane A11 is oblique. Draw, in red, the right-side view of triangle A11. Mark points 4 and 8 with small crosses and letter each point.

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There is no specific plane nomenclature table provided.
Points $B$, $C$, and $P$ are coplanar. Mark with an 'X' and cross the top view of point $B$ and the front view of point $P$.

Line $MN$ lies in plane $FHI$. Draw, in red, the front view of line segment $MN$.

Triangle $RST$ lies in plane $JKL$. Draw, in red, the front view of triangle $RST$.

Points and Lines in Planes

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Determine the two angles between the surfaces. 

\( \alpha \) and \( \beta \) are measured when the intersection line is taken. 

Angle Between Planes
Show on the true size of the angle between planes $OBD$ and $OBC$. 

Diagram to show the true size of the angle between its base planes.
Draw, in red, a normal view of surface ABCDEF of the truncated hexagonal prism.

Name: 

Section: 

Normal Views of Planes
Draw a view of the truncated rectangular prism that will be a normal view of surface ABCD.