THE EFFECTIVENESS OF OVERHEAD PROJECTUALS AND A

TRANSPARENT PROJECTION BOX IN TEACHING

ORTHOGRAPHIC PROJECTION

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THE EFFECTIVENESS OF OVERHEAD PROJECTUALS AND A TRANSPARENT PROJECTION BOX ON TEACHING ORTHOGRAPHIC PROJECTION

DISSERTATION

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By

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# CHAPTER I

## INTRODUCTION

The technological advancement which has occurred during the past decade has revolutionized the American way of life. This rapid transitional period not only has destined countless occupations to become obsolete, it has been the determinant of numerous new and highly skilled occupations. In relation to the rapid advancement in our economic opportunity, engineering drawing has emerged as one of the more critical and marketable skills in the world of work.

The results of a recent survey of 165 reporting companies in 27 states and parts of Canada indicate they employ 58.6 per cent more draftsmen than they employed five years ago. In 38 per cent of the companies the ratio of draftsmen to engineers is on a definite increase. In 49 per cent of the companies the preference was to employ inexperienced draftsmen, while 50 per cent of the companies preferred applicants with some training; 1 per cent was not reported (5, p. 11).

The trained applicants for drafting positions are graduates from colleges, business colleges, and technical high schools, while the inexperienced applicants tend to be high school graduates with an industrial arts background. While the majority of these applicants have only a broad overview of drafting, each applicant's success is dependent on his knowledge of orthographic projection and his ability with respect to image representation. The essentiality of this knowledge can vividly be understood in that nearly all drafting practices and procedures evolve from the basic concept of orthographic projection.

Research and scholarly literature reveal that most people possess, to some extent, the ability to visualize objects spatially. Stern (13, p. 124) stated that in order to develop this ability to its fullest, the person must translate the principle into function and receive effective instruction. In order to expand or supplement a person's understanding of image representation, the teacher may utilize various methods of instruction; however, the literature reveals that not all researchers and writers are in agreement concerning which instructional methods are best employed in the presentation of the principles of orthographic projection. The majority of these scholars do agree that only through proper teaching and channeled application of this ability will the student develop to his fullest potential. Many of the researchers and writers advocate that proper instruction should be a fast, effective method that utilizes as many of the student's sensory perceptions as possible (2, 3, 4, 6, 10, 14).

This study incorporated as many of the student's sensory perceptions as possible into a learning situation in a course identified as Industrial Arts 128, which is entitled

"Engineering Drawing," at North Texas State University, Denton, Texas. The beginning engineering drawing course requires each student to complete a workbook that contains approximately eighty-one drawings representative of the material taught during the semester. Included in the required assignment are approximately nineteen drawings which are entitled, "Orthographic Projection." The nine problem sheets in the workbook entitled "Sectioning" are closely related to orthographic projection because section drawings include the three principal views of front, top, and right side of an object. The importance of having a precise understanding of orthographic projection is essential because approximately one-third of the beginning engineering drawing course consists of orthographic projection problems.

## Statement of the Problem

The problem was a study of the effectiveness of overhead projectuals and a transparent projection box in teaching orthographic projection.

## Statement of Purposes

The purposes of the study were as follows:

1. To determine the effectiveness of overhead projectuals and a transparent projection box on the ability of students to visualize orthographic views.

2. To determine the effectiveness of overhead projectuals and a transparent projection box on the ability of

students to visualize objects from orthographic projection views.

3. To determine the change in the student's ability to visualize the application of orthographic principles in different units of engineering drawing.

4. To identify those units involving visualization that are most affected by study through application of orthographic principles in different units of engineering drawings.

Consistent with the purposes of this study, the student population was divided into control and experimental groups. To determine the effectiveness of the experimental variable each group was administered a pre-test, post-test and retest.

## Hypotheses

The following working hypotheses were formulated and tested in order to evaluate the effectiveness of instruction.

I. The control group will make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views.

II. The experimental group will make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views.

III. The experimental group will make a significantly greater mean gain than will the control group from the pre-test to the post-test on a comprehensive test of visualization of orthographic views.

A. The experimental group will make a significantly greater mean gain than will the control group as measured by a test of missing lines.

B. The experimental group will make a significantly greater mean gain than will the control group as measured by a test of surface identification.

C. The experimental group will make a significantly greater mean gain than will the control group as measured by a test of visualization of orthographic views.

D. There will be no significant difference in the mean gains of the two groups as measured by a test of visualization of surfaces.

IV. The control group will make a significant mean gain from the post-test to the retest on a comprehensive test of visualization of orthographic views.

V. The experimental group will make a significant mean gain from the post-test to the retest on a comprehensive test of visualization of orthographic views.

VI. The experimental group will make a significantly greater mean gain than will the control group from the post-test to the retest on a comprehensive test of visualization of orthographic views.

A. There will be no significant difference in the mean gain of the two groups as measured by a test of missing lines.

B. There will be no significant difference in the mean gain of the two groups as measured by a test of surface identification.

C. There will be no significant difference in the mean gain of the two groups as measured by a test of visualization of surfaces.

D. The experimental group will make a significantly greater mean gain than will the control group as measured by a test of visualization of third angle projection.

## Definition of Terms

For the purpose of this study the following definitions were formulated.

1. _Overhead projectuals_.--An instructional medium consisting of transparent material used to project images onto a screen.

2. _Transparent projection box_.--An instructional aid used to illustrate the theory of orthographic projection by the application of image planes, points, and lines that illustrate principles of orthographic projection.

3. _Orthographic projection_.--A type of drawing which illustrates the correct front, top, and right side views of an object.

4. _Method A (Control)_.--A method of instruction in orthographic drawing through the use of lecture, demonstration, discussion, textbooks, and chalkboard media.

5. Method B (Experimental).--A method of instruction in orthographic drawing through the use of lecture, demonstration, discussion, textbooks, and chalkboard media supplemented with overhead projectuals and a transparent projection box.

6. Unit Test in Engineering Drawing.--A standardized test consisting of sixteen units which encompass all phases of engineering drawing.

7. Presentation time.--The classroom time which is utilized by the instructor in presenting information to the students as a group.

## Limitations of the Study

For the purpose of the study, the following limitations were imposed.

1. This study included only students who were enrolled in the course identified as Industrial Arts 128, at North Texas State University, Denton, Texas, during the fall semester of 1968.

2. Recommendations or conclusions cannot be drawn regarding the relative effectiveness of the projectuals or the projection box alone; all interpretations of the data must include both factors as related to the study.

3. It was recognized that the teaching procedure employed in the study violated certain principles of accepted learning theories; however, these violations were the same in each group and utilized as variable controls.

## Assumptions

The experimental design of the study was based on these assumptions.

1. It was assumed that neither the control nor the experimental groups would be uniquely affected by any uncontrolled variables.

2. It was assumed the material taught during the twelve-day interim period before the formal study began would have no effect on the validity of the study.

## Background and Significance

The authors of engineering drawing books tend to agree that orthographic projection is the foundation on which the entire structure of drafting is built. No matter how technical or how comprehensive the drafting program becomes, the program is only as strong as its foundation, orthographic projection.

The nature of orthographic projection makes it difficult to teach. In orthographic projection, the student is required to visualize various spatial relationships in terms of correct view representation. This ability to visualize in three dimension is one of the most important requisites of a successful engineer. Giesecke stated that "to the designer it is the ability to synthesize or form a mental picture before the object exists" (8, p. 89). Once the object is visualized, it is then the responsibility of the draftsman to express this image in its correct representation through the use of orthographic views. If the representation of the views is incorrect or inaccurate, the best lettering or dimensioning cannot make the drawing correct (12, p. 38).

Schilling (12) in his research to compile a standardized drafting test, stated that research and not hearsay should answer questions such as these: Is it better to (1) teach sketching before shape description, (2) teach revolutions before auxiliary views, and (3) teach drawing skills with the assistance of visual aids.

Industrial arts drafting teachers have long realized the value of using visual aids in the educational process. The use of models, posters, textbooks, bulletin boards, pictures, motion pictures, slide pictures, opaque pictures and mock-ups, have been and are an integral part of the industrial arts teacher's instructional media. However, for most industrial arts teachers the question of how to consolidate visual aids and teacher demonstrations to obtain maximum effect still remains unanswered.

Most drafting instructors who have taught sizable groups admit they are dissatisfied with their classroom demonstrations. This dissatisfaction is due partially to the inability of the instructor to accurately illustrate on the chalkboard the steps and procedures involved in making a drawing. Chalk does not lend itself to making accurate drawings due to the varying change in line widths as the chalk is used. Also, the instructor cannot consistently illustrate a drawing to a size that will be visible to all the students and still preserve the true proportions of the drawing.

The teacher who has endeavored to hold or adjust the chalkboard drafting machine while demonstrating knows the difficulties involved. The teacher must effectively and efficiently explain the procedures as the demonstration proceeds or draw the problem on the chalkboard before the class arrives. If the teacher uses the chalkboard drafting machine to draw the problem while he is explaining the procedures, he will, by necessity, block the view of part of the students a large portion of the time. These interruptions tend to result in a loss of continuity for the pupil and a lag in interest and attention.

When the chalkboard is used to demonstrate the principles and techniques of correctly solving a problem, there is no chance to review each step separately without the completed problem presenting confusion. To illustrate one particular step without distraction or confusion, the instructor must erase the complete problem and proceed from the start. Earle (6, p. 24) points out that the teaching of engineering drawing has been hampered by the limitations imposed by the use of the chalkboard. The advent of the overhead projector, according to Earle (6, p. 24), has provided the drafting teacher with a more effective and versatile means of presenting orthographic projection problems.

The transparent projection box has been used successfully for many years in drafting classrooms to demonstrate planes of projection and the placement of views in relation to each other. In most instances the use of the transparent projection box is restricted to the demonstration of only one particular model, due to the image being painted on each projection plane. In other cases the transparent projection box is used by drawing the model image on each projection plane with a grease pencil. Time and potential are lost in both of these methods, due to the permanency of one and the technique of the other.

The overhead projector and the transparent projection box are not the answer for all the faults and shortcomings of the drafting room demonstrations; nevertheless, the overhead projector has been found to have certain definite advantages:

1. The instructor can demonstrate while facing the students at all times.

2. The instructor can draw, write, or letter on the projected surface and have every stroke of the pencil projected onto the screen in back of the instructor as the demonstration is done.

3. Much time can be saved for both, the student and the instructor.

4. The overhead projector can be operated with the room fully lighted.

5. With the exception of the pencil, the instructor can use the same type of instruments the student uses (14, p. 353).

The transparent projection box as used in this study was found to have definite advantages over the various other styles. In this study the transparent projection box utilized the same principle as the overhead projector because the projection box was equipped with transparencies similar to the problem illustrated on the overhead projector. Each projection plane was constructed to hold a transparency of the correct model image. This method of utilization enabled the projection box to be more versatile, due to the small amount of time required to change each projection plane transparency.

The importance of improving the methods of teaching orthographic projection is reflected in the questions raised by Schilling (12) and the statements made by Earle (6). The implication that research should be conducted to determine which teaching methods are most effective in this vital area indicates the significance of this study. The study was an attempt to find a more effective method of teaching orthographic projection than those previously used. The new methods that were devised for using the transparent projection box and the uniquely designed overlays may enhance the study's contribution to drafting and industrial arts.

The significance of this study may be seen in that the study provided the students with tangible review materials that are not possible with the present instructional methods. The projectuals were available to the students for individual review and for clarification of points not understood. The transparent projection box was, also, available for students to study in order to better visualize the relationship of projection planes to the problem under study. With these instructional aids available to the students for self-study and exploration, the instructor had more time to help those individuals who did not understand certain principles.

## Description of Instruments

### Unit Tests in Engineering Drawing

The *Unit Tests in Engineering Drawing* (Appendix A, p. 112) were developed by the American Society of Engineering Education and published by The Educational Testing Service. The test battery is designed to measure aptitudes which have been found important for success in engineering. After a close review of the test battery, it was found that only units I, II, and III were related to orthographic projection; therefore, only these three units were administered to the students participating in the study.

The format of each of the units is similar. The question or problem has five possible solutions. The student selects the solution he believes is the most correct and marks the answer on the separate answer sheet that is provided with each test unit.

Unit I, part I, measures the student's ability to identify and locate positions for missing lines. One of the three views is incomplete because of one missing line. The missing line may be visible or invisible and may belong in the front, top, or side view of the object. Five possible positions for the one missing line are indicated in each drawing. The student selects the proper location of the missing line by choosing one of the five indicated positions.

In the second part of unit I, there are five orthographic views of one object. The visible surfaces are indicated by letters. Numbers are used to identify the surfaces where they appear as lines. The student is required to select the numbers which identify the given surfaces in the other views.

Unit II measures the student's ability to visualize visible and invisible surfaces. Statements are given concerning each of the indicated surfaces. The student must study the given views and choose the correct statement.

Unit III measures the student's ability to visualize the correct orthographic views of an object. In the first part of unit III, the student is given a pictorial view of an object and is asked to select the correct orthographic views from six possible choices. In the second part of unit III, the student is given two orthographic views and asked to select the third correct view from six possible choices. In the third part of unit III, the student is given a pictorial view of the object and three different sets of orthographic views. The student is asked to mark the correct response to five statements concerning the orthographic views given.

## Organization of the Dissertation

The body of this study is composed of five chapters. The first chapter identifies the problem and the purposes of the study. In chapter II, a review of research, related literature, and previous studies is presented. Chapter III presents a detailed report of the research design and the practices and procedures employed in conducting the study. Chapter IV includes a presentation of the data obtained in the study and the statistical treatment of the data is presented through the use of tables. Chapter V presents a summary of the study, the findings of the study, and the conclusions and recommendations that were made from an analysis of the findings.

## Value of the Study

Orthographic projection knowledge is considered an essential element in all areas of drafting. Because drafting is an integral part of the high school industrial arts program and the college industrial arts curriculum, this study may contribute to education and industrial arts in the following ways:

1. The information gained through this study could culminate in an effective method of teaching orthographic projection principles.

2. This study should reveal those areas of orthographic projection that can be taught most successfully with overhead projectuals and a transparent projection box.

3. The results of this study may provide information that will influence progressive administrators to consider creation of a visual aids program for industrial arts departments.

4. This study could lead to other research and further contributions to education and industrial arts in that recommendations are made for future study.

## CHAPTER BIBLIOGRAPHY

1. American Society of Engineering Education, Unit Tests in Engineering Drawing, Princeton, New Jersey, The Educational Testing Services, 1948.

2. Brooks, Weston T., "An Experimental Analysis of the Effectiveness of Overhead Transparencies on Learning and Retention (In Selected Units) in Beginning Woodworking," unpublished doctoral dissertation, School of Industrial Education, Texas A & M University, College Station, Texas, 1964.

3. Buh, Joseph F., "A Teacher's Guide for Preparation and Utilization of Selected Overhead Drafting Projectuals," unpublished master's thesis, San Diego State College, San Diego, California, 1966.

4. Chance, Clayton William, "An Evaluation in the Utilization of 200 Colored Transparencies for the Teaching of Engineering Descriptive Geometry," unpublished doctoral dissertation, School of Education, The University of Texas, Austin, Texas, 1963.

5. Draftsman Survey, Industrial Arts and Vocational Education, LIV (May, 1965), 11.

6. Earle, James H., "On Using the Overhead Projector in Drafting," Industrial Arts and Vocational Education, LI (December, 1962), 37-38.

7. Garrett, Henry E., Statistics in Psychology and Education, 3rd ed., New York, Longmans, Green and Co., 1947.

8. Giesecke, Frederick E., Alva Mitchell, and Henry C. Spencer, Technical Drawing, 4th ed., New York, The MacMillan Company, 1964.

9. Glazner, Everett R., "An Experimental Determination of the Value of Selected Visual Aids in Teaching Beginning Mechanical Drawing," unpublished doctoral dissertation, Pennsylvania State University, University Park, Pennsylvania, 1958.

10. Gundry, Russell W., "Teaching the Basic Elements of Industrial Drawing Through the Use of Selected Teacher Made Transparencies," unpublished master's thesis, Chico State College, Chico, California, 1965.

11. Luzadder, W. J., Basic Graphics for Engineers and Technical Students, Englewood Cliffs, Prentice-Hall, Inc., 1962.

12. Schilling, James L., "Orthographic Projection, A Key to Measuring Drafting Achievement," Industrial Arts and Vocational Education, LIV (April, 1965), 39.

13. Stern, William L., Psychology of Early Childhood, New York, Holt and Sons, 1930.

14. Warner, M. E., "Overhead Projector for Teaching Drafting," Industrial Arts and Vocational Education, XLII (December, 1953), 350-353.

15. Wilkes, Doran F., "A Comparison of Two Methods of Teaching Engineering Drawing: Film Slides versus the Conventional Approach," unpublished doctoral dissertation, School of Industrial Education, University of Missouri, Columbia, Missouri, 1964.

16. Yeager, Lowery Dale, "An Experimental Study to Determine the Value of Projectuals in Presenting Selected Units of Basic Electricity," unpublished doctoral dissertation, School of Industrial Education, Texas A & M University, College Station, Texas, 1965.

CHAPTER II

## SURVEY OF RELATED LITERATURE

Visualization is the medium through which shape information on a drawing is translated to give the reader an understanding of the object represented. The ability to visualize is often said to be a "gift" that is innate in some people but not in others. According to Dember (9, pp. 98-102) and El Koussy (13, pp. 4-8), this appears not to be true. Psychology indicates that all people of educable intelligence have a visual memory as can be seen from the ability to recall and describe certain events which have occurred previously (19, pp. 261-268). Stout stated as follows:

> The apprehension of a spacial order in the way of position, distance, direction and shape arises through a progressive union of extensity with motion-experiences and motor-experiences. Thus, human beings have to learn by a gradual process to discern shape, situation, distance, etc., of objects (46, p. 475).

McDougall maintains a similar point of view in that he states:

> The acceptable theory of spatial perception must be nativistic and of the psychic stimulus type, that is to say; (1) It must recognize that spatial perception is an extremely complex function, the capacity for which is not built by each of us de novo, but is laid down in our innate constitution, its spontaneous development during the life of the individual being promoted and furthered by exercise: (2) It must admit that

> their position, distance, size, shape and pattern, is achieved only by a mental activity, to which the sense stimulations and qualities of sensory experience that immediately follow upon them are but the provocations (29, p. 245).

Stern stated that by the end of the first year the child tends to have the spadework in the mastery of space accomplished, in short, "he has roughly a perception of space which certainly is capable of many misconceptions and will need in years to come to be refined, and made clearer and developed" (45, p. 124).

A drawing is made by visualizing units or shapes, one at a time, and mentally orienting and combining these details to interpret the whole object (16, p. 120). The form taken in this visualization may not be the same for all people. The ability to visualize a shape in a drawing is almost completely governed by a person's knowledge of the principles of orthographic projection (16, p. 93). The common adage that "the best way to learn to read a drawing is to learn to make one" appears to be correct, because in learning to make a drawing a person is forced to study and apply the principles of orthographic projection (16, p. 119).

Schamehorn (34) studied the opinions of educators and engineers on the importance of engineering graphics topics. He surveyed practicing engineers, engineering graphics instructors, and engineering instructors to determine what engineering drafting topics are the most important to the beginning engineer. The practicing engineers stated that the beginning course in engineering drawing is the most important of the six primary areas of study. These same engineers indicated that the most important areas of this basic course are size representation (dimensions) and orthographic projection. Working drawings are considered important to these engineers, while the area of pictorial drawing is considered to be of limited importance.

The engineering graphics educators have stressed the importance of four basic skills. They have indicated that orthographic projection is by far the most important skill followed by surface visualization, size representation, and techniques. The area of working drawings was considered to be of limited importance.

The engineering educators from engineering degree granting institutes considered orthographic projection and basic skills to be the most important areas of drafting. These same educators considered surface and pictorial drawings to be of limited importance, while working drawings and size representation are of small importance.

Schamehorn concluded that orthographic projection is the core of drafting and visualization. However, one of the primary problems of teaching drafting is how to convey the concepts of orthographic projection to the student. There are many methods of teaching orthographic projection, but there is no one method that the leading educators in engineering will agree as being the best method.

and inquiry when decisions are to be made regarding content, methods, and equipment to be utilized in the drafting classroom.

## Methods of Teaching Industrial Arts Drafting

Spence (43) categorized all the known research completed in industrial arts between the years 1892-1933 and 1933-1961. The findings indicated that between the years 1892-1933 drafting was the most researched area of industrial arts. Between the years 1933-1961 the amount of research completed in the area of drafting, as compared to the total research in industrial arts, had declined and ranked fourth. The majority of this early research was directed toward comparing methods of teaching. Spence's research prompted him to conclude that "future research should be oriented toward the technical aspects of industrial arts rather than toward teaching methods" (43, p. 58). However, most of the research that has been reported since Spence's recommendations were made has continued to be directed toward the method aspects.

Several studies have been conducted to determine which method of instruction employed by the teacher is the most effective in presenting orthographic projection. However, most of these studies are outdated and need restudy. Arthur Twogood (56), 1931, Edwin Digby (10), 1933, and Edwin Shoemaker (40), 1939, were some of the earlier researchers in the methods of teaching drafting.

McSpadden (30), 1950, investigated the relative effectiveness of two methods of teaching mechanical drawing. The sample was divided into two groups. The control group was taught by using problem workbooks, while the experimental group was taught by using model blocks. McSpadden concluded that neither method was superior to the other for teaching seventh grade mechanical drawing. However, the students taught through the use of model blocks achieved more in visualization than the students taught by using the problem workbooks.

Helper (20), 1957, conducted an experimental study to determine the relative effectiveness of teaching orthographic projection followed by pictorial representation as compared with teaching pictorial representation followed by orthographic projection.

In his conclusions, Helper stated that teaching orthographic projection followed by pictorial representation appears superior to or more effective than teaching pictorial representation followed by orthographic projection in the development of informational achievement, drawing skills, and ability to visualize.

In a similar study in 1960, Hoskins (22) studied the effect of teaching multi-view drawings with pictorial sketching being the experimental variable. The purpose of the study was to determine if previous knowledge of pictorial drawing has any effect on the acquisition of knowledge related to multi-view drawings. The findings indicated that students who had some knowledge of pictorial sketching showed greater growth in multi-view drawing than those students who did not have knowledge of pictorial sketching. These findings were in direct contrast to the conclusions drawn by Helper in his 1957 study. Further investigation of pictorial drawings and orthographic projection was done by Fonesca.

Fonesca (15), 1963, developed an experimental investigation to determine the relative effectiveness of two methods of teaching grade nine drafting. The two groups were studied with particular reference to (a) the student's ability to express himself through the use of orthographic projection and pictorial drawing, and (b) his ability to read mechanical drawings.

The control group was taught to work from prepared drawings and to use instruments while the experimental group was taught to work from models and to use the sketch method.

The primary conclusion drawn from this study was that those students in the experimental group were superior to the control group at the .05 level of significance in ability to read mechanical drawings and to express themselves through the use of orthographic projection and pictorial drawing.

Rowlett (33), 1960, conducted an experimental comparison of direct detailed and direct discovery methods of teaching orthographic projection principles and skills. The directed "hints" was contrasted with a direct detailed procedure involving highly specific instructions. The purpose of Rowlett's study was to test the effectiveness of the two methods of instruction as measured by (a) initial learning, (b) retention, and (c) transfer.

Orthographic projection principles and skills were used as the learning task. These principles were illustrated and applied as the subjects studied the three-dimensional objects provided them and as they solved the problems in their workbooks.

Rowlett concluded that there was no significance of difference between the direct detailed and the directed discovery methods in regard to initial learning of orthographic projection principles. However, the direct discovery method appears to be superior to the direct detailed method in regard to retention and transfer of orthographic projection principles and skills.

In a similar experimental study Suess (48), 1962, studied the effectiveness of varying degrees of manipulation on the direct discovery method of presenting principles of orthographic projection. The primary purpose of the study was to secure evidence on the type and sequence of manipulation in the directed discovery method of teaching orthographic projection. A secondary purpose of the study was to replicate the experimental directed discovery method developed by Rowlett in 1960 at the University of Illinois, Urbana.

The method and content of the instructional material were identical in all groups with the order and amount of manipulation varied. Manipulation was varied in two ways. Groups II and III utilized three scale model blocks with the first three workbook problems. Subjects in groups I and IV were not provided scale models for the same problems but were urged to "visualize" pictorial drawings of the objects. The remaining problems in the workbook were keyed to the principles taught in the first three problems.

A treatment-X-level analysis of variance was used to test the research hypotheses. Suess concluded from the data there was nonsignificant difference in achievement between the treatment groups on a test of initial learning or a test of retention. There was nonsignificant difference in achievement between the treatment groups on tests of initial transfer or retention transfer.

In a 1964 study conducted by Sullivan (49), the effectiveness of two methods of teaching orthographic projection in terms of retention and transfer was studied. The purpose of the experimental study was to determine the effectiveness of the traditional method utilizing instruction in orthographic projection followed by isometric drawing as compared with the experimental method of "Eckhard Axonometry." The experimental method utilized isometric problems correlated with three multi-view projections. The methods, media, and content of instruction, with the exception of the projective system, were the same for both groups.

Sullivan's conclusion was that the "Eckhard Axonometry" appeared to be more effective in terms of initial learning and retention. The study indicated that the experimental group of students could transfer to another system of drawing with greater ease than could those students in the traditional method. Also, the experimental group of students understood the principles of orthographic projection better than the control group of students.

In 1966, Ellis (14) conducted a study to compare the effectiveness of the construction method of teaching drafting with the workbook method of teaching drafting. The study involved a rotation group type of experiment with the method of teaching drawing being the experimental variable.

The primary conclusions drawn by Ellis in his study were that the construction method and the workbook method are equally effective in regard to the students' informational achievement and the two methods are equally effective in regard to the students' understanding of spatial relationships. However, it appears that the workbook method is somewhat more effective than the construction method with respect to the development of drafting skills.

Wilkes (59), 1966, conducted a study to compare the effectiveness of two methods of teaching engineering drawing. The two methods utilized in the study were film slides and the conventional method. Film slides were used in the study to present instruction to the experimental group, while the control group was taught by the conventional approach of sketching on the chalkboard. Students were individually matched and assigned to groups by randomization.

When the two groups were administered the post-test, the achievement level of the experimental group was significantly greater than the achievement level of the control group. The experimental group also ranked ahead of the control group on the visualization test. In both instances, the difference in the amount of achievement between the two groups was significant beyond the .01 level. The quality of work completed by the experimental group was significant at the .01 level above the control group. However, there was nonsignificant difference in the amount of work completed by the two groups.

From the gathered data, Wilkes drew the following conclusions:

> 1. The teaching of engineering drawing using the comprehensive film slides appears to be a more effective means of teaching than the conventional chalkboard approach in terms of instructional information, ability to visualize, quality of work completed, student attitude, and time required for presenting instructional information.
> 2. The two approaches appear to be equally effective in terms of quantity of work completed by the students (59, p. 205).

Bjorkquist (2) in 1965 studied the discrimination transfer from scale models orthographic projection. The primary purpose of his study was to determine the relative effectiveness of scale models and pictorial drawings in helping beginning students learn principles of orthographic projection.

The study was conducted with subjects under three experimental treatments in a learning situation followed by a transfer task which was the same for all subjects. Models, pictorial drawings, and no aid treatments were used in the learning task. Subjects in the model group were shown a full size model of the object involved in each problem. Isometric drawings were shown with the problem in the pictorial drawing group, while the no aid group solved the problems without the use of visual aids. In both the learning and transfer task the number of responses required by the subjects to complete the task was recorded. Two way analysis of variance was used to test the effects of the treatments.

In the learning and transfer task the achievement of the pictorial drawing group was greater than the model group's and the difference was significant at the .01 level. The achievement of the model group in both the learning and transfer task was greater than the no aid group's and the difference was significant at the .01 level. It was concluded that pictorial drawings appear to be more effective than scale models and no aids in helping beginning students

Schilling (35) stated that research should determine which method of instruction employed by the teacher best illustrates to the student the principles of orthographic projection and whether certain visual aids actually aid in the learning of drawing skills.

Visual Aids in Teaching Industrial Arts

The past decade of rapid technological advancement has provided a vast array of instructional teaching media. A review of professional literature indicated that for a period of time there has been a demand for research in all teaching fields to determine better methods of teaching. In response to this demand there has been an increasing number of research studies undertaken in all teaching areas. An increasing number of these recent studies reflect a growing interest in the use of visual aids in industrial arts.

Industrial arts has perhaps the greatest wealth of illustrative material directly applicable to visual aids because of the many sequences and step-by-step procedures utilized in the learning process. Unfortunately, not all areas of industrial arts have utilized the materials and visual equipment that are available to them.

Glazner (18) completed a study in 1958 that emphasized the value of visual aids in teaching industrial arts drafting. Reported in the section entitled "Conclusions" was the following:

1. Certain results tend to support the hypotheses that the achievement of students in selected units of beginning mechanical drawing is greater when selected visual aids are utilized in addition to traditional methods.
2. There appears to be more interest, more attention, more general comprehension and understanding, less noise and more participation and motivation by students in the experimental group than in the control group (18, p. 129).

Glazner's conclusions prompted study in other areas of industrial arts to determine the effectiveness of specific visual aids.

In the past five years more interest has been directed toward the overhead projector than any other of the numerous visual aids available to educators. However, experimental research in industrial arts on the use of the overhead projector in the teaching of drafting has not been formalized even though there are four major companies producing commercial transparencies for use in the area of drafting.

One of the more important requirements for student success in the industrial arts curriculum is the ability to identify materials of industry. Trautwein (53) used the overhead projector in 1962 to conduct an experimental study to compare three methods of testing the student's recognition of industrial materials. The "traditional" method placed numbered samples about the laboratory and asked for individual identification of each material. The response was recorded on a checklist provided for the test. Students using the "traditional" method could make use of all five senses in their attempt to identify the numbered sample. A second method, referred to as the "museum" method, involved using sight alone in the attempt to identify the sample. The third method, referred to as the "stereo" method, consisted of a three-dimensional color transparency viewing system. The system made use of sight but in combination with a photographic representation rather than with the real material.

Each of 300 college students took the three tests in varying order or sequences as determined by random selection. Since identification ability was being tested students marked only those materials they felt they knew positively. Thus, the scores on each test represented the individual's ability to identify by each of the three methods.

The F-test and the t test indicated that all methods tested differed significantly at the .05 level. The findings indicated that the traditional method was superior, the museum method was not as effective as the traditional method, and the three-dimensional transparency system (stereo) was considerably inferior.

Chance (7), 1963, evaluated the effectiveness of 200 colored transparencies for the teaching of engineering descriptive geometry. In the findings, using a 100-point grading system, the grade average of the experimental group was 4.4 points higher than the control group. Students repredominant in the experimental group, while 75 per cent of the students receiving a semester grade of "F" were in the control group. In Chance's findings he stated that the experimental group was superior in that

1. Formal lecture time was reduced by 20 per cent in the experimental group.
2. The experimental method allowed a more professional appearance in lectures and demonstrations.
3. The experimental method was advantageous because it (1) allowed a larger viewing image (2) had addition of colors (3) student attention improved (4) allowed time for more student questions and (5) was easily reviewed by turning the overlays (7, p. 84).

Brooks (3), 1964, tested the effectiveness of overhead transparencies on learning and retention of selected units in beginning woodworking. The five most difficult instructional areas of beginning woodworking were selected by a panel of jurors. Those units rated most difficult to teach were (a) elements of design, (b) plan of procedure, (c) bill of material, (d) joints, and (3) measuring. A comprehensive test was developed to be used as a pre- and post-experimental test while five short tests consisting of matching or five-response multiple choice type questions were designed to be administered at the conclusion of the appropriate unit. Each of the tests was validated by the panel of jurors. When the validity was established, reliability coefficients were determined on each test.

Identical procedures were used for both experimental and control groups with the exception of instruction being supplemented with overhead projectuals in the experimental classes. A total of 2,240 samples was taken from the 320 students used in the study. Factor analysis of variance was used in arriving at the conclusions.

There were several significant conclusions drawn from the analysis of the data. Brooks stated from the findings that

1. The statistical analysis in the investigation supports the hypothesis that achievement of students in selected units of woodworking is significantly greater when special overhead transparencies are used to supplement conventional methods of instruction.
2. The experimental groups' overall retention of the selected units was significantly greater than that of the control groups.
3. Teachers favored overhead transparencies because of increased student interest, logical presentation of materials, reduced lecture time and favorable review techniques (3, p. 178).

In a similar study in 1965, Yeager (61) studied the value of projectuals in teaching selected units of basic electricity. The purpose of this investigation was to determine the effectiveness of an experimental method used in teaching electricity, whereby the normal teaching time was reduced by one-third. Compared to control methods of lecture, discussion, and demonstration, the experimental method included the aforementioned, supplemented with projectuals. The basic objective was to determine the effectiveness of projectuals upon increasing initial learning, increasing overall retention, and facilitating review procedures.

Yeager, in his findings, stated the following:

> 1. As compared to teaching time required by control methods of lecture, discussion and demonstration, teaching time required by the same items supplemented with projectuals can be successfully reduced by one third; whereas, resulting initial learning and overall retention are equal between methods.
> 2. Final test scores indicate not only that review time for such tests can be favorably reduced by one third; the experimental method is superior to the control method at the 0.01 level of confidence is also indicated (61, p. 110).

Gallentine (17) conducted a similar study in 1965 on the effects of overhead projection on achievement in the biological sciences. The two-part study attempted to evaluate the effectiveness of instruction utilizing the overhead projector in college science classes. The study included large lecture groups and small laboratory groups.

The first part of the study was conducted with large lecture groups in general botany. The conventional method was used in the fall semester of 1963, while the experimental method was used in the fall semester of 1964. Both conventional and experimental methods involved fifty-minute lectures and were taught by the same instructor, in the same classroom, and at the same hour of the day. The instructional period for both groups was four weeks. The conventional group had lectures illustrated by the use of chalkboard drawings while the experimental group had the same lecture content illustrated by the use of overhead projectuals. As a result of a 2 x 3 factor analysis of variance, it was concluded there was no significance of difference between the conventional and experimental groups at the .05 level of confidence.

The second part of the study evaluated the effectiveness of overhead projection in small classes of students enrolled in embryology laboratory sections. The students in the laboratories were taught in the same manner except the conventional method used the chalkboard for illustrations, while the experimental group used the overhead projectuals.

It was concluded from the analysis of data that there was nonsignificant difference between the conventional and experimental groups. The results, although not significant, indicated that the experimental method of instruction may increase the students' ability to think critically as compared to the conventional method.

A review of the *Dissertation Abstracts* (57), the *Phi Delta Kappan* (12), and the leading industrial arts research magazines, *Abstracts of Research and Related Materials in Vocational and Technical Education* (50, 51, 52), and *Review and Synthesis of Research in Industrial Arts Education* (25, 47, 54) indicate there has not been any reported research in drafting since 1966.

In summary, the research of literature and studies indicate there are numerous methods used in teaching orthographic projection but none of concerning which instructional method is the best. The overhead projector has proven beneficial in many areas of instruction but the projector's effectiveness has yet to be tested in the area of drafting instruction.

## CHAPTER BIBLIOGRAPHY


1. Barrett, L. S., "To Determine the Relationship Between Visual Imagery, Drafting Achievement and Mechanical Aptitude," unpublished master's thesis, North Texas State University, Denton, Texas, 1948.

2. Bjorkquist, David Carl, "Discrimination Transfer from Scale Models and Pictorial Drawings in Learning Orthographic Projection," unpublished doctoral dissertation, University of Minnesota, Minneapolis, Minnesota, 1965.

3. Brooks, Weston T., "An Experimental Analysis of the Effectiveness of Overhead Transparencies on Learning and Retention (In Selected Units) in Beginning Woodworking," The TIAA Bulletin, XI (February, 1967), 5.

4. __________________, "An Experimental Analysis of the Effectiveness of Overhead Transparencies on Learning and Retention (In Selected Units) in Beginning Woodworking," unpublished doctoral dissertation, Texas A & M University, College Station, Texas, 1964.

5. Burnett, Gilbert W., "A Study of Teaching Basic Electricity," unpublished master's thesis, Kansas State College of Pittsburg, 1965.

6. Carnevale, Daniel J., "The Overhead Projector and Drawing Instruction," School Shop, XXV (October, 1965), 49.

7. Chance, Clayton William, "An Evaluation in the Utilization of 200 Colored Transparencies for the Teaching of Engineering Descriptive Geometry," unpublished doctoral dissertation, School of Education, The University of Texas, Austin, Texas, 1963.

8. Christal, Raymond E., Factor Analytic Study of Visual Memory, New York, The American Psychological Association, Inc., 1958.

9. Dember, William N., Visual Perception, New York, John Wiley & Sons, Inc., 1964.

10. Digby, Edwin E., "A Comparative Study of Two Methods of Teaching Mechanical Drawing," unpublished master's thesis, Ohio State University, Columbus, Ohio, 1933.

11. Earle, James H., "On Using the Overhead Projector in Drafting," Industrial Arts and Vocational Education, LI (December, 1962), 37-38.

12. Elam, Stanley, editor, Research Studies in Education, Bloomington, Illinois, Phi Delta Kappa, 1950-1968.

13. El Koussy, A. A., The Visual Perception of Space, London, Cambridge University Press, 1935.

14. Ellis, Neil Gilbert, "An Experimental Comparison of the Construction Method and the Workbook Method of Teaching Drafting," unpublished doctoral dissertation, University of Missouri, Columbia, Missouri, 1966.

15. Fonseca, Benjamin G., "An Experimental Investigation to Determine the Relative Effectiveness of Two Different Methods of Teaching Grade Nine Drafting," unpublished master's thesis, Western Washington State College, Bellingham, Washington, 1963.

16. French, Thomas E. and Charles J. Vierck, Engineering Drawing, New York, McGraw-Hill Book Company, Inc., 1960.

17. Gallentine, Jerry Lynn, "The Effects of Overhead Projection on Achievement in the Biological Sciences at the College Level," unpublished doctoral dissertation, University of Toledo, Toledo, Ohio, 1965.

18. Glazner, Everett R., "An Experimental Determination of the Value of Selected Visual Aids in Teaching Beginning Mechanical Drawing," unpublished doctoral dissertation, Pennsylvania State University, University Park, Pennsylvania, 1958.

19. Guilford, J. P., "Printed Classification Test," AAF Aviation Psychological Report, Washington, D.C., U.S. Government Printing Office, 1947.

20. Helper, Earl, "Order of Presenting Orthographic Projection and Pictorial Representation and Its Effect on Achievement in Engineering Drawing," unpublished doctoral dissertation, School of Education, University of Missouri, Columbia, Missouri, 1957.

21. Horton, Bolin E., "Order of Presenting Orthographic Projection and Its Effect on Achievement in Mechanical Drawing," unpublished master's thesis, Kansas State College of Pittsburg, 1964.

22. Hoskins, Richard Harwood, "The Teaching of Multiview Drawing with Pictorial Sketching as the Experimental Variable," unpublished master's thesis, The Ohio State University, Columbus, Ohio, 1960.

23. Johnson, William R., "A Comparative Study of Two Methods of Teaching Tool Bit Grinding," unpublished master's thesis, Chicago Teachers College, Chicago, 1962.

24. Lantz, John D., "Making Transparent Overlays in the Drafting Classroom," Industrial Arts and Vocational Education, LIV (February, 1965), 34-35.

25. Larson, Milton E., Review and Synthesis of Research in Technical Education, Columbus, The Ohio State University Press, 1966.

26. Lawver, Earl A., "A Study of Two Established Methods of Teaching Mechanical Drawing," unpublished master's thesis, Colorado Agricultural and Mechanical College, Greeley, Colorado, 1936.

27. Levens, A. S., Graphics, New York, John Wiley and Sons, Inc., 1962.

28. Luzadder, W. J., Basic Graphics for Engineers and Technical Students, Englewood Cliffs, Prentice-Hall, Inc., 1962.

29. McDougall, W., An Outline of Psychology, London, Cambridge University Press, 1935.

30. McSpadden, C. B., "An Experimental Investigation of the Relative Effectiveness of Two Methods of Teaching Mechanical Drawing," unpublished master's thesis, North Texas State University, Denton, Texas, 1950.

31. Mitchell, D. R., "The Design, Construction, and Use of Projection Box to be Used in Teaching a Course in Descriptive Geometry," unpublished master's thesis, Department of Industrial Arts, North Texas State University, Denton, Texas, 1963.

32. Parkinson, John Robert, "A Comparison of Student Performance in Tasks Involving Familiar and Unfamiliar Material when Viewed Under Varying Conditions of Projected and Ambient Light Combinations," unpublished doctoral dissertation, Syracuse University, Syracuse, New York, 1966.

33. Rowlett, John D., "An Experimental Comparison of Direct-Detailed and Directed Discovery Methods of Teaching Orthographic Projection Principles and Skills," unpublished doctoral dissertation, University of Illinois, Urbana, Illinois, 1960.

34. Schamehorn, Ernest C., "Opinions of Educators and Engineers on the Importance of Engineering Graphic Topics," unpublished doctoral dissertation, Western Reserve University, Cleveland, Ohio, 1965.

35. Schilling, James L., "Orthographic Projection, A Key to Measuring Drafting Achievement," Industrial Arts and Vocational Education, LIV (April, 1965), 39.

36. Schramm, Howard R., "Helpful Teaching Aids for Industrial Education," Industrial Arts and Vocational Education, XLIII (October, 1954), 277.

37. Schwartz, Gilbert, "Making and Using--Overhead Projector Materials in Drafting," Industrial Arts and Vocational Education, LIII (December, 1954), 44, 45, and 60.

38. ________________, "Using the Overhead Projector to Teach Technical Drawing," Industrial Arts and Vocational Education, LIV (December, 1965), 24-26.

39. Shavlis, Wayne R., "Relative Effectiveness of the Order of Presenting Pictorial Representation and Multiview Projection in Beginning Engineering Drawing," unpublished master's thesis, California State College, California, Pennsylvania, 1965.

40. Shoemaker, Edwin Allen, "A Comparative Study of Two Methods of Teaching Drawing (Guide Sheet Method Versus Oral Method)," unpublished master's thesis, Ohio State University, Columbus, Ohio, 1939.

41. Silvey, H. M., editor, Master's Thesis in Education, Cedar Falls, Research Publications, 1950-1968.

42. Snyder, Burton K., "The Education of Draftsmen for the Space Age," The Journal of Industrial Arts Education, XXIII (January-February, 1964), 37.

43. Spence, William P., "Research in Industrial Education: A Look at the Past," Industrial Arts and Vocational Education, LIII (December, 1964), 56-58.

44. Springer, R. D., L. G. Palmer, W. A. Kleinhenz, and P. W. Bullen, Basic Graphics, Boston, Allyn and Bacon, Inc., 1963.

45. Stern, William L., Psychology of Early Childhood, New York, Holt and Sons, 1930.

46. Stout, G. F., Manual of Psychology, Cambridge, The University Press, 1932.

47. Streichler, Jerry, Review and Synthesis of Research in Industrial Arts Education, Columbus, Ohio, The Ohio State University Press, 1966.

48. Suess, Alan Roman, "An Experimental Study Comparing the Effectiveness of Varying Degrees of Manipulation on the Directed Discovery Method of Presenting Principles of Orthographic Projection," unpublished doctoral dissertation, University of Illinois, Urbana, Illinois, 1962.

49. Sullivan, Frank Victor, "An Experimental Study of the Effectiveness of Two Methods of Teaching Orthographic Projection in Terms of Retention and Transfer," unpublished doctoral dissertation, School of Education, University of Illinois, Urbana, Illinois, 1964.

50. Taylor, Robert E., director, Abstracts of Research and Related Materials in Vocational and Technical Education, Columbus, The Ohio State University Press, Fall, 1967.

51. ________________, director, Abstracts of Research and Related Materials in Vocational and Technical Education, Columbus, The Ohio State University Press, Winter, 1967.

52. ________________, director, Abstracts of Research and Related Materials in Vocational and Technical Education, Columbus, The Ohio State University Press, Summer, 1968.

53. Trautwein, Calvin Leroy, "An Experimental Comparison of Three Methods Used to Identify Industrial Materials," unpublished doctoral dissertation, Colorado State College, Greeley, Colorado, 1962.

54. Tuckman, Bruce W. and Carl J. Schaefer, Review and Synthesis of Research in Trade and Industrial Education, Columbus, The Ohio State University Press, 1966.

55. Turner, William W., Carson P. Buck, and Hugh P. Ackert, Basic Engineering Drawing, New York, Ronald Press Company, 1950.

56. Twogood, Arthur P., "Teaching Fundamentals of Mechanical Drawing to Beginners by Means of Film Slides," unpublished master's thesis, Iowa State University, Iowa City, Iowa, 1931.

57. University Microfilms, Dissertation Abstracts, Ann Arbor, University Microfilms, 1950-1968.

58. Warner, M. E., "Overhead Projectors for Teaching Drafting," Industrial Arts and Vocational Education, XLII (December, 1953), 350-353.

59. Wilkes, Doran F., "A Comparison of Two Methods of Teaching Engineering Drawing: Film Slides Versus the Conventional Approach," unpublished doctoral dissertation, School of Industrial Education, University of Missouri, Columbia, Missouri, 1964.

60. Williamson, Scott, "Using Colors to Teach Drafting," Industrial Arts and Vocational Education, XLV (April, 1956), 136-137.

61. Yeager, Lowery Dale, "An Experimental Study to Determine the Value of Projectuals in Presenting Selected Units of Basic Electricity," unpublished doctoral dissertation, School of Industrial Education, Texas A & M University, College Station, Texas, 1965.

# CHAPTER III

## METHODS AND PROCEDURES

The methods and procedures employed for the purpose of testing the research hypotheses of the study necessitated two major considerations. The first major consideration was the development of the instructional design. The second major consideration was the development of the experimental design.

### Instructional Design

In the development of the instructional design, several important factors were considered. These factors were the (a) development and design of the instruction period, (b) development of the lesson plans, (c) development of the overhead projectuals and the transparent projection box, and (d) application of the two teaching aids used in combination for teaching orthographic projection.

### Instructional Period

In the study the effectiveness of a teaching method was under scrutiny. The length of the instructional period was not being tested but was very crucial to the study. In order to evaluate method A and method B in relation to time used for class lectures and demonstrations, each presentation was scheduled on a time basis. The time schedule is presented in Figure 1.

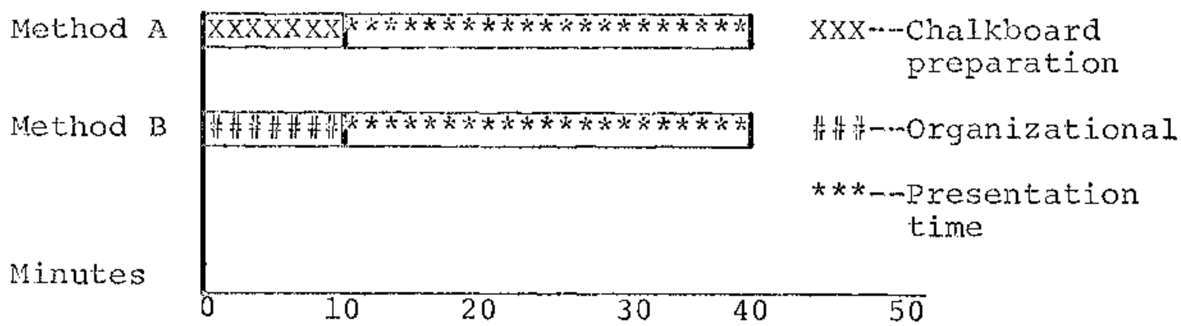


Fig. 1--Time schedule for instructional design

Figure 1 shows that the control group taught by method A was presented material that was scheduled to consume a maximum of forty minutes. This amount of time was chosen because the instructors in the control group were required to draw the example problems on the chalkboard. Each problem had to be of correct proportion and drawn in a correct procedure. The chalkboard drafting machine was utilized to meet these requirements. It was arbitrarily decided that ten minutes would be consumed by the instructor when drawing the problems on the chalkboard.

The ten minutes that were consumed in drawing the problems on the chalkboard were scheduled at the beginning of the class period. During this time, the students prepared for the day's assignment or finished any previous assignment. The final thirty minutes of the instructional period were devoted to actual presentation of the lesson.

The experimental group taught by method B was scheduled to be presented material for a maximum of thirty minutes. This block of time was a 25 per cent reduction when compared to the method A or controlled instruction time. The first ten minutes of the class period were spent checking the class roll, making assignments, or in other routine work. The following thirty minutes were scheduled as the presentation period. This schedule enabled the thirty-minute experimental presentation time to correspond with the thirty-minute control presentation time.

This procedure was chosen to eliminate the ten additional minutes the experimental group could utilize during the laboratory period. Through the use of this design both experimental and control sections completed the assigned presentation at approximately the same time. This gave both groups approximately the same amount of laboratory time to translate the observed principles of orthographic projection in solving the related assignments in their workbooks.

Each presentation and demonstration was not scheduled to consume the maximum time allotted for instruction. The amount of instruction time varied in regard to the principles and practices taught in the planned lesson. The same ratio of instruction time prevailed between the two groups in that the experimental, or method B, was shorter by 25 per cent. However, the actual presentation time for both groups was scheduled to begin and conclude simultaneously.

Each instructor involved in the study was provided lesson plans which were identical with the exception of the amount of time utilized in drawing the problems on the chalkboard. In order to insure correct length of presentation time each instructor utilized a timer clock. It was recognized that the time used in each presentation would not be concluded simultaneously but with the aid of the timer clock the variation of time was held to a minimum.

## Development of Lesson Plans

Lesson plans (Appendix B, pp. 125-172) were constructed to control information presented to the control and experimental groups. They also directed the use of the overhead projectuals and the transparent projection box. The lesson plans were developed from the course outline used in Industrial Arts 128.

After the lesson plans were written, they were submitted to a jury composed of three regular staff members teaching in the area of drawing at North Texas State University, Denton, Texas. The jury evaluated the lesson plans for course content and the validity of the content. The lesson plans that were judged to be incomplete or invalid were rewritten and returned to the jury for another evaluation. This procedure was followed until all eleven lesson plans were approved for this study.

The lesson plans were identical for both the control and the experimental groups, with the exception of the notation as to when the supplementary visual aids were to be presented to the experimental group. When the use of a projectual or the projection box was recommended within a lesson plan, the word "overlay" or "projection box" appeared and was enclosed in parentheses. Each of the thirty-five overlays was numbered in succession, beginning with the first overlay utilized in the first lesson. The overlays required for each lesson were identified in the lesson plans by a corresponding number. This procedure was followed to differentiate the visual aid from the main body of the lesson plan.

## Development of the Overhead Projectuals and the Transparent Projection Box

The pre-developed lesson plans were studied to determine those areas of orthographic projection that could be best presented by employing an overhead projectual. It was determined that thirty-five projectuals could be included in the lesson plans to supplement instruction. Each projectual frame was numbered to provide easy organizational procedures with reference to the lesson plans. Fourteen of the projectuals were single film transparencies, while the remaining twenty-one projectuals were characterized by one or more overlays. The overlays were designed to as to involve successive steps to either build a concept or analyze a concept through problem solving.

Commercially prepared transparencies may be purchased from several leading distributors of industrial arts and educational teaching media (Appendix C, pp. 173-175). From a close analysis of the leading sets of engineering drawing transparencies, it was determined that none of the projectual sets utilized the reference plane method of teaching orthographic projection. However, the set of transparencies developed by Keuffel and Esser Company, Hoboken, New Jersey, appeared to present the best problems for teaching orthographic projection. The set of transparencies contained nineteen frames related to orthographic projection, of which sixteen were chosen to be used in the study. To meet the requirements of the lesson plans, the commercially developed transparencies had to be revised. The manufacturer stated, "the use of the overlay with the projection lines is optional since some teachers may prefer to use dividers or transparent scales to indicate the transference of depth dimensions" (4). Each of the selected transparencies was revised by removing the forty-five degree projection film and inserting a film utilizing the reference plane method of projection. The new film contained two reference plane lines which represented the edge view of the plane necessary to complete an orthographic drawing. The Keuffel and Esser transparency film number 125 was used for the inserted film on each commercially prepared set of overlays.

The beginning segment of plane representation was not illustrated in any of the commercially prepared projectuals. In order to illustrate this important segment of drawing, original projectuals had to be developed. Drafting textbooks and other commercial materials were surveyed to determine how authorities in the area of drafting illustrate these concepts. Nineteen original overlays were developed to illustrate those concepts identified in the survey. The original overlays were presented for evaluation to the same jury which evaluated the lesson plans. The projectuals that were of questionable validity were revised until all nineteen projectuals were approved.

The original projectuals were assembled and utilized color film because "there is an advantage, in some cases, in using different colors for different parts of the drawing" (8, p. 353). All of the original projectuals were developed on Thermo-Fax color film number 888. In the original projectuals, the frontal plane was represented by a red color, the horizontal plane by a yellow color, and the profile plane by a blue color. The utilization of different colors to represent each plane enabled the students to visualize the relationship of each plane to the orthographic view. The complete orthographic view was in one color which differed from the colors used to represent the projection planes.

The comparable parts of the problem presented on the chalkboard in the control group were illustrated with colored chalk that corresponded to the colors utilized on the projectuals and the projection box.

The transparent projection box has been used for several years to aid in the development of visualization of abstract principles. However, the construction of most projection boxes has limited the number of principles that can be successfully illustrated. The projection box designed and built by most instructors has the object image painted or taped on the reference planes. This feature limits the instructor to the utilization of only one particular block in the projection box.

The projection box utilized in this study had several original features which were incorporated solely for this study. The projection box was designed in such a manner as to enable a wide variety of block models to be studied. The thirty-five overhead projectuals and the projection box were used in combination to teach the same principles of orthographic projection. To enable the projection box to illustrate the same number of principles as were illustrated in the projectuals, eleven wooden blocks were constructed: one block for each problem presented in the projectuals. Each model block was painted a color that was in contrast with the three colors used to represent projection planes on the projectuals and the projection box. The blocks were painted different colors because "various colors can be used for emphasis" (7, p. 277).

Instead of painting or taping the model image on the projection box, a set of three full-scale orthographic views was developed for each of the eleven wooden blocks. Each orthographic view in the eleven sets was developed on a five and one-half by eight and one-half inch clear transparency film. The film used was Thermo-Fax 125. The black line transparencies of the three views were inserted into the clear plastic pockets that were provided on each plane of the projection box. This procedure enabled the projection box to be as versatile as the thirty-five projectuals. Whenever the model block was changed in the projection box, the model image was changed on the projection planes by removing the preceding image film and inserting the film which illustrated the image of the new block. This method of presentation enabled each block in the study to be presented in the projection box with the correct image being shown on the projection planes.

The edges of the clear plexiglass projection planes on the projection box were covered with colored plastic tape. The edges of the frontal plane were covered with red tape, the horizontal plane edges with yellow tape, and the profile plane edges with blue tape. The color of each projection plane was the same color as the film used to represent that plane on the overhead projectuals. The colors enabled the student to associate each plane on the three-dimensional transparent projection box with the planes on the two-dimensional overhead projectuals.

To enable each student to view the projection box perpendicularly, a swivel caster was attached to the bottom of the base. The swivel base allowed the instructor to revolve the projection box, and thus give each student a clear view of the projection planes.

### Use of the Overhead Projectuals and the Transparent Projection Box

The methodology for presenting technical information in this study was developed from an analysis of the lesson plans. Each participating instructor presented information following the guideline prescribed in the lesson plans. The lesson plans were identical for both the control and the experimental groups with the exception of the notation as to when the supplementary visual aids were to be presented to the experimental group.

The overhead projectuals and the transparent projection box were used in a combination to form one basic instructional medium. The overhead projectuals were used to illustrate the two-dimenstional method of making an orthographic drawing, while the transparent projection box was used to illustrate three-dimensional abstract principles.

The overhead projectuals, projection box, model block, and projection box transparencies were assembled before the students arrived for class. The model block was placed inside the projection box and the correct projection plane transparencies were inserted into the plastic pockets on the projection planes. When these materials were inserted, the projection box was equipped to demonstrate the same principles as the overhead projectuals. When the projection box was prepared, it was covered with a cloth to eliminate any distraction of the students' attention during the presentation of the overhead projectuals.

The overhead projectuals were used to introduce the problem being studied. The projectuals were a two-dimensional description of how to obtain measurements from reference planes. Through the use of the problem illustrated on the projectuals, the instructor taught the principles of projection by using dividers to measure from the reference plane to the object line. In this method, students were taught the abstract principles of reference planes and orthographic projection. At the conclusion of the demonstration involving the projectuals, the transparent projection box was uncovered and used to illustrate in a three-dimensional review the procedure involved in solving the problem.

The edges of the three projection planes on the projection box corresponded in color to the reference planes on the overhead projectuals. This enabled the student to relate the principles of the projection box to the problem that was presented abstractly in the overhead projectuals. The projection box illustrated how the problem block was positioned in regard to the horizontal, frontal, and profile planes. This observation reinforced the necessary procedure of measuring, with dividers, the distance from the reference plane to the object.

This method of teaching was employed in each lecture and demonstration presented to the experimental group. The control group was presented the same information but with only the chalkboard being employed to illustrate the principles of projection.

At the conclusion of each instruction period, the students in both the control and experimental groups translated the observed principles into function and attempted to solve the assigned problems in their workbooks. The problem presented in each demonstration was not identical to the one assigned in the student's workbook; however, the principles required for solving the problem were always the same.

## Experimental Design

In the development of the experimental design, there were three important factors to be considered. These factors were the (a) selection of the sample, (b) procedure for collecting the data, and (c) statistical analysis of the data.

### Selection of the Sample

Eight sections of engineering drawing (Industrial Arts 128) were listed on the schedule of classes in the Industrial

Arts Department, North Texas State University for the fall semester of the 1968-69 school year. The sample used in the study consisted of 173 students enrolled in the eight sections. The students who participated in this study were permitted to register for the course sections on an individual choice basis. No effort was made to match the sections or students during this period. Upon the completion of registration and the beginning of classes, each student completed a student information sheet (Appendix D, p. 176). The information sheets were used to identify those students to be excluded from the study. The students selected to participate in the study were required to meet the limitations set forth in the research design. Information concerning previous experience in drafting, and pre-test scores of students were not included in the study if the students had completed five semesters or more of high school drafting or were over twenty-two years of age. Ten of the students had five or more semesters of high school drafting and eleven were over twenty-two years of age. These twenty-one students remained in their respective sections, but the data collected on these students were not included in the study. When the data received from the 21 ineligible students were removed from the prospective sample, a total of 152 students were eligible to participate in the study.

During the first three weeks of the 1968 fall semester, all eight sections of Industrial Arts 128 were taught as nearly identical as possible. The regular course outline for the course was followed by all instructors. During this three-week period, data secured from the student information sheet were gathered and summarized. At the conclusion of the three-week period, the pre-test, Unit Tests in Engineering Drawing (1), was administered to each student in each section involved in the study.

Procedure for Collecting Data

The instructional staff was composed of one full-time staff member whose instructional field is engineering graphics, and three half-time staff members who were working toward the doctoral degree. Each of the half-time staff members had three or more years teaching experience in industrial arts. Each instructor taught one experimental and one control section of Industrial Arts 128. The effect of time variables was eliminated in that one experimental group and one control group received instruction at the same time in adjacent classrooms.

The four instructors were paired together to help eliminate the effect of personality traits and any other uncontrollable variables related to the time or presentation. Instructor A and instructor B taught classes at the same time on Monday, Wednesday, and Friday mornings and at the same time on Tuesday and Thursday mornings. Instructor C and instructor D taught classes at the same time on Monday, Wednesday, and Friday mornings and afternoons. A schedule of the class assignments is presented in Table I.

TABLE I

SUMMARY OF THE SCHEDULE OF INSTRUCTION, INCLUDING THE INSTRUCTORS OF THE CONTROL AND THE EXPERIMENTAL SECTIONS

| Day | Time | Control | Experimental |
|---|---|---|---|
| M-W-F | 8:00-10:00 | Instructor A | Instructor B |
| M-W-F | 10:00-12:00 | Instructor C | Instructor D |
| M-W-F | 1:00- 3:00 | Instructor D | Instructor C |
| Tues-Thur | 8:00-11:00 | Instructor B | Instructor A |

The assignments of control and experimental sections were determined by the flip of a coin. As indicated in Table I, instructors A and B flipped the coin to determine which instructor would teach the experimental section on Monday, Wednesday, and Friday mornings. The reversal of the assignment was made on Tuesday and Thursday mornings. Instructor C and D flipped the coin to determine which instructor would teach the experimental section on Monday, Wednesday, and Friday mornings with the reversed teaching assignment being made for the afternoon classes.

When the control and experimental sections were determined, it was possible to match the control and experimental groups. The two groups were matched by group mean scores of nonsignificant difference in terms of (a) age of the students,

(b) previous drafting experience as determined by semesters completed in classroom study, and (c) degree of initial familiarization with the technical information to be presented in the study as measured by the pre-test on units I, II, and III of the Unit Tests in Engineering Drawing (1). In order to match the two groups in terms of drafting experience and surface visualization ability as measured by Unit II, it was necessary to exclude data from six students enrolled in the experimental sections. These students remained in their respective sections, but data from them were not included in the study.

To be matched groups, according to Garrett (3, pp. 212-213), it was not necessary for each group to have the same number of students. Therefore, no effort was made to equalize the number of students in the two groups. When the two groups were matched, the control group had a total of seventy-four students, while the experimental group had a total of seventy-two students.

The first three weeks of the semester were utilized as an interim period to match and determine experimental and control groups. The formal study began at the beginning of the fourth week and was concluded at the end of the eleventh week.

When the formal study began, the control sections were presented content using method A of instruction for a period of four weeks. A post-test was administered to each control section at the conclusion of the four-week instruction period to determine, as indicated by the test scores, if a change in visualization had occurred. The post-test consisted of the same three units from the Unit Tests in Engineering Drawing (1) that were administered as the pre-test.

When the formal study began, the experimental sections taught by method B were presented course content in the same manner as the control sections taught by method A except that method B was supplemented with overhead projectuals and a transparent projection box. At the conclusion of the four-week instructional period, each experimental section was administered the same post-test that was administered to the control classes.

This concluded all formal instruction as outlined for the control method A and the experimental method B lesson plans. The eight sections of Industrial Arts 128 continued to the next units of the course as prescribed by the course outline. Some of the basic principles of orthographic projection were used in the "sectioning" and "auxiliary" units, but the principles of orthographic projection were not retaught. The cooperating instructors were not provided lesson plans upon the conclusion of the formal four-week instruction period. Each instructor utilized his own method to teach the succeeding units; however, the instructor utilized the same method in both the control and the experimental sections.

At the conclusion of a second four-week period, each section was administered a retest to determine if a change in visualization had occurred due to the translation of orthographic projection principles in certain areas of drawing. If a change in visualization had occurred, the change was indicated by the test scores. The retest consisted of the same three units from Unit Tests in Engineering Drawing (1) that were administered as the pre-test and the post-test.

The pre-test, post-test, and retest scores were added to each student's personal information sheet.

## Procedures for Treating Data

Each student's pre-test, post-test, and retest scores were entered on IBM punch cards; computations were made by the Data Processing Center at North Texas State University, Denton, Texas.

The data used in making comparisons between the two groups were obtained from the standardized test administered to the students during the study. The test was described in Chapter I.

The mean score of the pre-test and the mean score of the post-test were computed using the raw score formula for the Fisher $t$ program at the Data Processing Center. The calculated mean scores were used to test Hypothesis I and Hypothesis II.

The Fisher t technique was employed for the test of significance for each of the mean gain factors. The formula employed in the Fisher t program computed by the Data Processing Center is:

$$\underline{t} = \frac{M_D}{S_{M_D}} = \frac{\Sigma D}{\sqrt{\dfrac{N\Sigma D \;\; - \; (\Sigma D)^2}{N - 1}}}$$

The derivation of this formula is from McNemar (6, pp. 102-103).

A test of significance was calculated for the stated hypotheses identified as III, III-A, III-B, III-C, and III-D, using the Fisher t technique for the test of significant difference between matched groups. The formula employed in the Fisher t program computed by the Data Processing Center is a derivation from McNemar (6, pp. 102-103).

$$t = \frac{\overline{X}_C - \overline{X}_E}{\sqrt{\text{within variance } \left(\frac{1}{N_C} + \frac{1}{N_E}\right)}} = \frac{\overline{X}_C - \overline{X}_E}{\sqrt{\dfrac{N_C S_C{}^2 + N_E S_E{}^2}{N_C + N_E - 2} \left(\frac{1}{N_C} + \frac{1}{N_E}\right)}}$$

The tests of significant difference were interpreted using the tables of Fisher's t (6, p. 430). The comparisons that were made are presented in Figure 2.

Figure 2 shows the comparisons that were made in testing Hypotheses I, II, III, III-A, III-B, III-C, and III-D. The mean score of the control pre-test and the mean score of the control post-test were compared in testing Hypothesis I. The mean score of the experimental pre-test and the mean

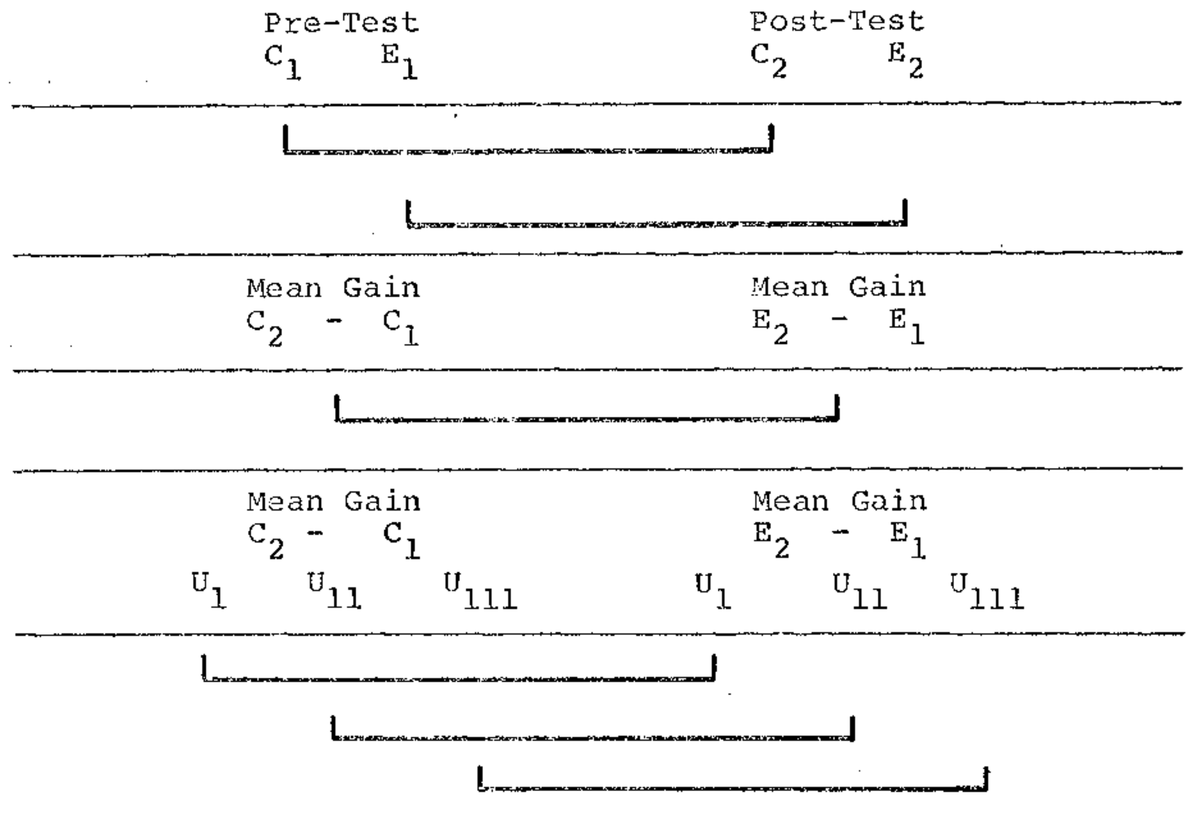


Fig. 2--A summary of the comparison of the pre-test and the post-test mean scores, mean gain scores, and unit mean gain scores of the Control and Experimental groups.

score of the experimental post-test were compared in testing Hypothesis II.

The mean gain score of the control group and the mean gain score of the experimental group were compared in testing Hypothesis III.

Each unit of the comprehensive test was compared separately in testing Hypotheses III-A, III-B, III-C, and III-D. In testing Hypothesis III-A, the mean gain scores of each group on unit I, part I, were compared. In testing Hypothesis III-B, the mean gain scores of each group on unit I, part II, were compared. In testing Hypothesis III-C, the mean gain scores of each group on unit II were compared. The mean gain scores of each group on unit III were compared in testing Hypothesis III-D.

The mean score of the post-test and the mean score of the retest were calculated for the experimental and the control group to test Hypothesis IV and Hypothesis V. The Fisher *t* technique was employed for the test of significance for each of the mean gain factors.

A test of significance was calculated for Hypotheses VI, VI-A, VI-B, VI-C, and VI-D using the Fisher *t* technique for the test of significant difference between matched groups.

The tests of significant difference were interpreted using the tables of Fisher's *t* (6, p. 430). The comparisons that were made are presented in Figure 3.

Figure 3 shows the comparisons that were made in testing Hypotheses IV, V, VI, VI-A, VI-B, VI-C, and VI-D. The mean score of the control post-test and mean score of the control retest were compared in testing Hypothesis IV. The mean score of the experimental post-test and the mean score of the experimental retest were compared in testing Hypothesis V.

The mean gain score of the control group and the mean gain score of the experimental group were compared in testing Hypothesis VI.

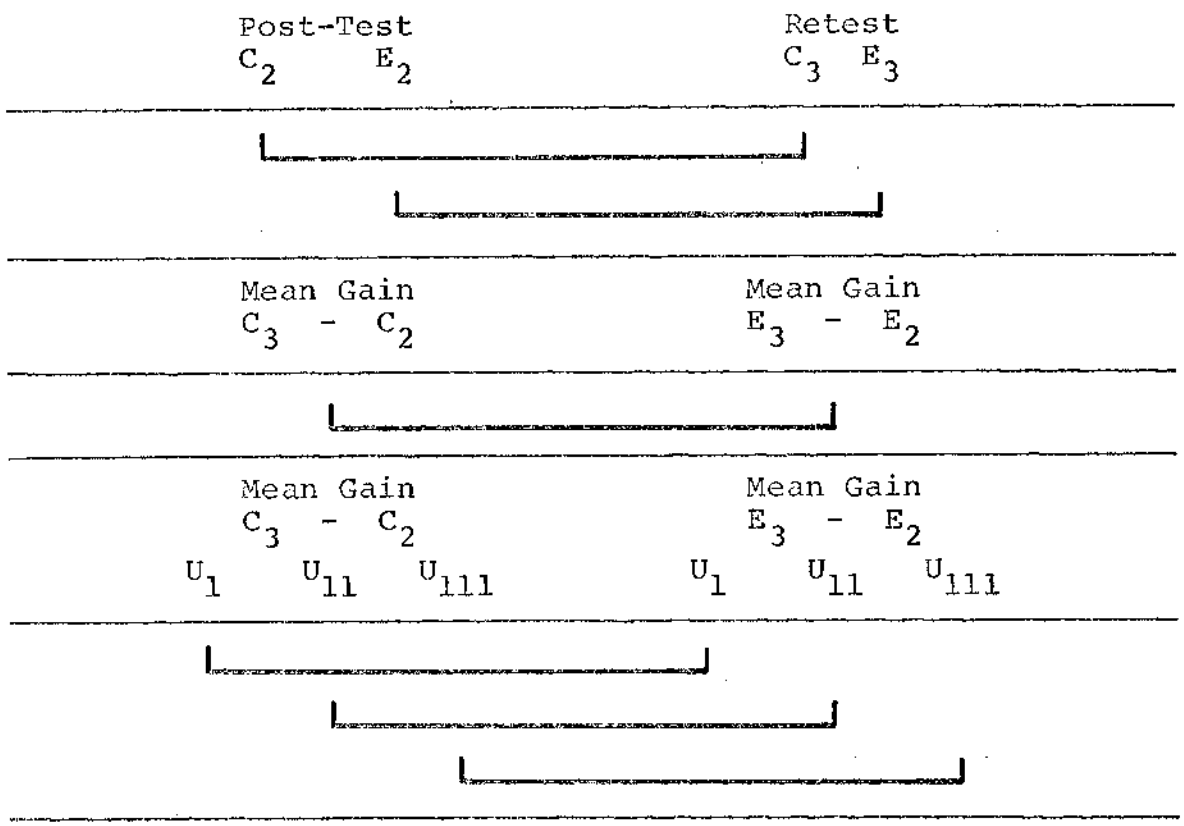


Fig. 3--A summary of the comparison of the post-test and the retest mean scores, mean gain scores, and unit mean gain scores of the Control and Experimental groups.

Each unit of the comprehensive test was compared separately in testing Hypotheses VI-A, VI-B, VI-C, and VI-D. In testing Hypothesis VI-A, the mean gain scores of each group on unit I, part I, were compared. In testing Hypothesis VI-B, the mean gain scores of each group on unit I, part II, were compared. In testing Hypothesis VI-C, the mean gain scores of each group on unit II were compared. The mean gain scores of each group on unit III were compared in testing Hypothesis VI-D.

The findings and conclusions drawn from this study were determined by the acceptance or rejection of the null hypothesis. When the t value reached the .05 level, the null hypothesis was rejected and the research hypothesis was accepted. The .05 level was considered significant, while the .01 level was considered highly significant.

Summary of the Experimental Design

The experimental design of the investigation involved matched groups. This selection was based on the following rationale:

1. It will insure that the observed treatment effects are unbiased estimates of the true effects.
2. It will permit a quantitative description of the precision of the observed treatment effects regarded as estimates of the "true" effects.
3. It will insure that the observed treatment effects will have whatever degree of precision is required by the broader purposes of the experiment.
4. It will make possible an objective test of a specific hypothesis concerning the true effects.
5. It will be efficient (5, p. 462).

Before this investigation could be conducted satisfactorily, the control of many decisive factors was necessary. If certain contingent factors were not properly controlled, the experimental effects might have been altered. Therefore, it was mandatory that necessary controls be employed throughout the experiment.

In order to select drafting laboratories for the experiment, the four drafting rooms in the Industrial Arts Building were studied to determine if any similarities existed between the rooms. The physical facilities, academic atmospheres, and the availability of essential equipment were observed. It was determined that the following items were identical in two of the classrooms.

1. The rooms were uniformly organized.

2. The physical facilities, equipment, and classroom layout were identical.

3. Projection screens and overhead projectors of equal quality were available in each classroom.

4. All teachers involved in the study viewed the study as being vital and as a worthwhile contribution to industrial arts.

The following definite controls were employed throughout the experiment:

1. Four experienced teachers participated in the experiment. Each teacher taught two classes, of which one was selected by chance as a control class, and one was designed as an experimental class.

2. The students comprising the intact classes were enrolled in their first drafting course at college level.

3. Lesson plans were used to control the identical information presented the control and experimental groups. The identical information was presented to each group at the same time in identical adjacent classrooms.

4. Student performances were measured on identical forms of the same test. The measuring instruments were administered at the same time to each group in adjacent identical classrooms with the length of testing time being identical.

Even though many variables were carefully controlled, there were certain variables that could not be eliminated. The study habits, home life, health, and other classroom experiences of the two groups could not be matched. In discussing this problem, Best stated, ". . . most experiments must be conducted using intact existing class groups, trusting that the variables not controlled are irrelevant, or would not seriously alter the results obtained" (2, p. 129).

## CHAPTER BIBLIOGRAPHY


1. American Society of Engineering Education, Unit Tests in Engineering Education, Princeton, New Jersey, The Educational Testing Services, 1948.

2. Best, John W., Research in Education, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1959.

3. Garrett, Henry E., Statistics in Psychology and Education, 3rd ed., New York, Longmans, Green and Co., 1947.

4. Keuffel and Esser Co., "Technical Graphics," instruction sheet for K & E Diazo transparencies, Hoboken, New Jersey, 1964.

5. Lindquist, E. F., Design and Analysis of Experiments in Psychology, pp. 1, 6-7, summarized by Carter V. Good, Introduction to Educational Research, New York, Appleton-Century-Crofts, 1963.

6. McNemar, Quinn, Psychological Statistics, New York, John Wiley and Sons, Inc., 1960.

7. Schramm, Howard R., "Helpful Teaching Aids for Industrial Education," Industrial Arts and Vocational Education, XLIII (October, 1954), 277.

8. Warner, M. E., "Overhead Projector for Teaching Drafting," Industrial Arts and Vocational Education, XLII (December, 1953), 353.

# CHAPTER IV

## PRESENTATION AND ANALYSIS OF THE DATA

An analysis of the data was conducted to determine the effectiveness of overhead projectuals and a transparent projection box on teaching orthographic projection. In order to test the proposed variables, one experimental and one control group were established from the 146 students who participated in the study. The control group consisted of 74 students, while the experimental group consisted of 72 students. Both groups were taught, as nearly as possible, the same material. The method of instruction was the same for both groups except that the experimental group's instruction was supplemented with overhead projectuals and a transparent projection box.

The tenability of the hypotheses of the study as presented in Chapter I was determined by a statistical analysis of the collected data. The data obtained from the students were recorded on punch cards and computations were made by the Data Processing Center at North Texas State University, Denton, Texas. In order to determine the tenability of the hypotheses, the Fisher *t* technique as outlined by McNemar (2) was employed to test for significant differences between the two groups and within the groups. The research hypotheses were restated as null hypotheses and were rejected at the .05 level.

## Comparisons of the Pre-Experimental Data of Students in the Control and Experimental Groups

The initial step in the analysis of data was to determine if there were any significant differences between the control and experimental groups before the formal study began. The specific areas tested were the (a) age of the students, (b) previous drafting experience as determined by semesters completed in classroom study, and (c) degree of initial familiarization with the technical information to be presented in the study as measured by the pre-test on units I, II, and III of the Unit Tests in Engineering Drawing (1). A comparison of the means, standard deviations, and level of significance of the three variables is presented in Table II.

As shown in Table II, the mean age of the students in the control group was 18.88 years with a standard deviation of 1.21, and the mean age of students in the experimental group was 19.19 years with a standard deviation of 1.44.

A *t*-value with 144 degrees of freedom must reach 1.96 to be significant at the .05 level. As shown in Table II, a value of $t = 1.43$ was obtained. Using N - 2 degrees of freedom the *t*-value indicated a nonsignificant difference. Thus, the difference in the mean age of the two groups was

TABLE II

MEANS, STANDARD DEVIATIONS, t VALUE, AND LEVEL OF SIGNIFICANCE OF THE VARIABLES USED TO MATCH THE CONTROL AND EXPERIMENTAL GROUPS

| Variable | Control Group | | Experimental Group | | t-Value | Level of Significance |
|---|---|---|---|---|---|---|
| | Mean | S.D.** | Mean | S.D. | | |
| Age | 18.88 | 1.21 | 19.19 | 1.44 | -1.43 | NS*** |
| Drafting Experience | .86 | 1.34 | .92 | 1.23 | - .24 | NS |
| Comprehensive Pre-Test | 24.91 | 10.93 | 25.65 | 9.28 | - .44 | NS |
| Sub-Test | | | | | | |
| Unit I, Part I | 5.42 | 3.05 | 5.72 | 3.12 | - .59 | NS |
| Unit I, Part II | 2.14 | 2.82 | 2.24 | 2.76 | - .22 | NS |
| Unit II | 8.43 | 4.57 | 8.54 | 3.91 | - .15 | NS |
| Unit III | 8.92 | 2.92 | 9.15 | 2.70 | - .50 | NS |

*df = 144.

**S.D.--Standard Deviation.

***NS--Nonsignificant.

The previous drafting experience of each student, in terms of semesters completed in classroom study, was obtained from data gathered from the students through the aid of information sheets. As shown in Table II, the mean number of semesters of instruction in drafting study for the students in the control group was .86 with a standard deviation of 1.34, and the mean number of semesters of instruction in drafting study for students in the experimental group was .92 with a standard deviation of 1.23.

As shown in Table II, a value of t = .24 was obtained. Using N - 2 degrees of freedom, the t value indicated no significance of difference. Thus, the difference in semesters of classroom instruction in drafting between the control and experimental groups was nonsignificant as measured by mean scores.

To determine if there was a significant difference between the control group and the experimental group in terms of initial familiarization of the technical information to be presented in the study, the pre-test of each group was analyzed first for the test in its entirety and then for each of the sub-tests. The comprehensive pre-test mean score of the control group was 24.91 with a standard deviation of 10.93, and the comprehensive pre-test mean score of the experimental group was 25.65 with a standard deviation of 9.28.

As shown in Table II, a value of t = .44 was obtained. Using N - 2 degrees of freedom, the t value indicated no significance of difference in the mean scores of the control group and of the experimental group. Thus, the difference in the knowledge of the technical information being tested was nonsignificant as measured by mean scores.

Although there was nonsignificant difference between the mean scores of the control and experimental groups on the comprehensive pre-test, a test of significance was computed for each of the sub-tests. This analysis was to determine if there was a significant difference between the two groups in the specific areas of (a) missing line visualization, (b) surface identification, (c) surface visualization, and (d) visualization of third-angle projection. In order to test the sub-hypotheses under Hypothesis III and Hypothesis VI, the control and experimental groups were matched on both the comprehensive and sub-test parts of the pre-test.

The first part of unit I measured the student's ability to visualize missing lines. As shown in Table II, the pre-test mean score of the control group on unit I, part I, was 5.42 with a standard deviation of 3.05. The pre-test mean score of the experimental group on unit I, part I, was 5.72 with a standard deviation of 3.12.

As shown in Table II, a value of $\underline{t}$ = .59 was obtained. Using 144 degrees of freedom, the $\underline{t}$ value indicated no significance of difference in the mean scores of the control and experimental groups on unit I, part I. Thus, the small difference in the mean scores of the two groups on unit I, part I, indicates that the difference in the two groups to visualize missing lines was nonsignificant.

The second part of unit I measured the student's ability to locate and identify surfaces on orthographic views. The pre-test mean score of the control group on unit I, part II, was 2.14 with a standard deviation of 2.82, and the pre-test mean score of the experimental group on unit I, part II, was 2.24 with a standard deviation of 2.76.

As shown in Table II, a value of _t_ = .22 was obtained. Using N - 2 degrees of freedom, the _t_ value indicated no significance of difference in the mean scores of the control group and the experimental group on unit I, part II. Thus, the small difference in the mean scores of the two groups on unit I, part II, indicates that the difference in the two group to identify surfaces was nonsignificant.

Unit II of the pre-test measured the student's ability to visualize visible and invisible surfaces on orthographic views. The pre-test mean score of the control group on unit II was 8.43 with a standard deviation of 4.57, and the pre-test mean score of the experimental group on unit II was 8.54 with a standard deviation of 3.91.

As shown in Table II, a value of _t_ = .15 was obtained. Using N - 2 degrees of freedom, the _t_ value indicated no significance of difference in the mean scores of the control group and the experimental group on unit II. Thus, the small difference in the mean scores of the two groups on unit II indicates that the difference with respect to surface visualization was nonsignificant.

Unit III of the pre-test measured the student's ability to visualize third-angle projection. The pre-test mean score of the control group on unit III was 8.92 with a standard deviation of 2.92, and the pre-test mean score of the experimental group on unit III was 9.15 with a standard deviation of 2.70.

As shown in Table II, a value of t = .50 was obtained. Using 144 degrees of freedom, the t value indicated no significance of difference in the mean scores of the control group and the experimental group on unit III. Thus, the small difference in the mean scores of the two groups on unit III indicates that the difference in the two groups to visualize third-angle projection was nonsignificant.

In summary, the Fisher t technique was employed as a test of significance of the difference between the means of the three variables which were used to match the two groups. The results confirmed the assumption that the control group and the experimental group were nonsignificantly different in terms of age of students, previous classroom drafting experience, and degree of familiarization with the technical information before starting the formal experimental unit of instruction; however, the advantage of the small nonsignificant difference appeared to be in the direction of the experimental group.

### Comparisons of the Mean Gain Scores of the Control Group and the Experimental Group from the Pre-Test to the Post-Test

The initial query on which data were analyzed involved a comparison of the individual mean gain scores of the control group and the experimental group from the pre-test to the post-test. This comparison necessitated the calculation of post-test mean scores of both the control and experimental groups. The mean scores of the pre-test had previously been calculated in order to match the two groups. The mean gain score for the control and the experimental groups was the difference between the groups' mean score on the pre-test and mean score on the post-test. A summary of the mean scores, standard deviation, mean gain scores, t value, and level of significance for the mean gain scores of the control and the experimental groups is presented in Table III.

Table III presents the comprehensive and unit pre-test and post-test mean scores, standard deviations, mean gain scores, degrees of freedom, t value and level of significance for both the control and experimental groups. The comprehensive pre-test mean score of the control group was 24.91 with a standard deviation of 10.93, and the comprehensive post-test mean score was 37.37 with a standard deviation of 12.38. The difference between the two mean scores, which is the comprehensive mean gain for the control group, was 12.46 with a standard deviation of 8.27.

The first hypothesis was, "the control group will make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views." The criterion for this hypothesis was the mean gain score.

The t value required for significance with 73 degrees of freedom is 2.00 at the .05 level. As shown in Table III,

TABLE III

COMPREHENSIVE TEST AND UNIT TEST MEAN SCORES, STANDARD DEVIATIONS, MEAN GAIN SCORES, FISHER *t* VALUE, AND LEVEL OF SIGNIFICANCE OF THE PRE-TEST AND POST-TEST FOR THE CONTROL AND EXPERIMENTAL GROUP ON UNIT TESTS IN ENGINEERING DRAWING (1)

| Variable | Pre-Test | Post-Test | Mean Gain | Degrees of Freedom | *t*-Value | Level of Significance |
|---|---|---|---|---|---|---|
| | | | Comprehensive Test | | | |
| Control Group | | | | | | |
| Mean | 24.91 | 37.37 | 12.46 | 73 | 12.88 | .001 |
| SD** | 10.93 | 12.38 | 8.27 | | | |
| Experimental Group | | | | | | |
| Mean | 25.65 | 38.82 | 13.17 | 71 | 14.36 | .001 |
| SD | 9.28 | 12.58 | 7.73 | | | |
| | | | Unit Test | | | |
| Control Group | | | | | | |
| Unit I, Part I: | | | | | | |
| Mean | 5.42 | 8.74 | 3.32 | * | * | * |
| SD | 3.05 | 3.34 | 3.23 | | | |
| Unit I, Part II: | | | | | | |
| Mean | 2.14 | 5.15 | 3.01 | * | * | * |
| SD | 2.82 | 3.95 | 3.38 | | | |
| Unit II: | | | | | | |
| Mean | 8.43 | 11.80 | 3.37 | * | * | * |
| SD | 4.57 | 4.92 | 3.78 | | | |
| Unit III: | | | | | | |
| Mean | 8.92 | 11.68 | 2.76 | * | * | * |
| SD | 2.92 | 2.97 | 2.99 | | | |

TABLE III--Continued

| Variable | Pre-Test | Post-Test | Mean Gain | Degrees of Freedom | t-Value | Level of Significance |
|---|---|---|---|---|---|---|
| | | | Unit Test | | | |
| Experimental Group | | | | | | |
| Unit I, Part I: | | | | | | |
| Mean | 5.72 | 8.96 | 3.24 | * | * | * |
| SD | 3.12 | 3.52 | 2.66 | | | |
| Unit I, Part II: | | | | | | |
| Mean | 2.24 | 5.68 | 3.44 | * | * | * |
| SD | 2.76 | 3.74 | 3.32 | | | |
| Unit II: | | | | | | |
| Mean | 8.54 | 12.61 | 4.07 | * | * | * |
| SD | 3.91 | 4.96 | 4.26 | | | |
| Unit III: | | | | | | |
| Mean | 9.15 | 11.57 | 2.42 | * | * | * |
| SD | 2.70 | 3.11 | 2.90 | | | |

*Computations not necessary in study.

**SD--Standard Deviation.

a value of $t = 12.88$ was obtained. Using N - 1 degrees of freedom, the $t$ value was found to be significant at better than the .001 level. Thus, the null hypothesis, the control group will not make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views, was rejected and the research hypothesis was accepted.

Since the mean gain difference was significant, it can be inferred that there was a significant gain in the control group's ability to visualize orthographic views.

As shown in Table III, the comprehensive pre-test mean score of the experimental group was 25.65 with a standard deviation of 9.28, and the comprehensive post-test mean score was 38.82 with a standard deviation of 12.58. The difference between the two mean scores, which was the comprehensive mean gain for the experimental group, was 13.17 with a standard deviation of 7.73.

The second hypothesis was, "the experimental group will make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views." The criterion for this hypothesis was the mean gain score.

The _t_ value required for significance with 71 degrees of freedom is 2.00 at the .05 level. As shown in Table III, a value of _t_ = 14.36 was obtained. Using N - 1 degrees of freedom, the _t_ value was found to be significant at better than the .001 level. Thus, the null hypothesis, the experimental group will not make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views was rejected and the research hypothesis was accepted. Since the mean gain difference was significant, it can be inferred that there was a significant gain in the experimental group's ability to visualize orthographic projection views.

Table III presents the pre-test and post-test mean scores, standard deviations, and mean gain scores on units I, II, and III of Unit Tests in Engineering Drawing (1) which were administered at the beginning and the end of the experimental unit of instruction to students in the control and experimental groups.

The pre-test mean score of the control group on unit I, part I, was 5.42 with a standard deviation of 3.05, and the post-test mean score was 8.74 with a standard deviation of 3.34. The difference between the two mean scores was the mean gain score of the control group on unit I, part I. The mean gain score was 3.32 with a standard deviation of 2.75.

The pre-test mean score of the control group on unit I, part II, was 2.14 with a standard deviation of 2.82, and the post-test mean score was 5.15 with a standard deviation of 3.95. The difference between the two mean scores was the mean gain score of the control group on unit I, part II, which was 3.01 with a standard deviation of 3.38.

The pre-test mean score of the control group on unit II was 8.43 with a standard deviation of 4.57, and the post-test mean score was 11.80 with a standard deviation of 4.92. The difference between the two mean scores was the mean gain score of the control group on unit II, which was 3.37 with a standard deviation of 3.78.

The pre-test mean score of the control group on unit III was 8.92 with a standard deviation of 2.92, and the post-test mean score was 11.68 with a standard deviation of 2.97. The difference between the two mean scores was the mean gain score of the control group on unit III, which was 2.76 with a standard deviation of 2.99.

The pre-test mean score of the experimental group on unit I, part I, was 5.72 with a standard deviation of 3.12, and the post-test mean score was 8.96 with a standard deviation of 3.52. The difference between the two mean scores was the mean gain score of the experimental group on unit I, part I, which was 3.24 with a standard deviation of 2.66.

The pre-test mean score of the experimental group on unit I, part II, was 2.24 with a standard deviation of 2.76, and the post-test mean score was 5.68 with a standard deviation of 3.74. The difference between the two mean scores was the mean gain score of the experimental group on unit I, part II, which was 3.44 with a standard deviation of 3.32.

The pre-test mean score of the experimental group on unit II was 8.54 with a standard deviation of 3.91, and the post-test mean score was 12.61 with a standard deviation of 4.96. The difference between the two mean scores was the mean gain score of the experimental group on unit II, which was 4.07 with a standard deviation of 4.26.

The pre-test mean score of the experimental group on unit III was 9.15 with a standard deviation of 2.70, and the post-test mean score was 11.57 with a standard deviation of 3.11. The difference between the two mean scores was the mean gain score of the experimental group on unit III, which was 2.42 with a standard deviation of 2.90.

Hypotheses III, III-A, III-B, III-C, and III-D were tested in regard to the greater mean gain score between the control and the experimental groups from the pre-test to the post-test. The greater mean gain score was the difference between the mean gain score of the control group and the mean gain score of the experimental group. A summary of the mean gain scores, mean difference score, $t$ value, and level of significance for the greater mean gain score between the control group and the experimental group is presented in Table IV.

As shown in Table IV, the mean gain scores on the comprehensive test and each sub-test for the control and the experimental groups were tested for significant difference.

The third hypothesis was, "the experimental group will make a significantly greater mean gain than will the control group from the pre-test to the post-test on a comprehensive test of visualization of orthographic views." The criterion for this hypothesis was the greater mean gain score.

TABLE IV

SUMMARY OF FISHER t COMPARING MEAN GAIN SCORES OF THE CONTROL AND THE EXPERIMENTAL GROUPS FROM THE PRE-TEST TO THE POST-TEST ON UNIT TESTS IN ENGINEERING DRAWING (1)

| Test | Mean Gain | | Mean Difference | *t* Value | Level of Significance |
|---|---|---|---|---|---|
| | Control Group | Experimental Group | | | |
| Comprehensive Test | 12.46 | 13.17 | -.71 | - .53 | NS** |
| Unit I, Part I | 3.32 | 3.23 | .09 | .20 | NS |
| Unit I, Part II | 3.01 | 3.44 | -.43 | - .77 | NS |
| Unit III | 2.76 | 2.42 | .34 | .69 | NS |
| Unit II | 3.36 | 4.07 | -.71 | -1.05 | NS |

*df = 144.

**Nonsignificant.

As shown in Table IV, the mean gain score of the control group was 12.46, and the mean gain score of the experimental group was 13.17. The difference between these two mean gain scores was .71 in the direction of the experimental group. The obtained value of *t* = .53 indicated that there was non-significant difference in the mean gain scores. Thus, the null hypothesis (the experimental group will not make significantly greater mean gain than will the control group from the pre-test to the post-test on a comprehensive test of visualization of orthographic views) could not be rejected;

Since the mean gain difference was small and indicated nonsignificant difference, it may be inferred that instruction method A and instruction method B were of reasonably equal value when utilized to teach orthographic projection. Even though the difference was nonsignificant, it appears that the experimental method was in some degree superior to the control method in that the experimental group scored a greater mean gain and a smaller deviation than the control group.

Hypothesis III-A was, "the experimental group will make a significantly greater mean gain than will the control group as measured by a test of missing lines." The criterion for this hypothesis was the greater mean gain score on unit I, part I.

As shown in Table IV, the mean gain score of the control group was 3.32, and the mean gain score of the experimental group was 3.23. The difference between the two mean gain scores was .09 in the direction of the control group. The obtained value of $\underline{t}$ = .20 indicated there was nonsignificant difference in the mean gain scores. Thus, the null hypothesis (the experimental group will not make a significantly greater mean gain than will the control group as measured by a test of missing lines) could not be rejected; therefore, the research hypothesis was rejected.

Since the mean gain difference was small and indicated nonsignificant difference, it may be inferred that instruction method A and instruction method B were equally effective in presenting missing line visualization as measured by the mean gain scores.

Hypothesis III-B was, "the experimental group will make a significantly greater mean gain than will the control group as measured by a test of surface identification." The criterion for this hypothesis was the greater mean gain score on unit I, part II.

As shown in Table IV, the mean gain score of the control group was 3.01, and the mean gain score of the experimental group was 3.44. The difference between the two mean gain scores was .43 in the direction of the experimental group. The obtained value of $\underline{t}$ = .77 indicated there was no significance of difference in the mean gain scores. Thus, the null hypothesis (the experimental group will not make a significantly greater mean gain than will the control group as measured by a test of surface identification) could not be rejected; therefore, the research hypothesis was rejected.

Since the mean gain difference was small and indicated nonsignificant difference, it may be inferred that instruction method A and instruction method B were equally effective in presenting surface identification as measured by the mean gain scores.

Hypothesis III-C was, "the experimental group will make a significantly greater mean gain than will the control group as measured by a test of visualization of orthographic views." The criterion for this hypothesis was the greater mean gain score on unit III.

As shown in Table IV, the mean gain score of the control group was 2.76, and the mean gain score of the experimental group was 2.42. The difference between the two mean gain scores was .34 in the direction of the control group. The obtained value of $\underline{t}$ = .69 indicated there was no significance of difference in the mean gain scores. Thus, the null hypothesis (the experimental group will not make a significantly greater mean gain than will the control group as measured by a test of visualization of orthographic views) could not be rejected; therefore, the research hypothesis was rejected.

Since the mean gain difference was small and indicated nonsignificant difference, it may be inferred that instruction method A and instruction method B were equally effective in presenting orthographic projection as measured by the mean gain scores.

Hypothesis III-D was, "there will be no significant difference in the mean gain scores of the two groups as measured by a test of visualization of surfaces." The criterion for this hypothesis was the greater mean gain score on unit II.

As shown in Table IV, the mean gain score of the control group was 3.36, and the mean gain score of the experimental group was 4.07. The difference between the two mean gain scores was .71 in the direction of the experimental group. The obtained value of $t$ = 1.05 indicated there was nonsignificant difference in the mean gain scores. Thus, the research hypothesis was accepted.

Since the mean gain difference was small and indicated no significant difference, it may be inferred that instruction method A and instruction method B were equally effective in presenting visualization of orthographic surfaces as measured by the mean gain scores.

Comparisons of the Mean Gain Scores Following the Translation of Orthographic Principles into Function

The second query on which data were analyzed involved a comparison of the individual mean gain scores of the control group and the experimental group from the post-test to the retest. This comparison necessitated the calculation of retest mean scores of both the control and experimental groups. The mean gain score for the control and experimental groups was the difference between the group's mean score on the post-test and mean score on the retest. A summary of the mean scores, standard deviations, mean gain scores, $t$ value, and level of significance for the mean gain scores of the control and the experimental groups is presented in Table V.

TABLE V

COMPREHENSIVE TEST AND UNIT TEST MEAN SCORES, STANDARD DEVIATIONS, MEAN GAIN SCORES, FISHER t VALUE AND LEVEL OF SIGNIFICANCE OF THE POST-TEST AND RETEST FOR THE CONTROL AND EXPERIMENTAL GROUP ON UNIT TESTS IN ENGINEERING DRAWING (I)

| Variable | Post-Test | Re-test | Mean Gain | Degrees of Freedom | t Value | Level of Significance |
|---|---|---|---|---|---|---|
| | | | Comprehensive Test | | | |
| Control Group | | | | | | |
| Mean | 37.36 | 41.82 | 4.46 | 73 | 6.48 | .001 |
| SD** | 12.38 | 12.29 | 5.91 | | | |
| Experimental Group | | | | | | |
| Mean | 38.82 | 43.85 | 5.03 | 71 | 6.70 | .001 |
| SD | 12.58 | 12.80 | 6.32 | | | |
| | | | Unit Test | | | |
| Control Group | | | | | | |
| Unit I, Part I: | | | | | | |
| Mean | 8.74 | 9.80 | 1.05 | * | * | * |
| SD | 3.34 | 2.66 | 2.04 | | | |
| Unit I, Part II: | | | | | | |
| Mean | 5.15 | 6.50 | 1.35 | * | * | * |
| SD | 3.95 | 3.80 | 2.94 | | | |
| Unit II: | | | | | | |
| Mean | 11.80 | 13.11 | 1.31 | * | * | * |
| SD | 4.92 | 5.09 | 3.19 | | | |
| Unit III: | | | | | | |
| Mean | 11.68 | 12.42 | .74 | * | * | * |
| SD | 2.97 | 3.07 | 2.75 | | | |

TABLE V--*Continued*

| Variable | Post-Test | Re-test | Mean Gain | Degrees of Freedom | *t* Value | Level of Significance |
|---|---|---|---|---|---|---|
| | | | Unit Test | | | |
| *Experimental Group* | | | | | | |
| Unit I, Part I: | | | | | | |
| Mean | 8.96 | 9.51 | .55 | * | * | * |
| SD | 3.52 | 3.36 | 2.35 | | | |
| Unit I, Part II: | | | | | | |
| Mean | 5.68 | 7.33 | 1.65 | * | * | * |
| SD | 3.74 | 3.59 | 2.86 | | | |
| Unit II: | | | | | | |
| Mean | 12.61 | 13.99 | 1.38 | * | * | * |
| SD | 4.96 | 4.80 | 2.60 | | | |
| Unit III: | | | | | | |
| Mean | 11.57 | 13.01 | 1.44 | * | * | * |
| SD | 3.11 | 3.21 | 2.74 | | | |

*Computations not necessary in study.

**SD--Standard Deviation.

Table V presents the comprehensive and unit post-test and retest mean scores, standard deviations, mean gain scores, degrees of freedom, *t* value, and level of significance for both the control and experimental groups. The comprehensive post-test score of the control group was 37.36 with a standard deviation of 12.38, and the comprehensive retest mean score was 41.82 with a standard deviation of 12.29. The difference between the two scores, which is the comprehensive mean gain for the control group, was 4.46 with a standard deviation of 5.91.

The fourth hypothesis was, "the control group will make a significant mean gain from the post-test to the retest on a comprehensive test of visualization of orthographic views." The criterion for this hypothesis was the mean gain score.

As shown in Table V, a value of $\underline{t}$ = 6.45 was obtained. Using 73 degrees of freedom, the $\underline{t}$ value was found to be significant at better than the .001 level. Thus, the null hypothesis (the control group will not make a significant mean gain from the post-test to the retest on a comprehensive test of visualization of orthographic views) was rejected and the research hypothesis was accepted.

Since the mean gain difference was significant, it can be inferred that there was a significant gain in the control group's ability to visualize orthographic views.

As shown in Table V, the comprehensive post-test mean score of the experimental group was 38.82 with a standard deviation of 12.58, and the comprehensive retest score was 43.85 with a standard deviation of 12.80. The difference between the two scores, which is the comprehensive mean gain score for the experimental group, was 5.03 with a standard deviation of 6.32.

The fifth hypothesis was, "the experimental group will make a significant mean gain from the post-test to the retest on a comprehensive test of visualization of orthographic views." The criterion for this hypothesis was the mean gain score.

As shown in Table V, a value of t = 6.70 was obtained. Using 71 degrees of freedom, the t value was found to be significant at better than the .001 level. Thus, the null hypothesis (the experimental group will not make a significant mean gain from the post-test to the retest on a comprehensive test of visualization of orthographic views) was rejected and the research hypothesis was accepted.

Since the mean gain difference was significant, it can be inferred that there was a significant gain in the experimental group's ability to visualize orthographic projection views.

Table V presents the post-test and retest mean scores, standard deviations, and mean gain scores on unit I, II, and III of the Unit Tests in Engineering Drawing (1) which were administered at the beginning and at the end of the translation period to students in the control and experimental groups.

The post-test mean gain score of the control group on unit I, part I, was 8.74 with a standard deviation of 3.34, and the retest mean score was 9.80 with a standard deviation of 2.66. The difference between the two mean scores was the mean gain score of 1.05 with a standard deviation of 2.04.

The post-test mean score of the control group on unit I, part II, was 5.15 with a standard deviation of 3.95, and the retest mean score was 6.50 with a standard deviation of 3.80. The difference between the mean scores was the mean gain of the control group on unit I, part II, which was 1.35 with a standard deviation of 2.94.

The post-test mean score of the control group on unit II was 11.80 with a standard deviation of 4.92, and the retest mean score was 13.11 with a standard deviation of 5.09. The difference between the two mean scores was the mean gain score of the control group on unit II, which was 1.31 with a standard deviation of 3.19.

The post-test mean score of the control group on unit III was 11.68 with a standard deviation of 2.97, and the retest mean score was 12.42 with a standard deviation of 3.07. The difference between the two mean scores was the mean gain score of the control group on unit III, which was .74 with a standard deviation of 2.75.

The post-test mean score of the experimental group on unit I, part I, was 8.96 with a standard deviation of 3.52, and the retest mean score was 9.51 with a standard deviation of 3.36. The difference between the two mean scores was the mean gain score of the experimental group on unit I, part I, which was .55 with a standard deviation of 2.35.

The post-test mean score of the experimental group on unit I, part II, was 5.68 with a standard deviation of 3.74, and the retest mean score was 7.33 with a standard deviation of 3.59. The difference between the two mean scores was the mean gain score of the experimental group on unit I, part II, which was 1.65 with a standard deviation of 2.86.

The post-test mean score of the experimental group on unit II was 12.61 with a standard deviation of 4.96, and the retest mean score was 13.99 with a standard deviation of 4.80. The difference between the two mean scores was the mean gain score of the experimental group on unit II, which was 1.38 with a standard deviation of 2.60.

The post-test mean score of the experimental group on unit III was 11.57 with a standard deviation of 3.11, and the retest mean score was 13.01 with a standard deviation of 3.21. The difference between the two mean scores was the mean gain score of the experimental group on unit III, which was 1.44 with a standard deviation of 2.74.

Hypotheses VI, VI-A, VI-B, VI-C, and VI-D were tested in regard to the greater mean gain score between the control group and the experimental group from the post-test to the retest. The greater mean gain score was the difference between the mean gain score of the control group and the mean gain score of the experimental group. A summary of the mean gain scores, mean difference score, $t$ value, and level of significance for the greater mean gain score between the control group and the experimental group is presented in Table VI.

As shown in Table VI, the mean gain scores on the comprehensive test and each sub-test for the control group and the experimental group were tested for significance of difference.

TABLE VI

SUMMARY OF FISHER t COMPARING MEAN GAIN SCORES OF THE CONTROL AND THE EXPERIMENTAL GROUPS FROM THE POST-TEST TO THE RETEST ON UNIT TESTS IN ENGINEERING DRAWING (1)

| Test | Mean Gain: Control Group | Mean Gain: Experimental Group | Mean Difference | t Value | Level of Significance |
|---|---|---|---|---|---|
| Comprehensive Test | 4.46 | 5.03 | -.57 | - .58 | NS** |
| Unit I, Part I | 1.05 | .56 | .49 | 1.36 | NS |
| Unit I, Part II | 1.35 | 1.65 | -.30 | - .62 | NS |
| Unit II | 1.31 | 1.38 | -.07 | - .13 | NS |
| Unit III | .74 | 1.44 | -.70 | -1.53 | NS |

*df = 144.

**Nonsignificant.

The sixth hypothesis was, "the experimental group will make a significantly greater mean gain than will the control group from the post-test to the retest on a comprehensive test of visualization of orthographic views." The criterion for this hypothesis was the greater mean gain score.

As shown in Table VI, the mean gain score of the control group was 4.46, and the mean gain score of the experimental group was 5.03. The difference between the two mean gain scores was .57 in the direction of the experimental group. The obtained value of $t$ = .56 indicated there was nonsignificant difference in the mean gain scores. Thus, the null hypothesis (the experimental group will not make a significantly greater mean gain than will the control group from the post-test to the retest on a comprehensive test of visualization of orthographic views) could not be rejected; therefore, the research hypothesis was rejected.

Since the mean gain difference was small and indicated nonsignificant difference, it may be inferred that instruction method A and instruction method B were equally effective when utilized to teach orthographic projection as measured by the mean gain scores.

Hypothesis VI-A was, "there will be no significant difference in the mean gain of the two groups as measured by a test of missing lines." The criterion for this hypothesis was the greater mean gain score on unit I, part I.

As shown in Table VI, the mean gain score of the control group was 1.05, and the mean gain score of the experimental group was .56. The difference between the two mean gain scores was .49 in the direction of the control group. The obtained value of $t$ = 1.36 indicated that there was no significance of difference in the mean gain scores. Thus, the research hypothesis was accepted.

Since the mean gain difference was small and indicated nonsignificant difference, it may be inferred that instruction method A and instruction method B were equally effective in presenting missing line visualization as measured by the mean gain scores.

Hypothesis VI-B was, "there will be no significant difference in the mean gain of the two groups as measured by a test of surface identification." The criterion for this hypothesis was the greater mean gain score on unit I, part II.

As shown in Table VI, the mean gain score of the control group was 1.35, and the mean gain score of the experimental group was 1.65. The difference between the two mean gain scores was .30 in the direction of the experimental group. The obtained value of *t* = .62 indicated there was nonsignificant difference in the mean gain scores. Thus, the research hypothesis was accepted.

Since the mean gain difference was small and indicated nonsignificant difference, it may be inferred that instruction method A and instruction method B were equally effective in presenting surface identification as measured by the mean gain scores.

Hypothesis VI-C was, "there will be no significant difference in the mean gain of the two groups as measured by a test of visualization of surfaces." The criterion for this hypothesis was the greater mean gain score on unit II.

As shown in Table VI, the mean gain score of the control group was 1.31, and the mean gain score of the experimental group was 1.38. The difference between the two mean gain scores was .07 in the direction of the experimental group. The obtained value of *t* = .13 indicated there was no significance of difference in the mean gain scores. Thus, the research hypothesis was accepted.

Since the mean gain difference was small and indicated nonsignificant difference, it may be inferred that instruction method A and instruction method B were equally effective in presenting visualization of surfaces as measured by the mean gain scores.

Hypothesis VI-D was, "the experimental group will make a significantly greater mean gain than will the control group as measured by a test of visualization of third-angle projection." The criterion for this hypothesis was the greater mean gain score on unit III.

As shown in Table VI, the mean gain score of the control group was .74, and the mean gain score of the experimental group was 1.44. The difference between the two mean gain scores was .70 in the direction of the experimental group. The obtained value of $\underline{t} = 1.53$ indicated there was no significance of difference in the mean gain scores. Thus, the null hypothesis (the experimental group will not make a significantly greater mean gain than will the control group as measured by a test of visualization of third-angle projection) could not be rejected; therefore, the research hypothesis was rejected.

Since the mean gain difference was small and indicated nonsignificant difference, it may be inferred that instruction method A and instruction method B were equally effective in presenting visualization of third-angle projection as measured by the mean gain scores.

## Summary

A resume of the data obtained in the study is presented in Table VII.

TABLE VII

SUMMARY OF THE ANALYSIS OF DATA OBTAINED IN THE STUDY

| Hypothesis | Degrees of Freedom | *t* Value | Hypothesis Accepted or Rejected |
|---|---|---|---|
| I | 73 | -12.88 | Accepted |
| II | 71 | -14.36 | Accepted |
| III | 144 | - .53 | Rejected |
| III-A | 144 | .20 | Rejected |
| III-B | 144 | - .77 | Rejected |
| III-C | 144 | .69 | Rejected |
| III-D | 144 | - 1.05 | Rejected |
| IV | 73 | - 6.45 | Accepted |
| V | 71 | - 6.70 | Accepted |
| VI | 144 | - .56 | Rejected |
| VI-A | 144 | 1.36 | Accepted |
| VI-B | 144 | - .62 | Accepted |
| VI-C | 144 | - .13 | Accepted |
| VI-D | 144 | - 1.53 | Rejected |

CHAPTER BIBLIOGRAPHY


1. American Society of Engineering Education, Unit Tests in Engineering Drawing, Princeton, New Jersey, The Educational Testing Services, 1948.

2. McNemar, Quinn, Psychological Statistics, New York, John Wiley and Sons, Inc., 1960.

# CHAPTER V

# SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The problem was a study of the effectiveness of overhead projectuals and a transparent projection box in teaching orthographic projection. The experimental design of the investigation involved two groups that were matched by mean scores of nonsignificant difference in terms of (a) age of students, (b) previous classroom drafting experience, and (c) degree of familiarization with the technical information to be presented in the study.

After a three-week interim period, the experimental group was presented course content using the same method as the control group with the exception that the experimental method was supplemented with the overhead projectuals and a transparent projection box. Identical post-tests were administered to each group at the conclusion of the four-week instruction period to determine, as indicated by the test scores, if a change in visualization had occurred. At the conclusion of a second four-week period, the identical retest was administered to each group. The retest was administered to determine if an increase in visualization had occurred after the students had translated the principles of orthographic projection into function. If change had occurred, it would be indicated by the test scores.

The Fisher *t* technique for correlated groups was employed to determine whether significant difference existed between the mean scores of the pre-test, post-test, and retest for each group. In order to determine whether a significant difference existed between the mean gain scores of the control group and the experimental group, the Fisher *t* technique for matched groups was utilized.

To test the stated hypotheses, the data were analyzed for the comprehensive test and each of the three unit tests. The comprehensive test score was analyzed to determine the overall ability of the student to visualize problems involving orthographic projection. The unit tests scores were analyzed to determine if there was a significant difference in the mean scores of the two groups on missing line visualization, surface identification, orthographic view identification, and surface visualization.

The purposes of the study were stated as follows:

1. To determine the effectiveness of overhead projectuals and a transparent projection box on the ability of students to visualize orthographic views.

2. To determine the effectiveness of overhead projectuals and a transparent projection box on the ability of students to visualize objects from orthographic projection views.

3. To determine the change in the student's ability to visualize the application of orthographic principles in different units of engineering drawing.

4. To identify those units involving visualization that are most affected by study through application of orthographic principles in different units of engineering drawing.

The collected data were analyzed with respect to testing the following hypotheses:

I. The control group will make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views.

II. The experimental group will make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views.

III. The experimental group will make a significantly greater mean gain than will the control group from the pre-test to the post-test on a comprehensive test of visualization of orthographic views:

A. The experimental group will make a significantly greater mean gain than will the control group as measured by a test of missing lines.

B. The experimental group will make a significantly greater mean gain than will the control group as measured by a test of surface identification.

C. The experimental group will make a significantly greater mean gain than will the control group as measured by a test of visualization of orthographic views.

D. There will be no significant difference in the mean gains of the two groups as measured by a test of visualization of surfaces.

IV. The control group will make a significant mean gain from the post-test to the retest on a comprehensive test of visualization of orthographic views.

V. The experimental group will make a significant mean gain from the post-test to the retest on a comprehensive test of visualization of orthographic views.

VI. The experimental group will make a significantly greater mean gain than will the control group from the post-test to the retest on a comprehensive test of visualization of orthographic views:

A. There will be no significant difference in the mean gain of the two groups as measured by a test of missing lines.

B. There will be no significant difference in the mean gain of the two groups as measured by a test of surface identification.

C. There will be no significant difference in the mean gain of the two groups as measured by a test of visualization of surfaces.

D. The experimental group will make a significantly greater mean gain than will the control group as measured by a test of visualization of third-angle projection.

## Findings

The findings of this study were determined by an analysis of the collected data. The research hypotheses were restated and tested as null hypotheses. When the obtained *t* value reached the .05 level the null hypothesis was rejected and the research hypothesis was accepted. The .05 level was considered significant, while the .01 level was considered highly significant.

1. The first hypothesis stated that the control group would make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views. An analysis of the data indicated that the computed mean gain difference was highly significant at better than the .001 level; therefore, the null hypothesis was rejected.

2. The second hypothesis stated that the experimental group would make a significant mean gain from the pre-test to the post-test on a comprehensive test of visualization of orthographic views. When an analysis of the data indicated that the computed mean gain difference was highly significant at better than the .001 level, the null hypothesis was rejected.

3. The third hypothesis stated that the experimental group would make a significantly greater mean gain than would the control group from the pre-test to the post-test on a comprehensive test of visualization of orthographic views.

An analysis of the data indicated that the computed mean gains of the two groups were of nonsignificant difference; therefore, the null hypothesis could not be rejected.

4. The sub-hypothesis III-A theorized that the experimental group would make a significantly greater mean gain than would the control group as measured by a test of missing lines. However, an analysis of the data indicated that the computed mean gain scores of the two groups were of no significance of difference; therefore, the null hypothesis could not be rejected.

5. The sub-hypothesis III-B indicated that the experimental group would make a significantly greater mean gain than would the control group as measured by a test of surface identification. An analysis of the data indicated that the computed mean gain scores of the two groups were of nonsignificant difference; therefore, the null hypothesis could not be rejected.

6. The sub-hypothesis III-C stated that the experimental group would make a significantly greater mean gain than would the control group as measured by a test of visualization of orthographic views; however, an analysis of the data indicated that there was no significance of difference in the computed mean gain scores of the two groups. Therefore, the null hypothesis could not be rejected.

7. According to sub-hypothesis III-D, there would be no significant difference in the mean gain of the two groups

as measured by a test of visualization of surfaces. When an analysis of the data indicated there was nonsignificant difference in the computed mean gain scores of the two groups, the research hypothesis was accepted.

8. The fourth hypothesis stated that the control group would make a significant mean gain from the post-test to the retest on a comprehensive test of visualization of orthographic views. When an analysis of the data indicated that the computed mean gain difference was highly significant at better than the .001 level, the null hypothesis was rejected.

9. The fifth hypothesis indicated that the experimental group would make a significant mean gain from the post-test to the retest on a comprehensive test of orthographic views. An analysis of the data indicated that the computed mean gain difference was highly significant at better than the .001 level; therefore, the null hypothesis was rejected.

10. The sixth hypothesis theorized that the experimental group would make a significantly greater mean gain than would the control group from the post-test to the retest on a comprehensive test of visualization of orthographic views. An analysis of the data indicated that the computed mean gains of the two groups were of nonsignificant difference; therefore, the null hypothesis could not be rejected.

11. The sub-hypothesis VI-A stated that there would be no significant difference in the mean gain of the two groups as measured by a test of missing lines. When an analysis of

the data indicated that there was no significance of difference in the computed mean gain scores of the two groups, the research hypothesis was accepted.

12. The sub-hypothesis VI-B stated that there would be no significant difference in the mean gain of the two groups as measured by a test of surface identification. An analysis of the data indicated that the computed mean gains of the two groups were of nonsignificant difference; therefore, the research hypothesis was accepted.

13. The sub-hypothesis VI-C theorized that there would be no significant difference in the mean gain of the two groups as measured by a test of visualization of surfaces. When an analysis of the data indicated that there was nonsignificant difference in the computed mean gain scores of the two groups, the research hypothesis was accepted.

14. The sub-hypothesis VI-D indicated that the experimental group would make a significantly greater mean gain than would the control group as measured by a test of visualization of third-angle projection. An analysis of the data indicated that there was no significant difference in the computed mean gain scores of the two groups; consequently, the null hypothesis could not be rejected.

## Conclusion

The following conclusion was drawn from an analysis of the findings of the study.

Either method utilized in this study will be equally effective in teaching orthographic projection.

Inferences

It was hypothesized that a teaching method supplemented with overhead projectuals and a transparent projection box would be more effective in presenting orthographic projection than a teaching method that did not utilize these visual aids. The findings of the study indicate there were nonsignificant differences in the two teaching methods when measured by mean gain scores.

On the basis of the findings and the conclusions, the following inferences were drawn.

1. The attitude of each instructor toward the experimental study was important. It is possible that, in spite of the controls provided, the attitude of some of the instructors involved in the study was not positive and could have affected the study.

2. In the study, it was essential for each instructor to be skilled in the utilization of the overhead projectuals and the projection box. In spite of the orientation given each instructor concerning the use of the visual aids before and during the study, it is possible the degree of skill of each participating instructor to manipulate and to correlate the projectuals and the projection box into the teaching

situation may have varied. This variable could possibly be the reason the effectiveness of the two instructional methods appear to be equal.

3. The four-week instruction period may have been too short a period of time to evaluate the experimental variable.

4. The chalkboard drafting machine was utilized to draw the example problems for the control group. It is possible a significant difference between the two groups might have existed had the instructor sketched the example problems freehand on the chalkboard.

## Recommendations

On the basis of the findings, it is recommended that

1. A study should be conducted to investigate the effectiveness of overhead projectuals and a transparent projection box as separate variables in teaching orthographic projection.

2. Future study should investigate the effectiveness of the reference plan method of projection as compared to the effectiveness of the forty-five degree miter method of projection on teaching orthographic projection.

3. Research should be conducted to construct and standardize a new comprehensive test for measuring orthographic drafting ability.

4. A study should be conducted to determine the relationship between the attitude of the student toward drafting courses, drafting ability, and student creativity.

5. Further research should be conducted to determine if student success in drafting is correlated with student success in mathematics.

6. A study should be conducted to investigate success in industrial arts engineering drafting as related to industrial arts majors, interior design majors, art majors, and pre-engineering majors.

Folder No. 92

APPENDIX A

UNIT TESTS IN ENGINEERING DRAWING

# ORTHOGRAPHIC PROJECTION I

Form A

PREPARED BY

THE A.S.E.E. COMMITTEE ON ADVANCED CREDITS, DRAWING DIVISION

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IN COOPERATION WITH
THE EDUCATIONAL TESTING SERVICE

## DIRECTIONS

The questions which refer to the drawings in this folder are on a separate sheet. Your answers will be recorded in the appropriate spaces on the question sheet. Letter your name and the other information called for in the blanks on the question sheet, then finish reading these directions.

In this test you will find some questions which are easy and some which may be difficult for you. If you have no idea of the correct answer to a question, omit it and go on to questions you do understand. If you think you know the answer to a question but are not sure, it will be to your advantage generally to indicate your answer.

Make no unnecessary marks. If you change an answer, erase your first mark completely. Do not fold or crease your question sheet. MAKE NO MARKS ON ANY PAGE OF THIS FOLDER.

Further directions may be found on the question sheet and preceding the drawings in this folder.



**DO NOT OPEN THIS FOLDER UNTIL YOU ARE TOLD TO DO SO BY THE EXAMINER**

**DIRECTIONS**: Each of the three-view drawings given below is incomplete because one line is missing. The missing line may represent a visible or invisible surface or an intersection of surfaces, and may occur in the front, the top, or the side view. Five possible positions for the one missing line are indicated in each drawing by lettered points. Select the proper location of this missing line by choosing one of the five indicated positions. On the question sheet, identify your choice by marking an X in the box having the same number as the answer you select.

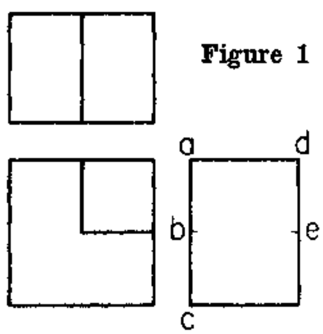



**Figure 1**

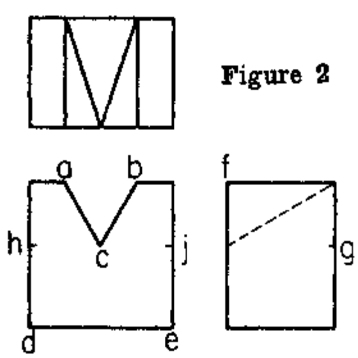



**Figure 2**

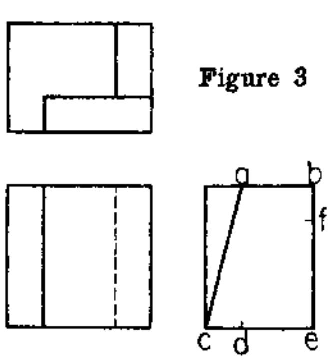



**Figure 3**

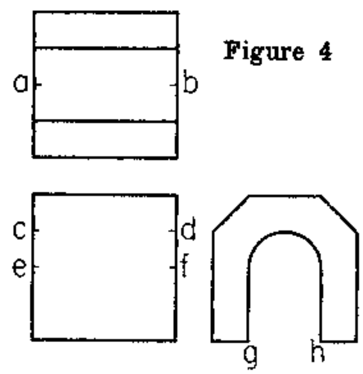



**Figure 4**

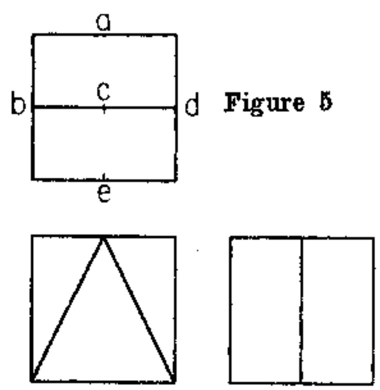



**Figure 5**

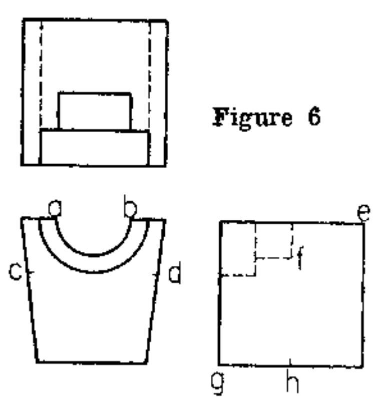



**Figure 6**

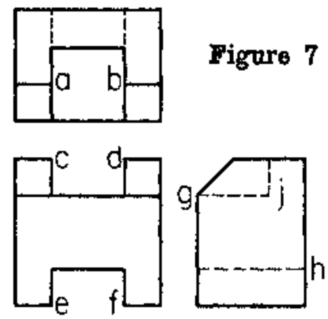



**Figure 7**

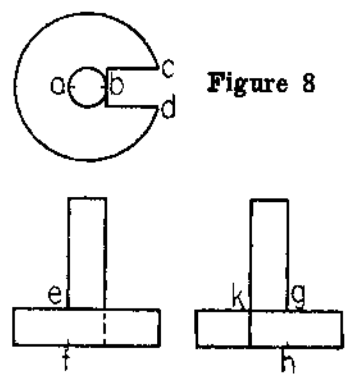



**Figure 8**

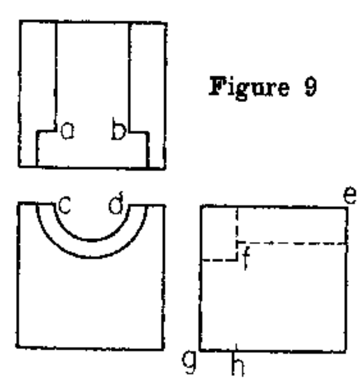



**Figure 9**

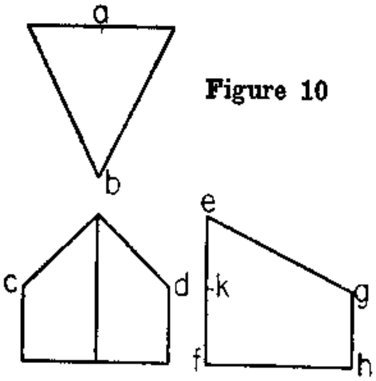



**Figure 10**

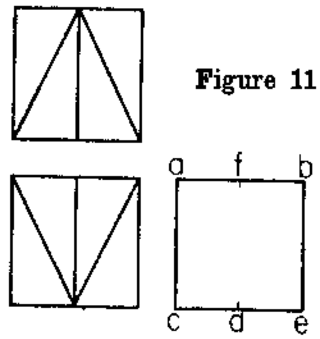



**Figure 11**

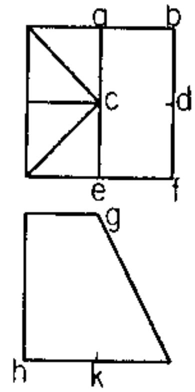



**Figure 12**

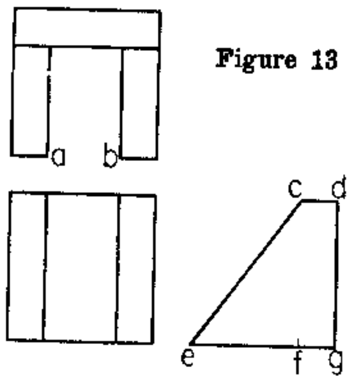



**Figure 13**

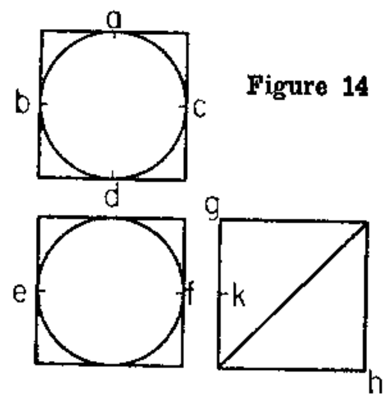
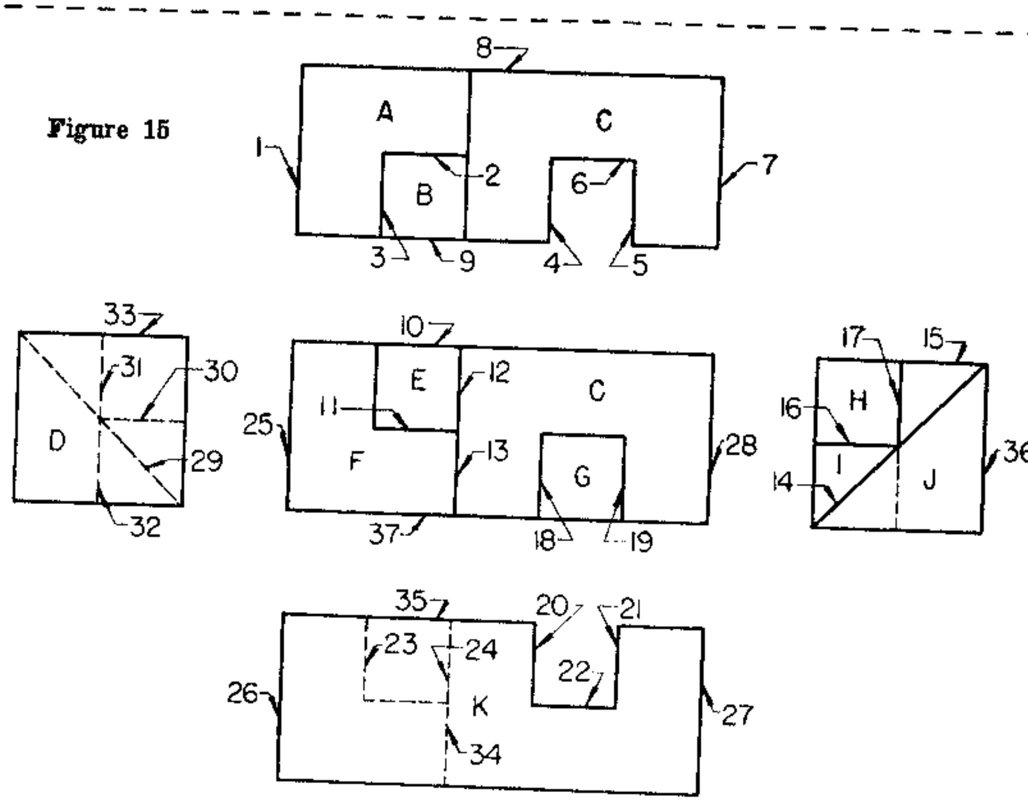



**Figure 14**

**DIRECTIONS**: In the figure below are five orthographic views of an object on which the visible surfaces are indicated by letters. The numbers identify the surfaces where they appear as lines. In problems 15 through 25 select the number, if any, which identifies the given surface in one of the other views.

**Figure 15**



Folder No. 92

UNIT TESTS IN ENGINEERING DRAWING

# ORTHOGRAPHIC PROJECTION II

Form A

PREPARED BY

THE A.S.E.E. COMMITTEE ON ADVANCED CREDITS, DRAWING DIVISION

RALPH S. PAFFENBARGER, Chairman, The Ohio State University
WEBSTER M. CHRISTMAN, JR., University of Wisconsin (Milwaukee Division)
MAURICE GRANEY, Purdue University
RANDOLPH P. HOELSCHER, University of Illinois
JOHN M. RUSS, The State University of Iowa

IN COOPERATION WITH
THE EDUCATIONAL TESTING SERVICE

## DIRECTIONS

The questions which refer to the drawings in this folder are on a separate sheet. Your answers will be recorded in the appropriate spaces on the question sheet. Letter your name and the other information called for in the blanks on the question sheet, then finish reading these directions.

In this test you will find some questions which are easy and some which may be difficult for you. If you have no idea of the correct answer to a question, omit it and go on to questions you do understand. If you think you know the answer to a question but are not sure, it will be to your advantage generally to indicate your answer.

Make no unnecessary marks. If you change an answer, erase your first mark completely. Do not fold or crease your question sheet. MAKE NO MARKS ON ANY PAGE OF THIS FOLDER.

Further directions may be found on the question sheet and preceding the drawings in this folder.



**DO NOT OPEN THIS FOLDER UNTIL YOU ARE TOLD TO DO SO BY THE EXAMINER**

**DIRECTIONS**: Figures 1 through 8 are three-view drawings of objects. Some of the surfaces shown in the drawings are identified by a letter and a subscript. The subscript "v" indicates a visible surface; the subscript "i" indicates an invisible surface. For each question, select the statement which applies to the given drawing, and mark your question sheet accordingly.

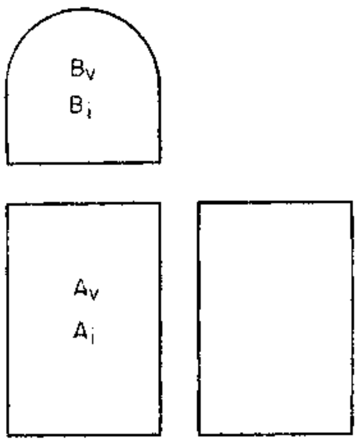



FIG.-1

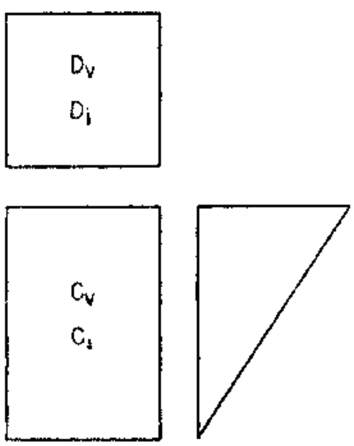



FIG-2

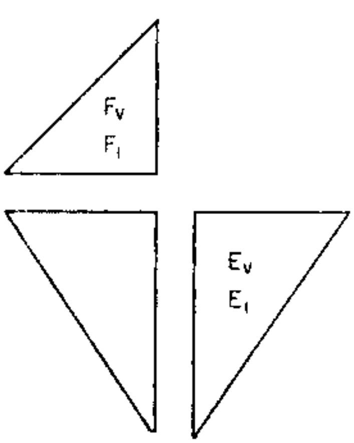



FIG-3

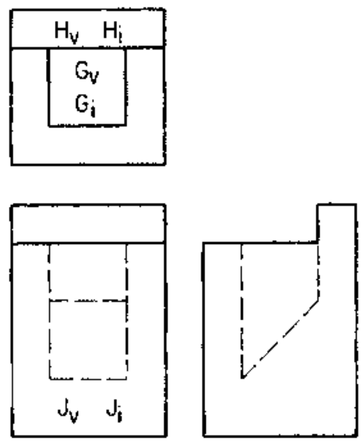



FIG.-4

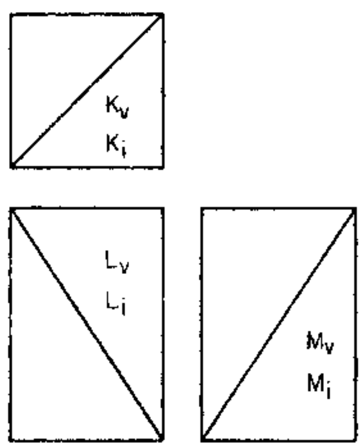



FIG-5

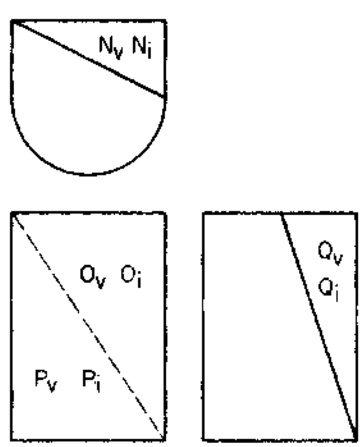



FIG.-6

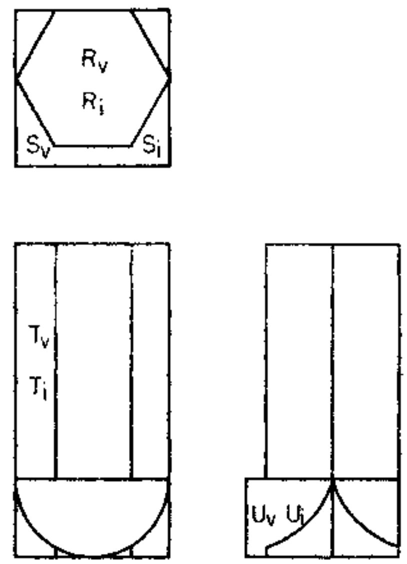



FIG.-7

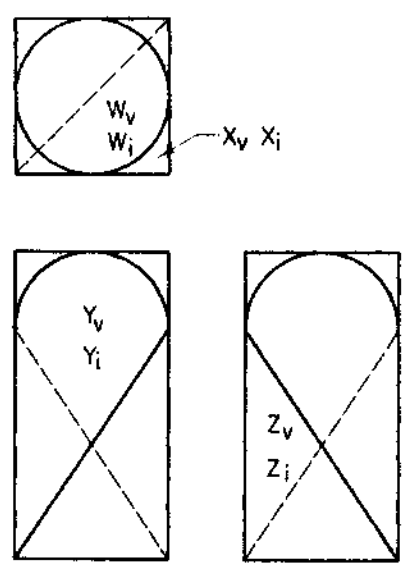



FIG.-8

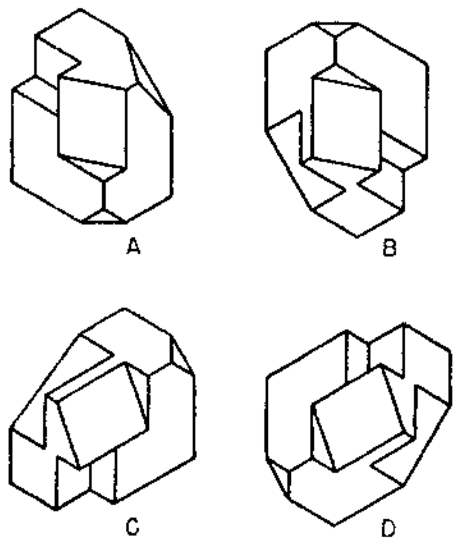



FIG-9

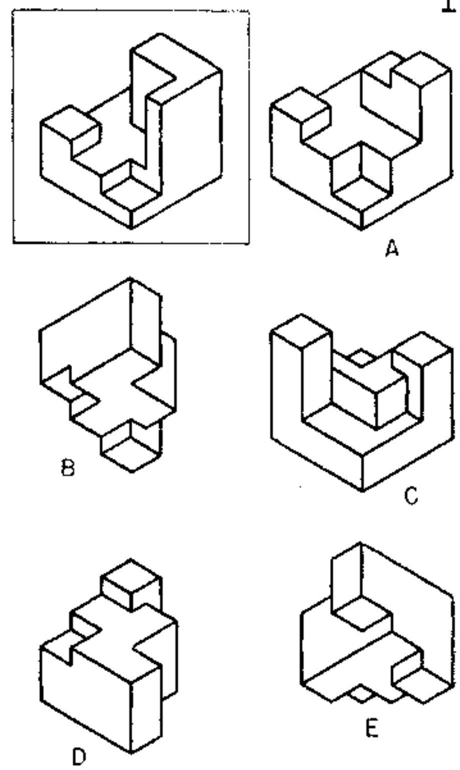



FIG-11

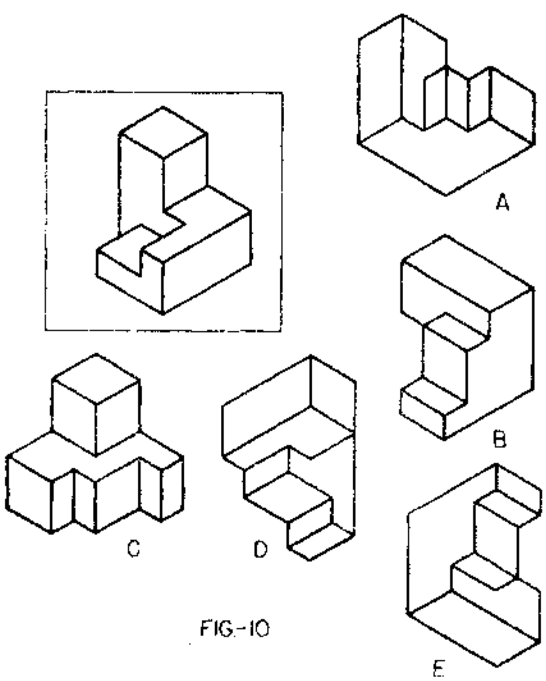



FIG-10

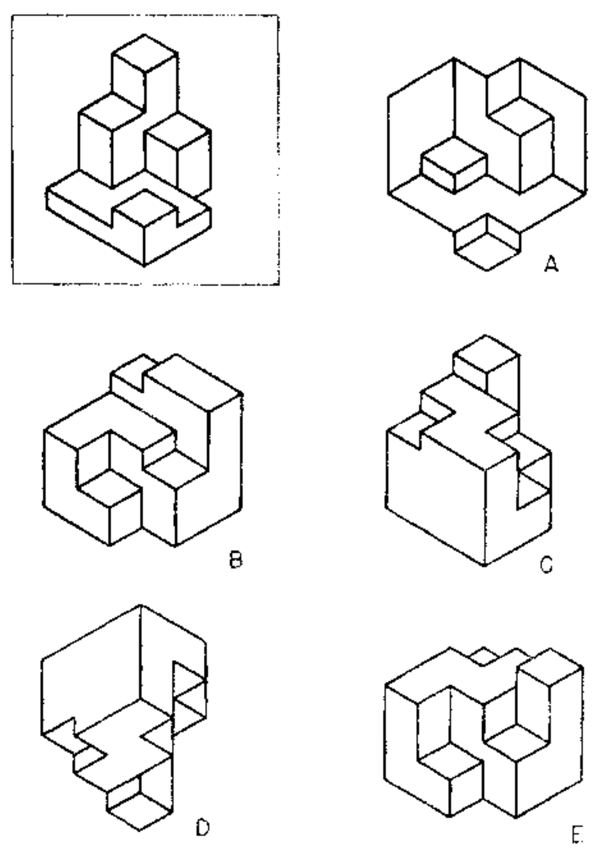



FIG-12

Folder No. 91

UNIT TESTS IN ENGINEERING DRAWING

# ORTHOGRAPHIC PROJECTION III

**Form A**

PREPARED BY

THE A.S.E.E. COMMITTEE ON ADVANCED CREDITS, DRAWING DIVISION

Ralph S. Paffenbarger, Chairman, The Ohio State University
Webster M. Christman, Jr., University of Wisconsin (Milwaukee Division)
Maurice Graney, Purdue University
Randolph P. Hoelscher, University of Illinois
John M. Russ, The State University of Iowa

IN COOPERATION WITH

THE EDUCATIONAL TESTING SERVICE

## DIRECTIONS

The questions which refer to the drawings in this folder are on a separate sheet. Your answers will be recorded in the appropriate spaces on the question sheet. Letter your name and the other information called for in the blanks on the question sheet, then finish reading these directions.

In this test you will find some questions which are easy and some which may be difficult for you. If you have no idea of the correct answer to a question, omit it and go on to questions you do understand. If you think you know the answer to a question but are not sure, it will be to your advantage generally to indicate your answer.

Make no unnecessary marks. If you change an answer, erase your first mark completely. Do not fold or crease your question sheet. MAKE NO MARKS ON ANY PAGE OF THIS FOLDER.

Further directions may be found on the question sheet and preceding the drawings in this folder.



**DO NOT OPEN THIS FOLDER UNTIL YOU ARE TOLD TO DO SO BY THE EXAMINER**

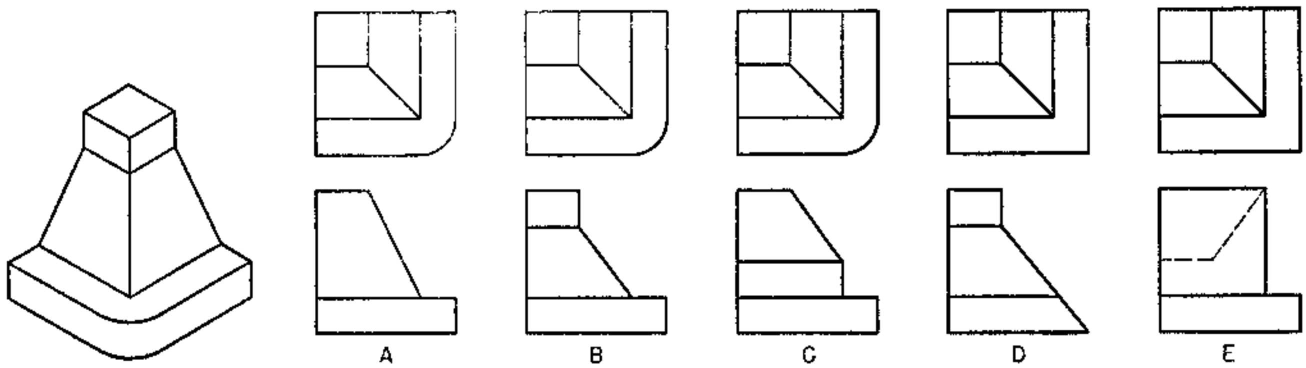



FIG - I

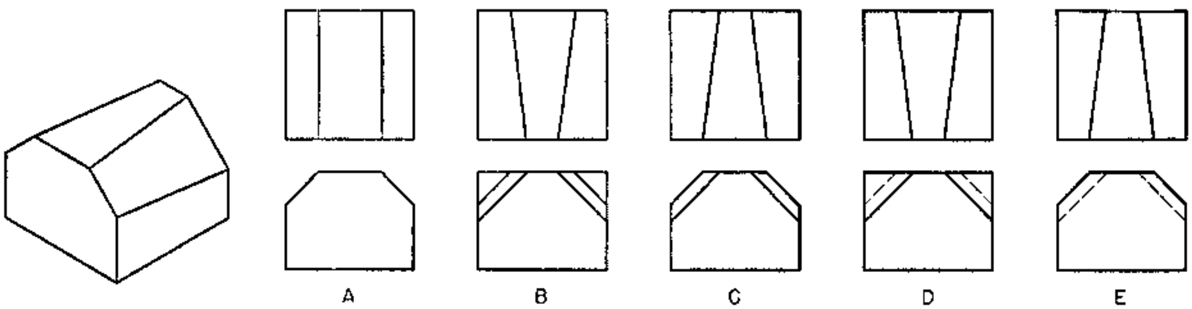



FIG.-2

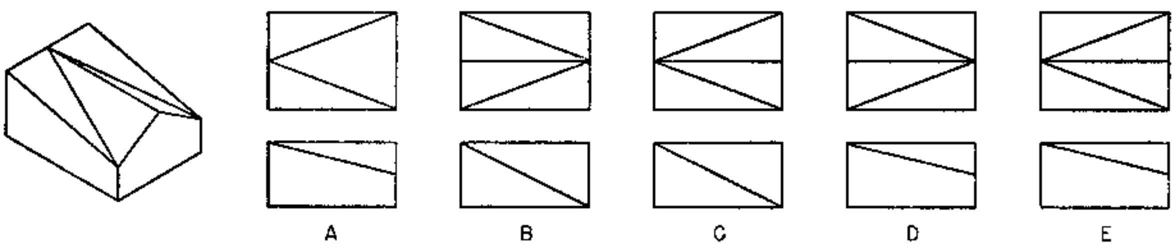



FIG.-3

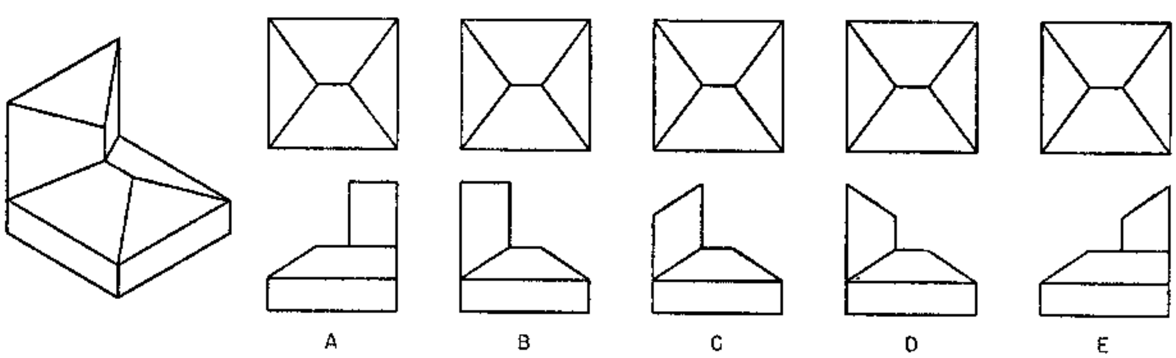
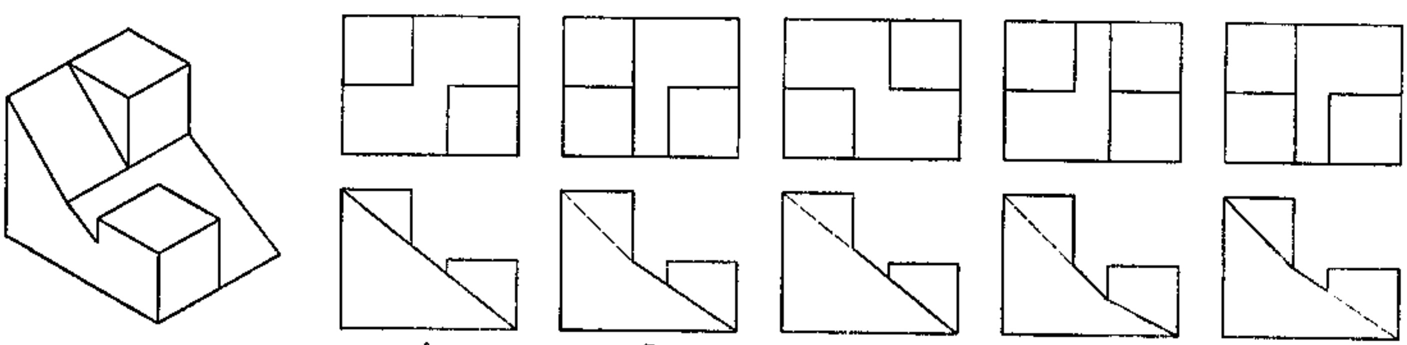



FIG.-4



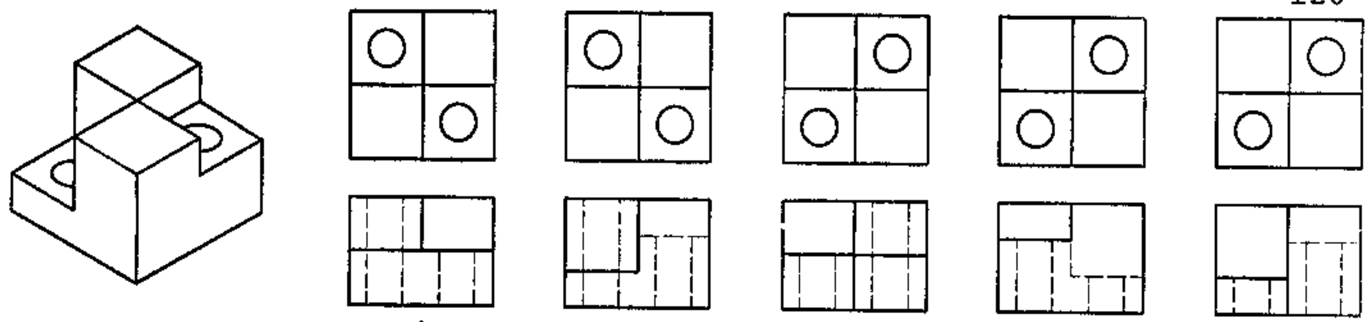



FIG.-6

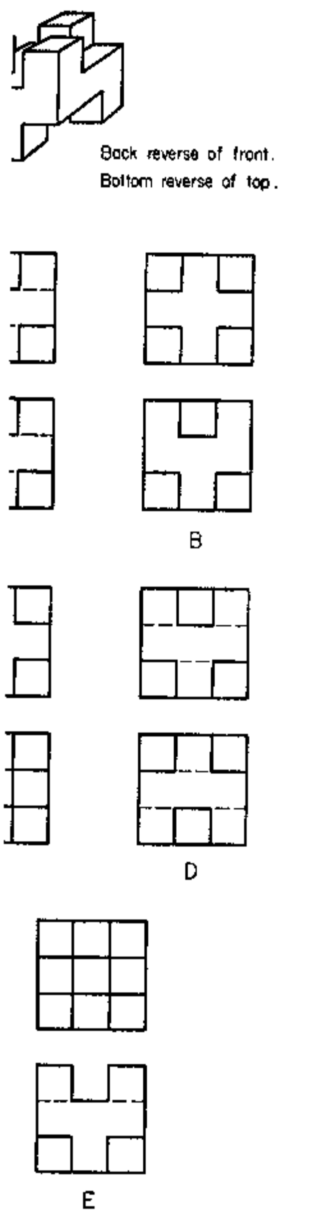



FIG.-7

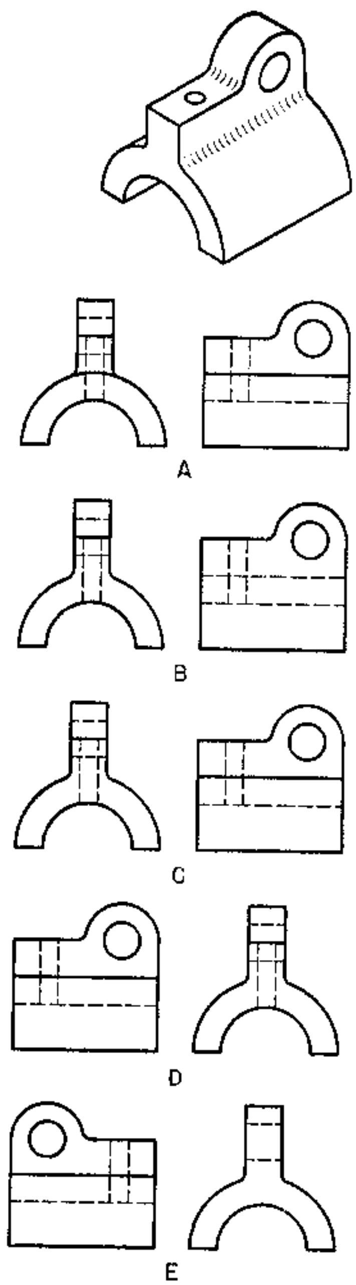



FIG.-8

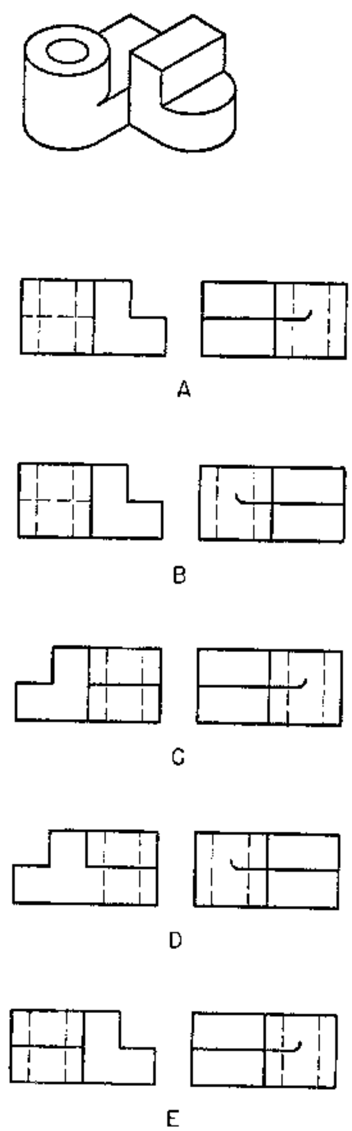



FIG.-9

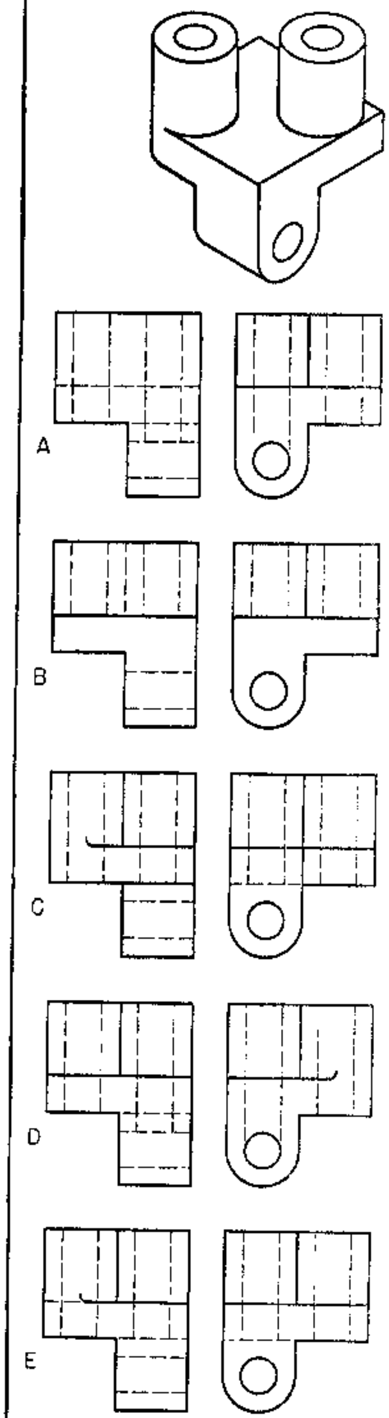



FIG.-10

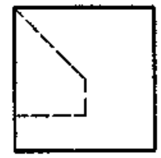
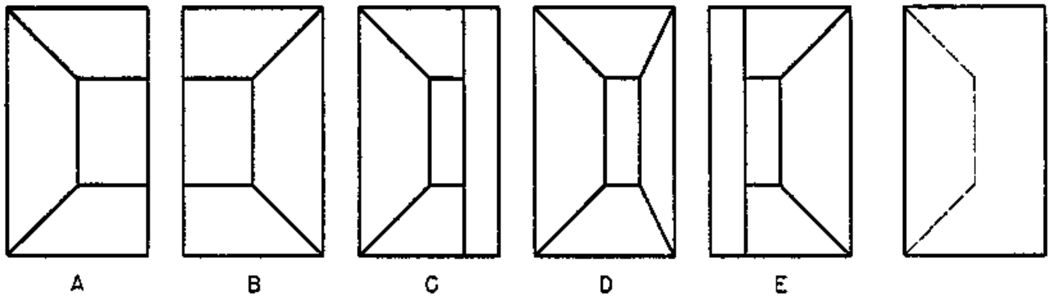


FIG.-11



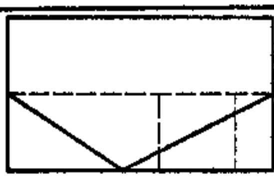
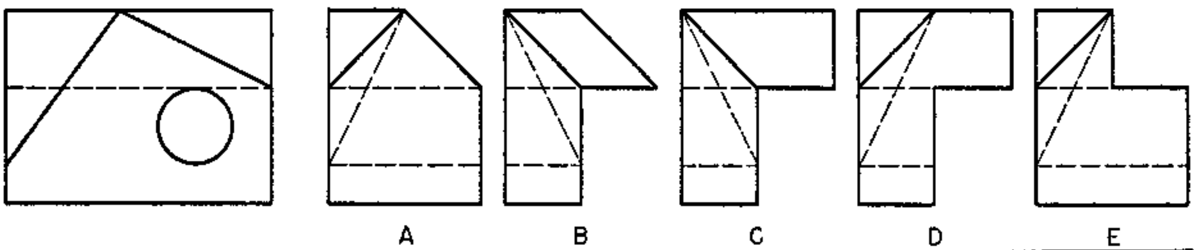



FIG.-12



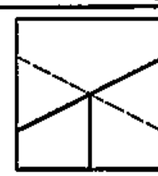
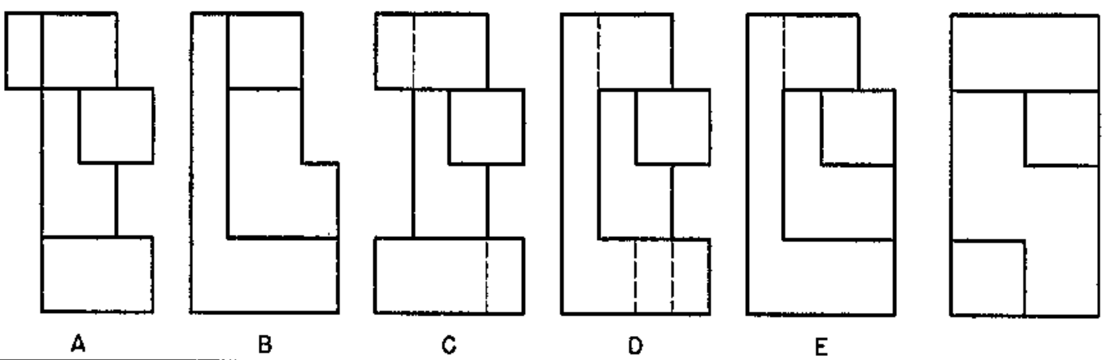



FIG.-13



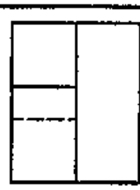
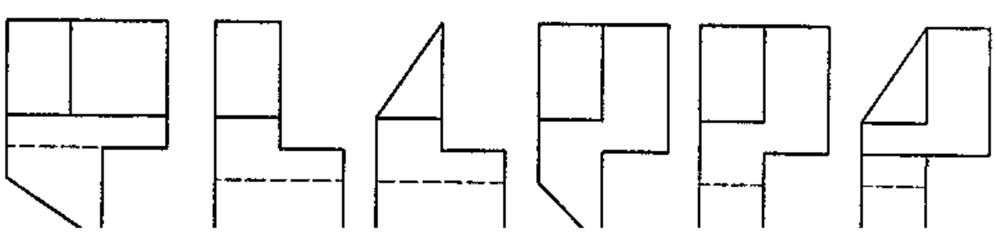



FIG.-14



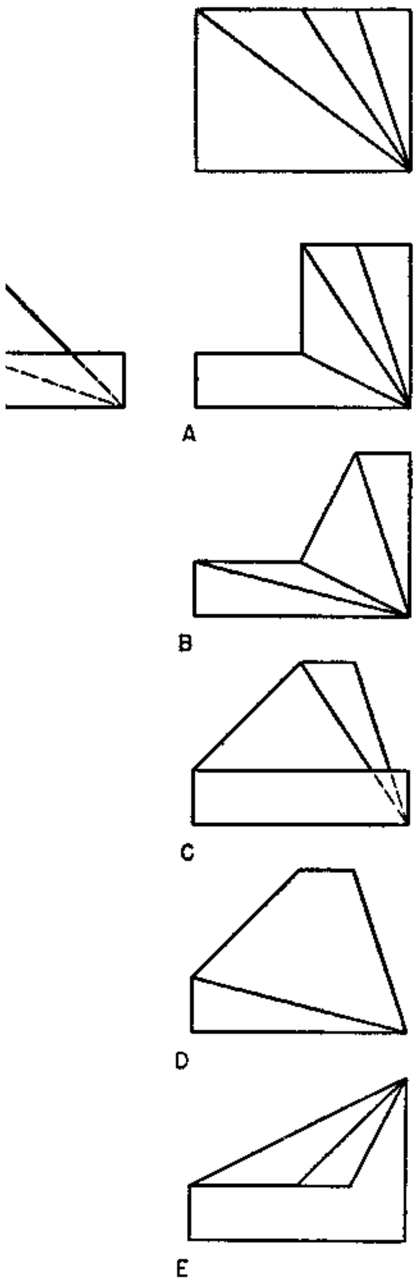


FIG.-15

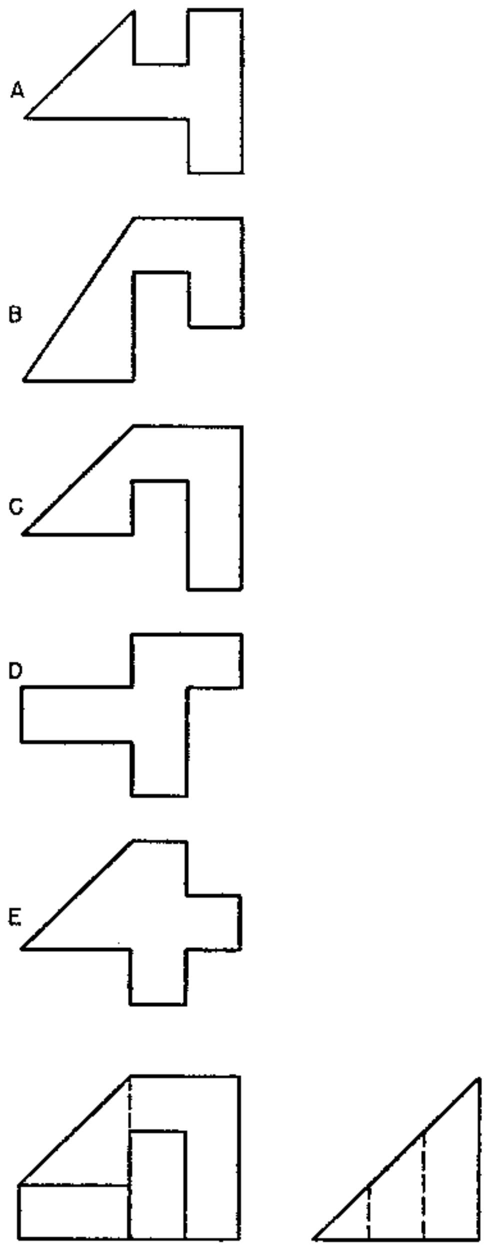


FIG.-16

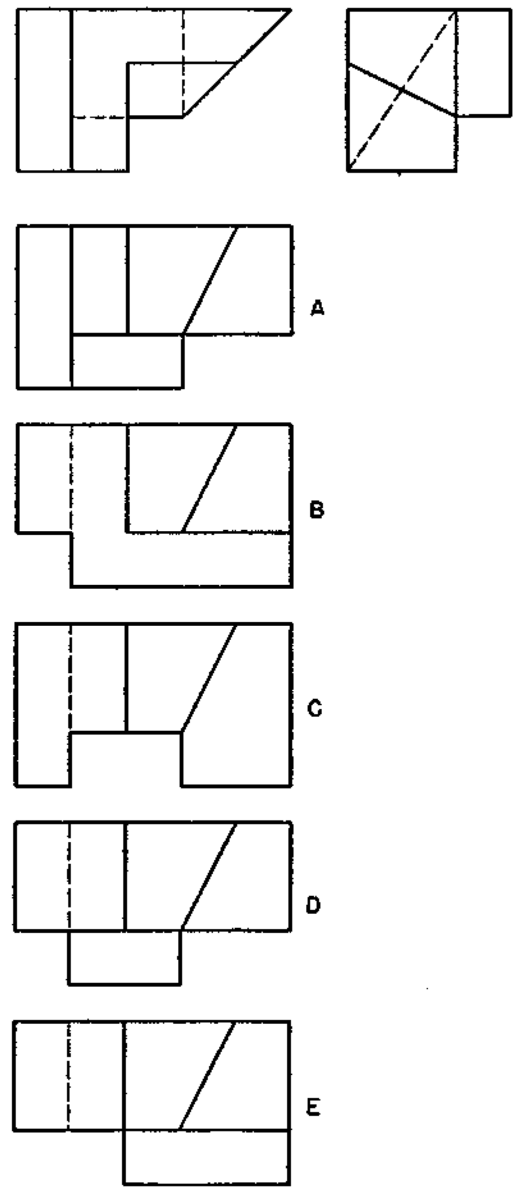


FIG.-17

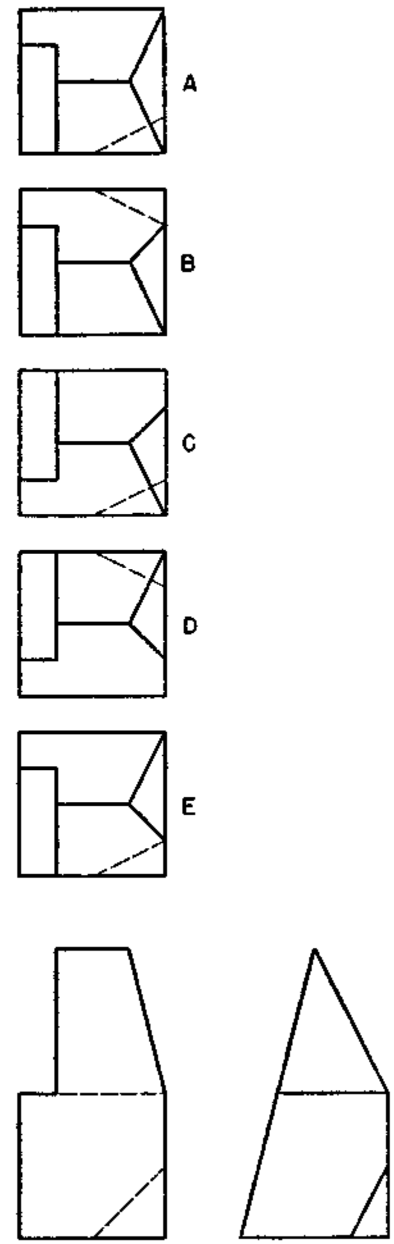


FIG.-18

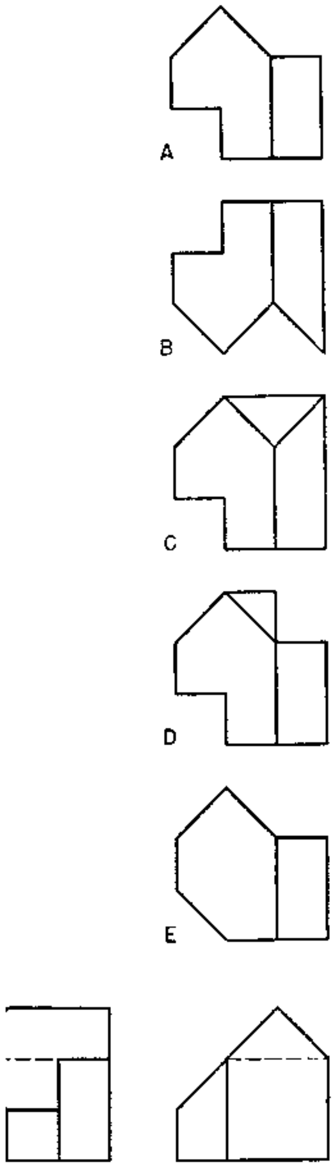



FIG.-19

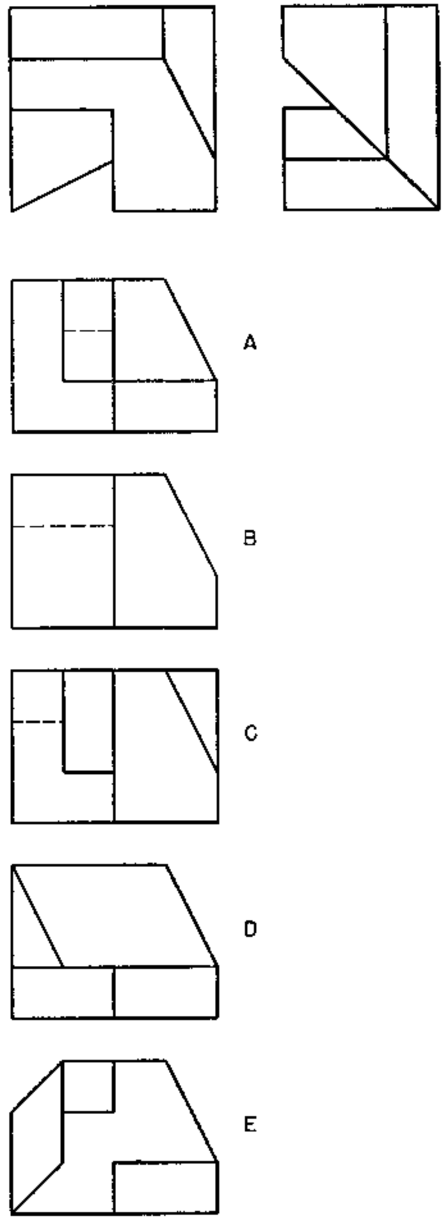



FIG.-20

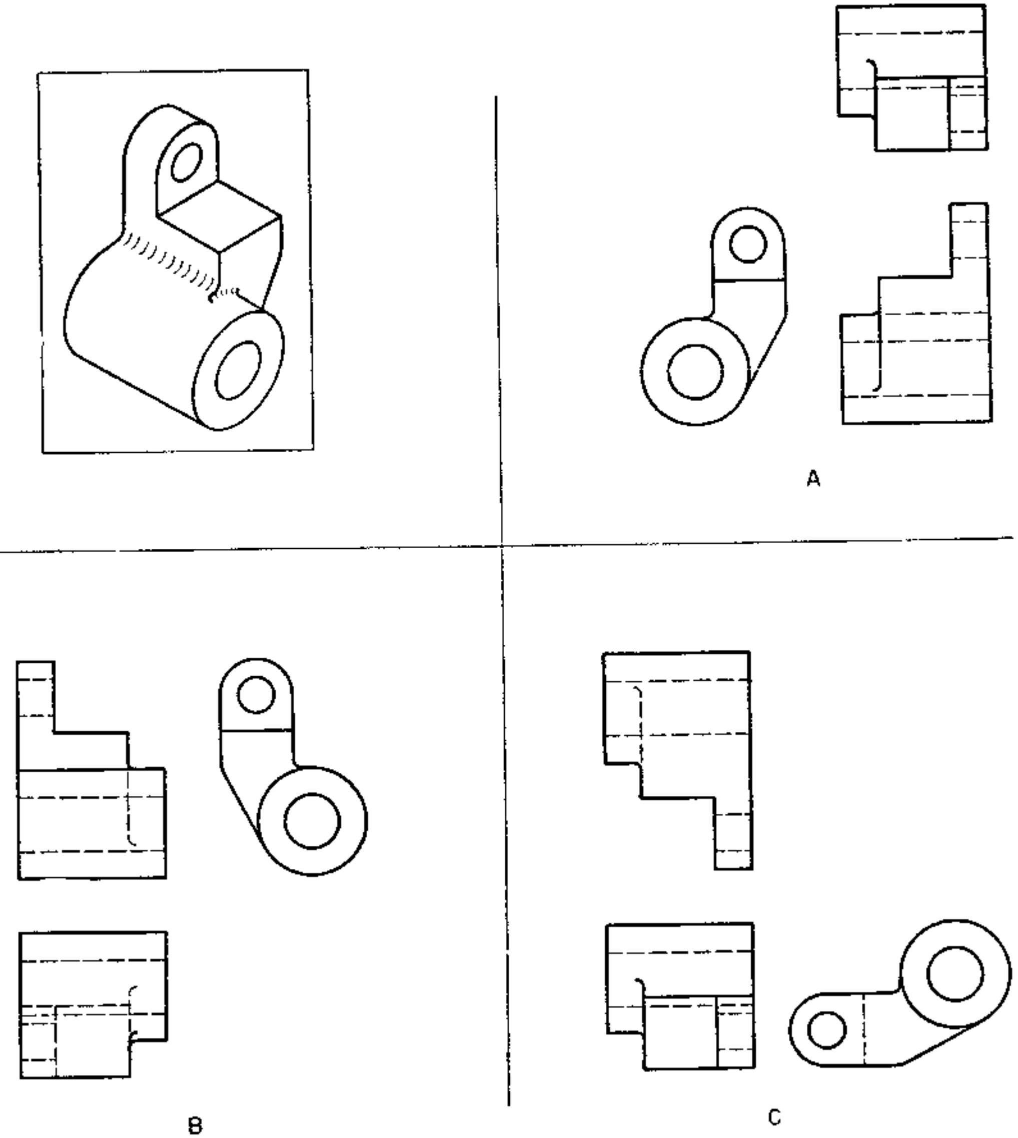



FIG.-21

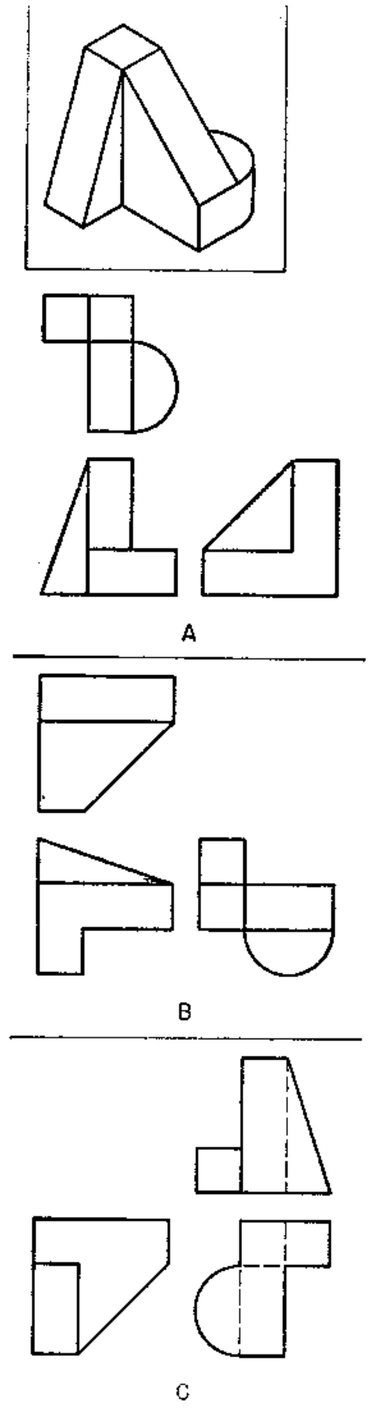



FIG.-22

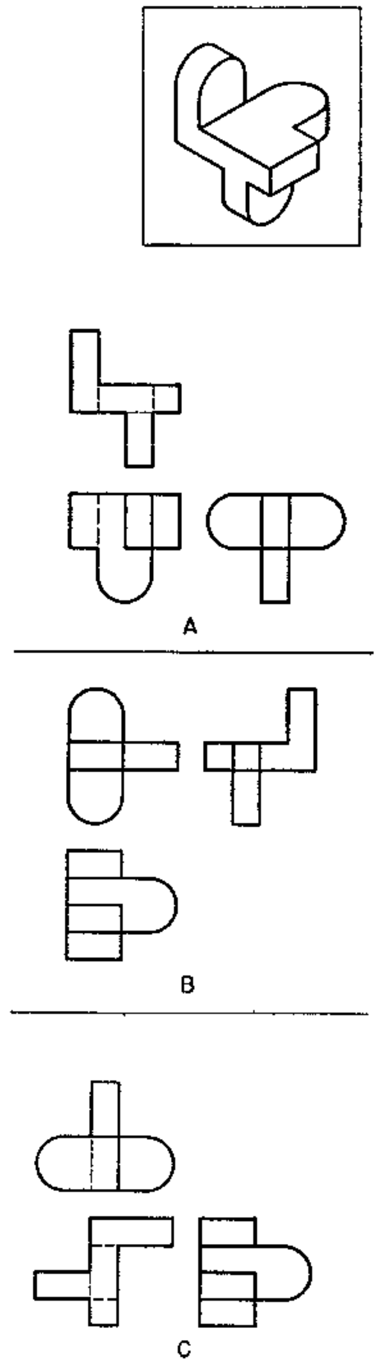



FIG.-23

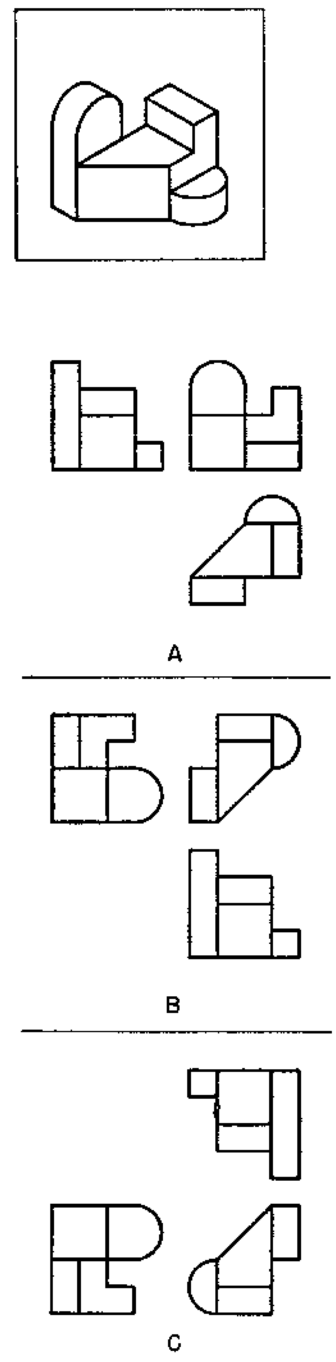



FIG.-24

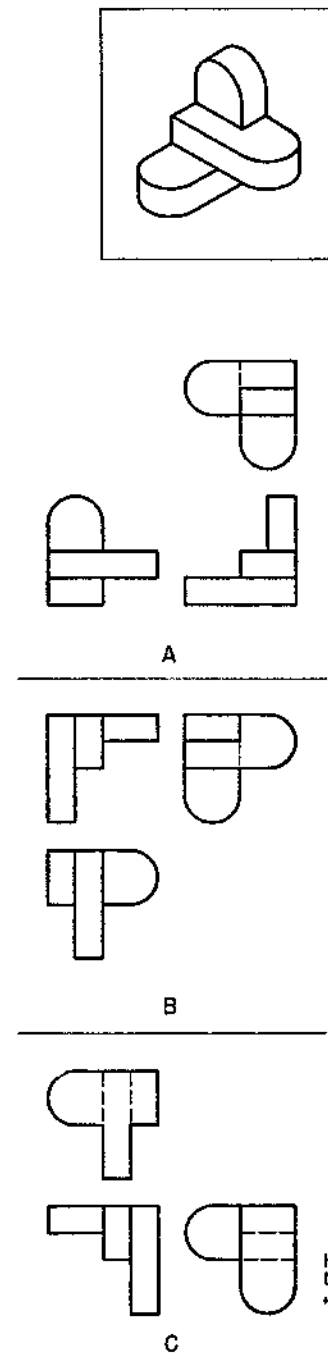



FIG.-25

## APPENDIX B

### LESSON PLAN NO. 1

Instructional Unit - Space dimensions

Type - Lecture and demonstration

Time Allotted - Experimental 20 minutes, Control 25 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk.

Instructional Media for Experimental - One overhead projector, one screen, one projection stand, one projection box, overlays # 1 and #2, model blocks #1 and #2, and the same media as the control group.

Reference - Giesecke, Mitchell, Spencer, and Hill, *Technical Drawing*, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, *Drafting Fundamentals*, College Station, Texas, Texas A & M University, 1965.

Study Assignment - Pages 129 - 140

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and notebook to register lecture notes.

Next Reading Assignment - Pages 139 - 143, 147 - 149, and 191 - 192

Space Dimensions and Sketching

Orthographic Problems

I. Presentation (Lecture and Demonstration)

A. Introduction (Experimental 2 minutes, Control 2 minutes)

1. Objectives

a. To teach students the correct space dimensions and their relationships to each view

b. To teach students how to express mechanical ideas through the medium of a freehand sketch

2. Reason

a. Students must acquire a thorough understanding of space dimensions and their relationships to each orthographic view before solving orthographic projection problems

b. Students must develop the ability to sketch objects correctly and proportionally

3. Review of Previous Instruction

a. Correct pencil for sketching

b. Method of sketching horizontal lines

c. Method of sketching vertical lines

d. Rules for sketching

B. Explanation and Demonstration (Experimental 12 minutes, Control 12 minutes)

* The projectuals are used only with the experimental group

1. Explain the three space dimensions and their relationships to each view (Projectual #1)

   a. Each orthographic view has only two space dimensions

   b. Each view is represented as appearing flat on a two dimensionsl surface

2. Explain the method of sketching orthographic views (Projectual #2 and model block #1 and #2)

   a. Block in front, top, and side view in correct position for model block #1

   b. Allow room between views for dimension lines

   c. Remove the notches in the front view

   d. Darken in object lines

   e. Label each view with the correct space dimension word (Height, Width, and Depth)

   f. Show by the arc method and by vertical and horizontal lines that the space dimensions are the same on each corresponding view

C. Demonstration

   * The projection box is used only with the experimental group

   1. Remove the folding planes from the projection box

   2. Insert model block #1 which is the object to be sketched

   3. Repeat the same sequence for both explanation and demonstration for model block #2

II. Review or Critique (Experimental 5 minutes, Control 5 minutes)

A. Summarize the lesson

1. Review the three views and their space dimensions

2. Review the method of sketching orthographic projection problems

B. Discussion Questions

* Use the projection box for reference when discussing the questions

1. What pencil should be used in sketching?

   Answer - F or HB

2. What important principle must be kept in mind when sketching?

   Answer - Keep the sketch in proportion

3. Are sketches made to a certain scale?

   Answer - No, only to proportion

4. What are the three principle views of an object?

   Answer - Front View, Top View, Right Side View or End View

5. What space dimensions are shown on the top view?

   Answer - Width and Depth

6. What space dimensions are shown on the front view?

   Answer - Height and Width

7. What space dimensions are shown on the right side view?

   Answer - Height and Depth

8. What is the first step in sketching an orthographic problem?

   Answer - Block in each view

III. Application (Experimental and Control 1 minutes)

A. Assign students problems 13 and 14 in the workbook

B. The supplementary problem will be to sketch the demonstration model block in isometric on the back of one of the workbook problems

C. Problems are due at the end of the period

D. Instructor's Activities

1. Supervise the class by observing the work of students

2. Individual attention is given to each student and his particular problem *

* Individual student questions will be answered at this time. This procedure will prevent student questioning from extending the prescribed lecture and demonstration period.

# LESSON PLAN NO. 2

Instructional Unit - Location of views

Type - Lecture and demonstration

Time Allotted - Experimental 30 minutes, Control 40 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk

Instructional Media for Experimental - One overhead projector, one screen, one projector stand, one projection box, overlays #2, 3, 4, 5, and #6, model blocks #3 and #4, and the same media as the control group

Reference - Giesecke, Mitchell, Spencer and Hill, Technical Drawing, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, Drafting Fundamentals, College Station, Texas, Texas A & M University, 1965.

Study Assignment - Pages 139 - 143, 147 - 149, and 191 - 192

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and notebook to register lecture notes

Next Reading Assignment - Pages 147 - 152

Location of Views and Sketching

Orthographic problems

I. Presentation (Lecture and Demonstration)

A. Introduction (Experimental 2 minutes, Control 2 minutes)

1. Objectives

a. To teach students how to correctly identify each orthographic view

b. To teach students the correct location of each orthographic view

c. To teach students how to distinguish between first and third angle projection

d. To teach students how to correctly sketch orthographic projection problems

2. Reason

a. Students must have a working knowledge of first and third angle projection for correct placement of views

b. Students must be able to sketch objects in proportion for correct orthographic representation

3. Review of Previous Instruction

a. Review space dimensions and the location an relationship of each to the orthographic views

b. Review the correct pencil and steps used in sketching

B. Explanation and Demonstration

(Experimental 20 minutes, Control 20 minutes)

** The projectuals are used only with the <u>experimental group</u>

1. Explain that orthographic projection is the engineer's method of drawing three dimensional objects on a two dimensional surface (Projectual #3)

2. This is visualized by imaginining the object inside a glass box and the views are projected perpendicularly onto the panes of the box (Projectual #3)

3. Image the panes are opened onto one flat surface. This gives the positions of each view in orthographic projection (Projectual #3 and #4)

4. Note that each dimension (height, width and depth) are common to two views. Note the location of each dimension (Projectual #1)

5. Explain the difference between First and Third angle projection

   a. Explain that in third angle projection the top view is logically placed over the front view and the right side view is placed to the right of the front view (Projectual #5)

   b. Explain that in first angle projection the right side view is on the left of the front view and the top view is below the front view. This is because the object is above the reference planes (Projectual #5)

6. Explain the method of sketching orthographic views (Projectual #2 and model blocks #3 and #4)

   a. Block in front, top, and side views in the correct location (Block #3)

   b. Allow room between views for dimension lines

   c. Remove unnecessary lines and add correct object lines

   d. Darken object lines

e. Label each view with the correct space dimension

f. Show by the arc method and by vertical and horizontal lines that the space dimensions are the same for each corresponding view location

C. Demonstration

* The projection box is used only with the experimental group

1. Use the projection box to illustrate opening each side outwardly to form one plane

2. Use the projection box to demonstrate how the top view is above the front view and the right side view is to the right of the front view in third angle projection

3. Use the projection box to demonstrate the difference between first and third angle projection. Remove the third angle projection planes and insert the first angle projection planes when illustrating the two methods

4. Use the projection box to illustrate the correct space dimensions after the views are folded outward

5. Place model block #3 in the projection box to be sketched

6. When finished sketching the model block insert the correct orthographic view in the pockets to check the sketch

7. Repeat the same sequence for both the explanation and demonstration for sketching model block #4

II. Review or Critique
(Experimental 7 minutes, Control 7 minutes)

A. Summarize the lesson

1. Review the location of the orthographic views

2. Review with the projection box the placement of views by unfolding each side

3. Review difference between first and third angle of projection

4. Review the space dimensions of each view

5. Review the method of sketching orthographic projection problems

B. Discussion Questions

* Use the projection box for discussing questions 1 - 6. Use overlay #5 for questions 7 - 10. Use overlay #6 for question 11.

1. What is the name of this view?

   Answer - Top view

2. What are its' space dimensions?

   Answer - Width and depth

3. What is the name of this view?

   Answer - Front view

4. What are its' space dimensions?

   Answer - Width and depth

5. What is the name of this view?

   Answer - Right side view

6. What are its' space dimensions?

   Answer - Height and depth

7. Where is the top view located in relation to the front view in third angle projection?

   Answer - Directly above the front view

8. Where is the right side view located in relation to the front view in third angle projection?

   Answer - Directly to the right side of the front view

9. Where is the right side view located in relation to the front view in first angle projection?

   Answer - Directly to the left side of the front view

10. Where is the top view located in relation to the front view in first angle projection?

    Answer - Directly below the front view

11. What angle of projection are these?

    Answer - a. Third
    b. First
    c. First
    d. Third

III. Application (Experimental and Control 2 minutes)

A. Assign students problems 15 and 17 in the workbook

B. The supplementary problem will be to sketch one of the demonstration problems in isometric on the back of one of the workbook problems

C. Problems are due at the end of the period

D. Instructor's Activities

1. Supervise the class by observing the work of students

2. Individual attention is given to each student and his particular problem *

   * Individual student questions will be answered at this time. This procedure will prevent student questioning from extending the prescribed lecture and demonstration period.

# LESSON PLAN NO. 3

Instructional Unit - Sketching

Type - Lecture and demonstration

Time Allotted - Experimental 14 minutes, Control 18 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk

Instructional Media for Experimental - One overhead projector, one screen, one projector stand, one projection box, overlays #2 and #7, and the same media as the control group

Reference - Giesecke, Mitchell, Spencer, and Hill, *Technical Drawing*, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, *Drafting Fundamentals*, College Station, Texas, Texas A & M University, 1965.

Study Assignment - Pages 147 - 152

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and note book to register lecture notes

Next Reading Assignment - Pages 160 - 173

Sketching

I. Presentation (Lecture and demonstration)

A. Introduction
(Experimental $1\frac{1}{2}$ minutes, Control $1\frac{1}{2}$ minutes)

1. Objectives

a. To teach the student how to sketch in proportion

b. To teach the student how to sketch arcs and circles in orthographic views

c. To develop student ability to visualize objects pictorially from orthographic views

2. Reason

a. Sketches are never made to scale but must always be in proportion

b. The ability to visualize objects is improved when the student can sketch the object both pictorially and orthographically

B. Explanation and Demonstration
(Experimental 8 minutes, Control 8 minutes)

* The projectuals are used only with the <u>experimental group</u>

1. Explain the methods of sketching a circle or an arc by the use of radius marks (Projectual #2)

2. Explain how to measure on the orthographic view and transfer the distance to the pictorial view (Projectual #2 and #7)

C. Demonstration

1. Demonstrate how to sketch pictorial drawings from orthographic views (Projectual #7)

2. Demonstrate how to obtain a third orthographic view from a pictorial sketch (Projectual #2 and #7)

II. Review or Critique
(Experimental 4 minutes, Control 4 minutes)

A. Summarize the lesson

1. Review the methods of sketching circles

2. Review how to transfer measurements from pictorials to orthographics and vice versa

B. Discussion Questions

*. Use overlays #2 and #7 for discussing the questions

1. What angle is a line drawn on the isometric drawing that is 180 degrees on the orthographic view?

<u>Answer</u> - 30 degrees

2. What angle is a line drawn on the isometric drawing that is 90 degrees on the orthographic view?

<u>Answer</u> - 90 degrees

3. What is the first step in sketching a pictorial drawing from two orthographic views?

<u>Answer</u> - Block the pictorial drawing in a box with the space measurements that are the same as the space dimensions of the orthographic views

III. Application (Experimental and Control 1 minutes)

A. Assign the students problems 16 and 19 in the workbook

B. The supplementary problem will be problem 18

C. Problems are due at the end of the period

D. Instructor's activities

1. Supervise the class by observing the work of students

2. Individual attention is given to each student and his particular problem *

* Individual student questions will be answered at this time. This procedure will prevent student questioning from extending the prescribed lecture and demonstration period.

LESSON PLAN NO. 4

Instructional Unit - Plane and view representation

Type - Lecture and demonstration

Time Allotted - Experimental 25 minutes, Control 35 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk

Instructional Media for Experimental - One overhead projector, one screen, one projector stand, one projection box, overlays #1, 8, 9, 10, and #11, model block #5, and the same media as the control group

Reference - Giesecke, Mitchell, Spencer, and Hill, Technical Drawing, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, Drafting Fundamentals, College Station, Texas, Texas A & M University, 1965.

Study Assignment - Pages 160 - 173

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and notebook to register lecture notes

Next Reading Assignment - Pages 173 - 181

Plane and View Representation

I. Presentation (Lecture and Demonstration)

A. Introduction
(Experimental 2 minutes, Control 2 minutes)

1. Objectives

a. To develop student ability to identify views of reference planes

b. To develop student ability to identify each type and location of reference planes

c. To teach students how to locate each reference plane when each plane is revolved outwardily until it lies in the stationary frontal plane

d. To teach students how to identify the corresponding view in each original plane location

e. To teach students how to identify the corresponding view in each plane when each plane is revolved outwardily until it lies in the stationary frontal plane

f. To teach students how to measure the correct space dimensions from each reference plane

2. Reason

a. Students must acquire a thorough understanding of projection planes and space dimensions to correctly solve orthographic projection problems

B. Explanation and Demonstration
(Experimental 13 minutes, Control 13 minutes)

* The projectuals are used only with the <u>experimental group</u>

1. Explain the two method of viewing a plane (Projectual #8)

2. Explain the type and location of each plane (Projectual #9 A-B)

3. Explain the location of each plane when each plane is revolved to the stationary frontal plane (Projectual #10 A-B)

4. Explain the view of each plane in relation to each orthographic view (Projectual #11 A-B)

5. Explain each dimension and the relationship to each orthographic view and each reference plane (Projectual #1)

C. Demonstration

* The projection box is used only with the experimental group

1. Use the projection box to illustrate the two methods of viewing a plane

2. Use the projection box to illustrate the location of each plane and the relation to the object

3. Use the projection box to demonstrate the method of revolving the three principle planes outwardily to form a stationary frontal plane

4. Use the projection box to demonstrate each plane in relation to each orthographic view

5. Use the projection box to illustrate the space dimensions obtained form each reference plane

II. Review or Critique
(Experimental 8 minutes, Control 8 minutes)

A. Summarize the lesson

1. Review two views of a plane

2. Review types and locations of planes

3. Review names and locations of views

4. Review the revolvement of planes

5. Review the space dimensions obtained form each reference plane

B. Discussion Questions

* Use the projection box for the discussion questions

1. How may a plane be viewed?

    Answer - Surface or edge

2. What is the name of this plane and what orthographic view does it contain?

    Answer - Frontal plane - front view

3. What is the name of this plane and what orthographic view does it contain?

    Answer - Horizontal plane - top view

4. What is the name of this plane and what orthographic view does it contain?

    Answer - Profile plane - right side view

5. What dimensions are contained on the horizontal plane and the top view?

    Answer - Width and depth

6. What dimensions are contained on the frontal plane and the front view?

    Answer - Width and height

7. What dimensions are contained on the profile plane and the right side view?

    Answer - Height and depth

8. What dimension is obtained by measuring from the horizontal plane?

    Answer - Height

9. What dimension is obtained by measuring from the frontal plane?

   Answer - Depth

10. What dimension is obtained by measuring from the profile plane?

    Answer - Width

III. Application (Experimental and Control 2 minutes)

A. Assign students problem 39 in the workbook

B. Problem is due at the end of the period

C. Instructor's activities

1. Supervise the class by observing the work of students

2. Individual attention is given to each student and his particular problem *

   * Individual student questions will be answered at this time. This procedure will prevent student questioning from extending the proscribed lecture and demonstration period.

LESSON PLAN NO. 5

Instructional Unit - Types and views of lines

Type - Lecture and demonstration

Time Allotted - Experimental 23 minutes, Control 30 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk

Instructional Media for Experimental - One overhead projector, one screen, one projector stand, one projection box, overlays #12 A-B-C, 13 and #14, line rod, and the same media as the control group

Reference - Giesecke, Mitchell, Spencer, and Hill, Technical Drawing, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, Drafting Fundamentals, College Station, Texas, Texas A & M University, 1965.

Study Assignment - Pages 173 - 181

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and notebook to register lecture notes

Next Reading Assignment - Pages 166 - 168

Types and Views of Lines

I. Presentation (Lecture and demonstration)

A. Introduction
(Experimental 2 minutes, Control 2 minutes)

1. Objectives

a. To teach the student the different ways objects lines are viewed in orthographic projection

b. To teach the student how to identify a line with relation to reference planes

c. To teach the student how to project and draw correct views of lines through the use of reference planes

2. Reason

a. Students must acquire an understanding of the different ways a line may be viewed

b. Students must acquire an understanding of how the view of a line will effect the view of the surface or corner that is represented by the line

c. Students must acquire an understanding of how to draw orthographic views by projection from reference planes

3. Review of Previous Instruction

a. Review types and location of reference planes

b. Review the relationship of each plane in each orthographic view

B. Explanation and Demonstration
(Experimental 10 minutes, Control 10 minutes)

* The projectuals are used only with the <u>experimental group</u>

1. Explain the types of lines and the name of each line (Projectual #12 A-B)

2. Explain how each type of line may be viewed and the effect of the view on the length of the line (Projectual #12 B-C)

C. Demonstration

1. Demonstrate how to project line views and how to obtain space dimensions through the use of reference planes (Projectual #13)

2. Use the projection box and rod to demonstrate each type of line

3. Use the projection box and rod to illustrate how reference planes are used to measure and transfer space dimensions.

II. Review or Critique (Experimental 10 minutes, Control 10 minutes)

A. Summarize the lesson

1. Review the name of each type of line

2. Review how each type of line may be viewed

3. Review how space dimensions are taken from each reference plane

B. Discussion Questions

*Use overhead projectual #12 A-B-C for discussion questions 1 - 3. Use overlay # 14 for discussion questions 4 - 7. Cover definitions.

1. What is the name of this line? Where is it seen true length? Why is it seen true length in the top view?

Answer - a. Horizontal line b. Top view
c. It is parallel to the horizontal plane

2. a. What is the name of this line? b. Where is it seen true length? c. Why is it seen true length in the front view?

   Answer - a. Frontal b. Front view c. It is parallel to the frontal plane

3. a. What is the name of this line? b. Where is it seen true length? Why is it seen true length in the right side view?

   Answer - a. Profile line b. Right side view c. It is parallel to the profile plane

4. What space dimension is projected to draw the top view? Overlay # 14

   Answer - Width

5. What reference plane would be used and what space dimension is transfered to draw the top view?

   Answer - Frontal reference plane - depth

6. What reference plane would be used and what space dimension is transfered to draw the profile view?

   Answer - Frontal reference plane - depth

7. What space dimensions are projected to draw the front view?

   Answer - Height and width

III. Application (Experimental and Control 1 minutes)

A. Assign the students the four problems on the hand out sheet

B. Assign the students problem 32 in the workbook

C. Problems are due at the end of the period

D. Instructor's activities

   1. Supervise the class by observing the work of students

2. Individual attention is given to each student and his particular problem *

   * Individual student questions will be answered at this time. This procedure will prevent student questioning from extending the prescribed lecture and demonstration period.

# LESSON PLAN NO. 6

Instructional Unit - Measuring from reference planes

Type - Lecture and demonstration

Time Allotted - Experimental 20 minutes, Control 24 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk

Instructional Media for Experimental - One overhead projector, one screen, one projector stand, one projection box, overlays #15 and #16, model blocks #1 and # 7, and the same media as the control group

Reference - Giesecke, Mitchell, Spencer, and Hill, Technical Drawing, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, Drafting Fundamentals, College Station, Texas, Texas A & M University, 1965.

Study Assignment - Pages 166 - 168

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and notebook to register lecture notes

Next Reading Assignment - Pages 166 - 168, 181 - 188

Measuring From Reference Planes

I. Presentation (Lecture and Demonstration)

A. Introduction
(Experimental 2 minutes, Control 2 minutes)

1. Objectives

a. To teach the student how to identify the correct reference plane required to complete the orthographic drawing

b. To teach the student how to take measurements from reference planes

c. To teach the student how to correctly number each corner of an orthographic projection problem

2. Reason

a. Correct reference planes must be established before orthographic projection problems can be solved using the reference plane method

b. The principles of the reference plane are the most beneficial method of solving orthographic projection problems because of the close relationships of the principles involved in the other areas of teaching drafting

B. Explanation and Demonstration
(Experimental 8 minutes, Control 8 minutes)

* The projectuals are used only with the <u>experimental group</u>

1. Explain which reference plane is needed to solve the missing view (Projectual #15)

2. Explain why the reference plane is placed on the object (Projectual #15)

3. Explain how each distance is laid off from the reference plane. Use dividers to illustrate (Projectual #15)

4. Explain why some corners are numbered outside the object while some are numbered inside the object (Projectual #15)

   a. The numbers outside the object represent corners that are visable or closest to you

   b. The numbers inside the object represent corners that are invisible or farthest from you

C. Demonstration

1. Use the projection box to demonstrate the reference plane used to solve the problem on overlay #15 (Model block #1)

2. Use the projection box to illustrate how to take space measurements from reference planes (Model block #1)

3. Use the projection box and the plane transparencies to show the correct solution to the problem (Model block #1)

II. Review or Critique
(Experimental 8 minutes, Control 8 minutes)

A. Summarize the lesson

1. Review which reference plane is needed to solve the problem (Projectual #15)

2. Review the placement of the reference plane

3. Review how to measure and lay off distances from the reference plane (Use dividers)

4. Review the numbering of corners

B. Discussion Questions

* Use projectual #16 and model block #7 only with the experimental group when discussing the questions

1. What space dimension can be projected to the right side view?

   Answer - Height

2. What space dimension is needed to complete the right side view?

   Answer - Depth

3. What reference plane is needed to obtain the needed space dimension?

   Answer - Frontal reference plane

4. Where should the frontal plane be placed in relation to the object?

   Answer - Front edge of the top view and to the right of the front view

5. Where is the required depth measurement obtained?

   Answer - Top view

   * Take each measurement with dividers and lay off on the profile view. Finish the overlay as the discussion proceeds

III. Application (Experimental and Control 2 minutes)

A. Assign students problem #34 and # 33 in the workbook

B. The supplementary problem will be to draw the three views of projectual #29. The overlay will be shown on the screen. The problem will be drawn on the back of problem # 34.

C. The problems are due at the end of the period

D. Instructor's activities

   1. Supervise the class by observing the work of students

2. Individual attention is given to each student and his particular problem *

   * Individual student questions will be answered at this time. This procedure will prevent student questioning from extending the prescribed lecture and demonstration period.

# LESSON PLAN NO. 7

Instructional Unit - Measuring from reference planes

Type - Lecture and demonstration

Time Allotted - Experimental 18 minutes, Control 22 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk

Instructional Media for Experimental - One overhead projector, one screen, one projector stand, one projection box, overlays #17 and #18, model blocks #8 and #9, and the same media as the control group

Reference - Giesecke, Mitchell, Spencer, and Hill, Technical Drawing, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, Drafting Fundamentals, College Station, Texas, Texas A & M University, 1965.

Study Assignment - Pages 166 - 168, 181 - 188

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and notebook to register lecture notes

Next Reading Assignment - Pages 142 - 145

## Measuring From Reference Planes

I. Presentation (Lecture and Demonstration)

A. Introduction
(Experimental 2 minutes, Control 2 minutes)

1. Objectives

a. To develop student ability to utilize reference planes in solving drafting problems

b. To develop student ability in visualizing and solving orthographic projection problems

2. Reason

a. The ability to apply the principle of the reference plane is essential in all areas of drafting

3. Review of Previous Instruction

a. Review how to number corners in orthographic projection problems

B. Explanation and Demonstration
(Experimental 9 minutes, Control 9 minutes)

* The projectuals are used only with the <u>experimental group</u>

1. Explain which space dimension can be projected and which space dimension must be transferred to solve the missing view (Projectual #17)

2. Explain which reference plane is used to transfer the missing space dimension

3. Explain the placement of the reference plane and the relationship to the object

4. Explain with the dividers how each dimension is transferred. (When each dimension is transferred label each point with the grease pencil) Projectual #17

C. Demonstration

1. Use the projection box to illustrate the problem (Model block #8)

2. Use the projection box to illustrate the correct reference plane required to solve the problem

3. Use the projection box to illustrate where the space dimensions are transferred

4. Unfold the projection box to illustrate the solved problem

II. Review or Critique
(Experimental 5 minutes, Control 5 minutes)

A. Summarize the lesson

1. Review the projected and transferred space dimensions required to solve the problem

2. Review the reference plane that is required to measure the transferred dimensions

3. Review the placement of the reference plane

4. Review transferring the required space dimensions and the completed view

B. Discussion Questions

* Use projectual #18 and model block #9 for discussion questions. Use only with the experimental group.

1. What space dimensions can be projected to the right side view?

Answer - Height

2. What space dimension is needed to complete the right side view?

Answer - Depth

3. What reference plane is used to obtain the needed space dimension?

Answer - Frontal reference plane

4. Where should the frontal plane be placed in relation to the object?

   Answer - Front edge of the right side view and above the front view

5. Where is the required depth measurement obtained?

   Answer - Top view

   * Take each measurement with dividers and lay off on the top view. Finish overlay for complete problem

III. Application
   (Experimental 2 minutes, Control 2 minutes)

A. Assign students problem #36 in workbook

B. The supplementary problem will be to draw the three views of projectual #30. The overlay will be shown on the screen. The problem will be drawn on the back of problem #36.

C. Problems are due at the end of the period

D. Instructor's activities

   1. Supervise the class by observing the work of students

   2. Individual attention is given to each student and his particular problem *

      * Individual student questions will be answered at this time. This procedure will prevent student questioning from extending the prescribed lecture and demonstration period.

# LESSON PLAN NO. 8

Instructional Unit - Two View Orthographic Problems

Type - Lecture and demonstration

Time Allotted - Experimental 14 minutes, Control 18 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk

Instructional Media for Experimental - One overhead projector, one screen, one projector stand, one projection box, overlays # 19 and 20, model block # 2, and the same media as the control group

Reference - Giesecke, Mitchell, Spencer, and Hill, Technical Drawing, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, Drafting Fundamentals, College Station, Texas, Texas A & M University, 1965.

Study Assignment - Pages 142 - 145

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and notebook to register lecture notes

Next Reading Assignment - Panges 171 - 183

Two View Orthographic Problems

I. Presentation (Lecture and Demonstration)

A. Introduction
(Experimental 2 minutes, Control 2 minutes)

1. Objectives

a. To teach students how to identify the types of objects that can correctly be represented by two orthographic views

b. To teach students how to correctly represent objects with two orthographic views

2. Reason

a. Many objects can be correctly represented by two orthographic views. The third orthographic view would be repetitious and consume unnecessary drafting time.

B. Explanation and Demonstration
(Experimental 8 minutes, Control 8 minutes)

* The projectuals are used only with the experimental group.

1. Explain which space dimension can be projected and which space dimension must be transferred to solve the missing view (Projectual #19)

2. Explain which reference plane is required to transfer the missing space dimension

3. Explain the placement of the reference plane and the relationship to the object

4. Explain with the dividers how each dimension is transferred (when each dimension is transferred label each point with the grease pencil) (Projectual #19)

5. Explain that the third view was not necessary because only two views were needed to describe clearly the the shape of the object (Projectual # 19)

6. Explain the selection of views on two view orthographic drawings (Projectual # 20)

   a. Explain that if only two views of the object are needed, and the left-side and the right-side are equally descriptive, the right side is customarily chosen

   b. Explain that if the top and bottom views are equally descriptive, the top view is customarily chosen

   c. Explain that if the top view and the right-side view are equally descriptive, the combination chosen is that which spaces best on the paper

7. Explain that on cylindrical surfaces the orthographic drawing can be complete with only one view and a note (Projectual #20)

C. Demonstration

   1. Use the projection box to illustrate the problem (Projectual #19 and model block # 2)

   2. Use the projection box to illustrate the correct reference plane required to solve the problem

   3. Use the projection box to illustrate where the space dimensions are transferred.

   4. Unfold the projection box to illustrate the solved problem

II. Review or Critique
(Experimental 3 minutes, Control 3 minutes)

A. Summarize the lesson

   1. Review the projected and transferred space dimensions required to solve the problem

   2. Review the reference plane that is required to obtain the transferred measurements

   3. Review the placement of the reference plane

   4. Review transferring the required space dimensions and the complete object

5. Review what type of objects require only two orthographic views

6. Review the views that are most customarily chosen when two views are equally descriptive

B. Discussion Question

1. None

III. Application
(Experimental 1 minutes, Control 1 minutes)

A. Assign students problem 35 in the workbook

B. The problem is due at the end of the period

C. Instructor's activities

1. Supervise the class by observing the work of students

2. Individual attention is given to each student and his particular problem *

* Individual student questions will be answered at this time. This procedure will prevent student questioning from extending the prescribed lecture and demonstration period.

# LESSON PLAN NO. 9

Instructional Unit - Missing Lines

Type - Lecture and demonstration

Time Allotted - Experimental 18 minutes, Control 23 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk

Instructional Media for Experimental - One overhead projector, one screen, one projector stand, one projection box, overlays #21, 22 and 23, model blocks #3, 4, and 5.

Reference - Giesecke, Mitchell, Spencer, and Hill, *Technical Drawing*, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, *Drafting Fundamentals*, College Station, Texas, Texas A & M University, 1965.

Study Assignment - Pages 171-183

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and notebook to register lecture notes

Next Reading Assignment - Test

## Missing Lines

I. Presentation (Lecture and Demonstration)

A. Introduction
(Experimental 2 minutes, Control 2 minutes)

1. Objectives

a. To develop student ability to visualize in three dimensions

b. To develop student ability to read lines in a logical way, to piece together the little things until a clear idea of the whole emerges

2. Reason

a. The ability to visualize or think in three dimensions is one of the most important requisites of the successful engineer

b. The ability to visualize multiview drawings is obtained only through study and understanding of lines and surfaces

B. Explanation and Demonstration
(Experimental 10 minutes, Control 10 minutes)

* The projectuals are used only with the <u>experimental group</u>.

1. Explain the method of solving a missing line problem (Projectual #21)

a. Explain which reference plane is needed to complete the right side view

b. Explain the projection of each corner to the right side view

c. Explain the space measurement that must be transferred. Use dividers.

d. Explain why the corners are represented by hidden lines

2. Explain the method of solving a missing line problem (Projectual #22)

   a. Explain which reference plane is needed to complete the missing view

   b. Explain the projection of each corner to the right side view

   c. Explain with dividers the space measurments that must be transferred for each corner

C. Demonstration

1. Use the projection box and model block #3 to illustrate projectual #21

   a. Use the projection box to illustrate the reference plane used to complete the right side view

   b. Use the projection box to illustrate the transfer of the space measurements

   c. Use the projection box to illustrate the correct solution to the problem

2. Use the projection box and model block #5 to illustrate projectual #22

   a. Use the projection box to illustrate the reference plane used to complete the right side view

   b. Use the projection box to illustrate the transfer of the space measurements

   c. Use the projection box to illustrate the correct solution to the problem

II. Review or Critique
(Experimental 4 minutes, Control 4 minutes)

A. Summarize the lesson

1. Review the method of solving missing line problems

a. Review the selection of the correct reference plane

b. Review the method of transferring the needed space dimensions for each corner

B. Discussion Questions

* Use projectual #23 and Model block #4 for discussion question. Use only with the experimental group

1. Are there any missing lines in this problem?

   Answer - Yes

2. In which view are the lines missing?

   Answer - Right side view

3. What reference plan should be used to solve this problem?

   Answer - Frontal reference plane

4. Where should the reference plane be placed in relation to the views?

   Answer - On the front edge of the top view and on the front edge of the right side view

5. What dimension is transferred to solve the missing lines?

   Answer - Depth

6. How is the front inclined surface seen in the right side view?

   Answer - Hidden

7. How is the back inclined surface seen in the right side view?

   Answer - Visible

* Solve the problem with the overlays as the questions are answered

III. Application (Experimental 2 minutes, Control 2 minutes)

A. Assign the students problems #37 and #38 in the workbook

B. Problems are due at the end of the period

C. Instructor's activities

1. Supervise the class by observing the work of students

2. Individual attention is given to each student and his particular problem *

* Individual student questions will be answered at this time. This procedure will prevent student wuestioning from extending the prescribed lecture and demonstration period.

# LESSON PLAN NO. 10

Instructional Unit - Test on missing lines

Type - Complete the third view

Time Allotted - As much time as the student requires to complete the test

Section Presented To - Industrial Arts 128, experimental and control

Instructional Media for Control - Hand out test

Instructional Media for Experimental - Hand out test

Student Assignment - Review all lecture notes and all reading assignments in the textbook

Student Equipment - Pencils, tape, erasers and straight-edges

Test On Missing Lines

I. Presentation (Test and Review)

A. Introduction (Experimental and Control    minutes)

1. Objectives

a. To measure the students ability to solve missing line problems

b. To locate areas where students are weak in orthographic projection

2. Reason

a. Tests are the best indicators of areas that are weak and need to be retaught

B. Explanation and Demonstration (Experimental and Control    minutes)

1. Give the test at the first of the period

2. Students will work on any problems they have not finished after completing the test

3. The test will be discussed after the conclusion of the experimental study using overlay #24 as the answer sheet

LESSON PLAN NO. 11

Instructional Unit - Recognition of pictorial views

Type - Lecture and demonstration

Time Allotted - Experimental 12 minutes, Control 15 minutes

Section Presented To - Industrial Arts 128, experimental and control groups

Personnel - None

Instructional Media for Control - One workbook, one textbook, chalkboard, one chalkboard drafting machine, and colored chalk

Instructional Media for Experimental - One overhead projector, one screen, one projector stand, one projection box, overlays #25, 26, 27, and #28, and the same media as the control group

Reference - Giesecke, Mitchell, Spencer, and Hill, Technical Drawing, New York, The Macmillan Company, 1966.

Street, Cleveland, and Earle, Drafting Fundamentals, College Station, Texas, Texas A & M University, 1965.

Study Assignment - None

Student Equipment - One textbook, one workbook, pencils, tape, erasers, and notebook to register lecture notes

Next Assignment - Comprehensive Exam over Orthographic Projection

## Recognition of Pictorial Views

I. Presentation (Lecture and Demonstration)

A. Introduction
(Experimental 2 minutes, Control 2 minutes)

1. Objectives

a. To develop the ability of the student to distinguish from two orthographic views the pictorial view of the object

2. Reason

a. Students must develop the ability to visualize objects in three dimension from a two dimension drawing

b. The ability to visualize in three dimension is one of the most vital requisites of being successful in any area of the engineering profession

B. Explanation and Demonstration
(Experimental 10 minutes, Control 10 minutes)

1. Explain each problem that is presented in overlays #25, 26, 27, and #28

a. Explain that only one of the pictorial solutions is correct

b. Explain that the student should arrive at the solution after taking into consideration all the principles that have been studied

C. Demonstration

* The projectuals are used only with the <u>experimental group</u>

1. Demonstrate the correct method of solving each problem in projectuals #25, 26, 27, and #28

2. Discuss each problem and each solution until agreement is made on one of the solutions

3. Cover the solutions with the opaque film to check the correct answer

II. Review or Critique

A. None

III. Application (Experimental and Control 1 minutes)

A. Have students finish any problems that they did not complete during the experimental design. This does not include supplementary problems

B. Instructors activities

1. Supervise the class by observing the work of students

2. Individual attention is given to each student and his particular problem *

* Individual student questions will be answered at this time. This procedure will prevent student questioning from extending the prescribed lecture and demonstration period

3. ANNOUNCE THAT EVERY STUDENT SHOULD BE PRESENT AT THE NEXT CLASS MEETING TO TAKE THE COMPREHENSIVE EXAM OVER ORTHOGRAPHIC PROJECTION

# APPENDIX C

## MATERIALS, EQUIPMENT, AND SERVICES FOR MAKING TRANSPARENCIES

Admaster Prints, Inc., 425 Park Ave. S., New York 16, New York. (General supplies and services for making transparencies, print-ons, and photocopies.)

Charles Beseler Co., 219 S. 18th St., East Orange, New Jersey. (Extensive line of transparency making materials.)

Robert J. Brady Co., 3227 M St., N.W., Washington 7, D.C. (Kits for transparencies.)

Arthur Brown and Brothers, Inc., 2 W. 47 St., New York 36, New York. (Materials for making transparencies through "color lift" process.)

Keystone View Company, Meadville, Pennsylvania. (Materials for preparation of transparencies and etched glass slides.)

Keuffel and Esser Co. (Audiovisual Division), Hoboken, New Jersey. (Extensive line of transparency making materials and kits through use of films and printing processes.)

Ozalid Division, General Aniline and Film Corp., Johnson City, New York. (Photocopy equipment and materials.)

Prestype Inc., 136 W. 21st Street, New York, 10011, New York. (Dry transfer texture sheets for application to prepared transparencies.)

Technifax Corporation, Holyoke, Mass. (Extensive line of kits, materials, and equipment for making transparencies.)

Thermo-Fax Visual Communications Group, Minnesota Mining and Manufacturing Company, St. Paul 19, Minnesota. (Equipment and materials for making transparencies through "heat sensitive" paper and film.)

Transpara, Seal, Inc., Shelton, Conn. (Materials for making transparencies through "color lift" process.)

Victorlite Industries, Inc., 4117 W. Jefferson Blvd., Los Angeles 16, California. (General supplies and prepared materials.)

Prepared Transparencies

Admaster Prints, Inc., 425 Park Ave. S., New York 16, New York. (Kit of projectuals in statistics.)

Robert J. Brady Co., 3227 M Street N.W., Washington, D.C. (Transparencies in Biology, Trigonometry, Driver Training, History, Geometry, Religion, Electronics, Geography, and other specialized areas.)

Keuffel and Esser Co., (Audiovisual Division), Hoboken, New Jersey. (Books consisting of masters used to produce transparencies in Geometry, Physics, and Chemistry.)

Ozalid Division, General Aniline & Film Corp., Johnson City, New York. (Transparency master kits in Biology, Algebra, Electronics, Chemistry, General Science, and Physics.)

State University of Iowa, Bureau of Audiovisual Instruction, Extension Division, Iowa City, Iowa. (Series of transparencies in Mechanical Drawing.)

McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 36, New York. (Series of transparencies in Mechanical Drawing.)

RCA Educational Services, Camden 8, New Jersey. (Transparencies in Electronics, Biology, Mechanical Drafting, Physics, Geometry, Trigonometry, and Chemistry.)

Technifax Corporation, Holyoke, Mass. (Transparencies available in Mathematics, Social Studies, Music, Physical Education, Accounting, Driver Education, Biology, Chemistry, General Science, and other special areas.)

Toslen Transparencies, 8 Bacon Lane, Babylon, New York. (Transparencies available in History, Biology, Physics, and Science.)

United Transparencies, Inc., 57 Glenwood Avenue, Binghamton, New York. (Transparencies including State, Continent, and Country Maps; Mathematics, Plane Geometry, Human Anatomy, Biology, Bookkeeping, Chemistry, Science and Social Studies.)

L. L. Weans Co., 3341 Beltagh Avenue, Wantagh, New York. (Transparencies in elementary subjects including Science, Mathematics, Social Studies, Art, Language Arts, and Music.)

## Sources of Projectors and Equipment

American Optical Company (Instrument Division), Buffalo 15, New York.

Bausch & Lomb, Inc. (Instrument Sales Division), 635 St. Paul St., Rochester 2, New York.

Charles Beseler Company, 219 S. 18th St., East Orange, New Jersey.

Buhl Optical Company, 1009 Beech Ave., Pittsburgh 33, Pennsylvania.

Keystone View Company, Meadville, Pennsylvania.

Laboratory Furniture Company, Inc., Old Country Road, P. O. Box 590, Mineola, New York.

E. Leitz, Inc., 468 Park Avenue, New York 16, New York.

Minnesota Mining and Manufacturing Company, 900 Bush Ave., St. Paul 19, Minnesota.

Ozalid Division, General Aniline and Film Corporation, Johnson City, New York.

Projection Optics Company, Inc., 271 Eleventh Avenue, East Orange, New Jersey.

Technifax Corporation, Holyoke, Mass.

Victorlite Industries, Inc., 4117 W. Jefferson Blvd., Los Angeles 16, California.

## Projection Screens

Da-Lite Company, Inc., 30 Grand Street, Warsaw, Indiana.

Hunter-Douglas Division, Bridgeport 2, Connecticut.

Radiant Manufacturing Company, 8220 North Austin Ave., Morton Grove, Illinois.

No. ____________

APPENDIX D

NORTH TEXAS STATE UNIVERSITY

INDUSTRIAL ARTS DEPARTMENT

FALL, 1968-1969

Please answer all items and record the information by your neatest method.

NAME ______________________________________________
Last First Middle

HOME ADDRESS ________________ CITY-STATE ______________

DENTON ADDRESS ____________________ PHONE ____________

AGE __________ MAJOR ______________________________

SEX __________ CLASSIFICATION ______________________

List Industrial Arts drafting courses in progress or completed on the college level.

______________________________________________________

______________________________________________________

List all courses related to drafting that you have completed in high school, trade school, business school, etc.

| COURSES | SEMESTERS COMPLETED |
| --- | --- |
| ______________ | ______________ |
| ______________ | ______________ |
| ______________ | ______________ |

List all of your employment in which you have utilized any form of drafting to fulfill the requirements of the employment. Please explain how drafting was integrated into your procedures.

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

BIBLIOGRAPHY

Books

Best, John W., Research in Education, Englewood Cliffs, Prentice-Hall, Inc., 1959.

Christal, Raymond E., Factor Analytic Study of Visual Memory, New York, The American Psychological Association, Inc., 1958.

Dember, William N., Visual Perception, New York, John Wiley & Sons, Inc., 1964.

El Koussy, A. A., The Visual Perception of Space, London, Cambridge University Press, 1935.

French, Thomas E. and Charles J. Vierck, Engineering Drawing, New York, McGraw-Hill Book Company, Inc., 1960.

Garrett, Henry E., Statistics in Psychology and Education, 3rd ed., New York, Longmans, Green and Co., 1947.

Giesecke, Frederick E., Alva Mitchell, and Henry C. Spencer, Technical Drawing, 4th ed., New York, The MacMillan Company, 1964.

Larson, Milton E., Review and Synthesis of Research in Technical Education, Columbus, The Ohio State University Press, 1966.

Levens, A. S., Graphics, New York, John Wiley and Sons, Inc., 1962.

Lindquist, E. F., Design and Analysis of Experiments in Psychology, pp. 1, 6-7, summarized by Carter V. Good, Introduction to Educational Research, New York, Appleton-Century-Crofts, 1963.

Luzadder, W. J., Basic Graphics for Engineers and Technical Students, Englewood Cliffs, Prentice-Hall, Inc., 1962.

McDougall, W., An Outline of Psychology, London, Cambridge University Press, 1935.

McNemar, Quinn, Psychological Statistics, New York, John Wiley and Sons, Inc., 1960.

Silvey, H. M., editor, Master's Thesis in Education, Cedar Falls, Research Publications, 1950-1968.

Springer, R. D., L. G. Palmer, W. A. Kleinhenz, and P. W. Bullen, Basic Graphics, Boston, Allyn and Bacon, Inc., 1963.

Stern, William L., Psychology of Early Childhood, New York, Holt and Sons, 1930.

Stout, G. F., Manual of Psychology, Cambridge, The University Press, 1932.

Streichler, Jerry, Review and Synthesis of Research in Industrial Arts Education, Columbus, The Ohio State University Press, 1966.

Taylor, Robert E., director, Abstracts of Research and Related Materials in Vocational and Technical Education, Columbus, The Ohio State University Press, Fall, 1967.

________________, director, Abstracts of Research and Related Materials in Vocational and Technical Education, Columbus, The Ohio State University Press, Winter, 1967.

________________, director, Abstracts of Research and Related Materials in Vocational and Technical Education, Columbus, The Ohio State University Press, Summer, 1968.

Tuckman, Bruce W. and Carl J. Schaefer, Review and Synthesis of Research in Trade and Industrial Education, Columbus, The Ohio State University Press, 1966.

Turner, William W., Carson P. Buck, and Hugh P. Ackert, Basic Engineering Drawing, New York, Ronald Press Company, 1950.

University Microfilms, Dissertation Abstracts, Ann Arbor, University Microfilms, 1950-1968.

## Articles

Brooks, Weston T., "An Experimental Analysis of the Effectiveness of Overhead Transparencies on Learning and Retention (In Selected Units) in Beginning Woodworking," The TIAA Bulletin, XI (February, 1967), 5.

Carnevale, Daniel J., "The Overhead Projector and Drawing Instruction," School Shop, XXV (October, 1965), 49.

Draftsman Survey, Industrial Arts and Vocational Education, LIV (May, 1965), 11.

Earle, James H., "On Using the Overhead Projector in Drafting," Industrial Arts and Vocational Education, LI (December, 1962), 37-38.

Lantz, John D., "Making Transparent Overlays in the Drafting Classroom," Industrial Arts and Vocational Education, LIV (February, 1965), 34-35.

Schilling, James L., "Orthographic Projection, A Key to Measuring Drafting Achievement," Industrial Arts and Vocational Education, LIV (April, 1965), 39.

Schramm, Howard R., "Helpful Teaching Aids for Industrial Education," Industrial Arts and Vocational Education, XLIII (October, 1954), 277.

Schwartz, Gilbert, "Making and Using--Overhead Projector Materials in Drafting," Industrial Arts and Vocational Education, LIII (December, 1954), 44, 45 and 60.

__________________, "Using the Overhead Projector to Teach Technical Drawing," Industrial Arts and Vocational Education, LIV (December, 1965), 24-26.

Snyder, Burton K., "The Education of Draftsmen for the Space Age," The Journal of Industrial Arts Education, XXIII (January-February, 1964), 37.

Spence, William P., "Research in Industrial Education: A Look at the Past," Industrial Arts and Vocational Education, LIII (December, 1964), 56-58.

Warner, M. E., "Overhead Projectors for Teaching Drafting," Industrial Arts and Vocational Education, XLII (December, 1953), 350-353.

Williamson, Scott, "Using Colors to Teach Drafting," Industrial Arts and Vocational Education, XLV (April, 1956), 136-137.

## Reports

Guilford, J. P., "Printed Classification Test," _AAF Aviation Psychological Report_, Washington, D.C., U.S. Government Printing Office, 1947.

## Publications of Learned Organizations

American Society of Engineering Education, _Unit Tests in Engineering Education_, The Educational Testing Services, Princeton, New Jersey, 1948.

Elam, Stanley, editor, _Research Studies in Education_, Bloomington, Illinois, Phi Delta Kappa, 1950-1968.

## Unpublished Materials

Barrett, L. S., "To Determine the Relationship Between Visual Imagery, Drafting Achievement and Mechanical Aptitude," unpublished master's thesis, North Texas State University, Denton, Texas, 1948.

Bjorkquist, David Carl, "Discrimination Transfer from Scale Models and Pictorial Drawings in Learning Orthographic Projection," unpublished doctoral dissertation, University of Minnesota, Minneapolis, Minnesota, 1965.

Brooks, Weston T., "An Experimental Analysis of the Effectiveness of Overhead Transparencies on Learning and Retention (In Selected Units) in Beginning Woodworking," unpublished doctoral dissertation, School of Industrial Education, Texas A & M University, College Station, Texas, 1964.

Buh, Joseph F., "A Teacher's Guide for Preparation and Utilization of Selected Overhead Drafting Projectuals," unpublished master's thesis, San Diego State College, San Diego, California, 1966.

Burnett, Gilbert W., "A Study of Teaching Basic Electricity," unpublished master's thesis, Kansas State College of Pittsburg, 1965.

Chance, Clayton William, "An Evaluation in the Utilization of 200 Colored Transparencies for the Teaching of Engineering Descriptive Geometry," unpublished doctoral dissertation, School of Education, The University of Texas, Austin, Texas, 1963.

Digby, Edwin E., "A Comparative Study of Two Methods of Teaching Mechanical Drawing," unpublished master's thesis, Ohio State University, Columbus, Ohio, 1933.

Ellis, Neil Gilbert, "An Experimental Comparison of the Construction Method and the Workbook Method of Teaching Drafting," unpublished doctoral dissertation, University of Missouri, Columbia, Missouri, 1966.

Fonseca, Benjamin G., "An Experimental Investigation to Determine the Relative Effectiveness of Two Different Methods of Teaching Grade Nine Drafting," unpublished master's thesis, Western Washington State College, Bellingham, Washington, 1963.

Gallentine, Jerry Lynn, "The Effects of Overhead Projection on Achievement in the Biological Sciences at the College Level," unpublished doctoral dissertation, University of Toledo, Toledo, Ohio, 1965.

Glazner, Everett R., "An Experimental Determination of the Value of Selected Visual Aids in Teaching Beginning Mechanical Drawing," unpublished doctoral dissertation, Pennsylvania State University, University Park, Pennsylvania, 1958.

Gundry, Russell W., "Teaching the Basic Elements of Industrial Drawing Through the Use of Selected Teacher Made Transparencies," unpublished master's thesis, Chico State College, Chico, California, 1965.

Helper, Earl, "Order of Presenting Orthographic Projection and Pictorial Representation and Its Effect on Achievement in Engineering Drawing," unpublished doctoral dissertation, School of Education, University of Missouri, Columbia, Missouri, 1957.

Horton, Bolin E., "Order of Presenting Orthographic Projection and Its Effect on Achievement in Mechanical Drawing," unpublished master's thesis, Kansas State College of Pittsburg, 1964.

Hoskins, Richard Harwood, "The Teaching of Multiview Drawing with Pictorial Sketching as the Experimental Variable," unpublished master's thesis, The Ohio State University, Columbus, Ohio, 1960.

Johnson, William R., "A Comparative Study of Two Methods of Teaching Tool Bit Grinding," unpublished master's thesis, Chicago Teachers College, Chicago, 1962.

Keuffel and Esser Co., "Technical Graphics," instruction sheet for K & E Diazo Transparencies, Hoboken, New Jersey, 1964.

Lawver, Earl A., "A Study of Two Established Methods of Teaching Mechanical Drawing," unpublished master's thesis, Colorado Agricultural and Mechanical College, Greeley, Colorado, 1936.

McSpadden, C. B., "An Experimental Investigation of the Relative Effectiveness of Two Methods of Teaching Mechanical Drawing," unpublished master's thesis, North Texas State University, Denton, Texas, 1950.

Mitchell, D. R., "The Design, Construction, and Use of Projection Box to be Used in Teaching a Course in Descripttive Geometry," unpublished master's thesis, Department of Industrial Arts, North Texas State University, Denton, Texas, 1963.

Parkinson, John Robert, "A Comparison of Student Performance in Tasks Involving Familiar and Unfamiliar Material When Viewed Under Varying Conditions of Projected and Ambient Light Combinations," unpublished doctoral dissertation, Syracuse University, Syracuse, New York, 1966.

Rowlett, John D., "An Experimental Comparison of Direct-Detailed and Directed Discovery Methods of Teaching Orthographic Projection Principles and Skills," unpublished doctoral dissertation, University of Illinois, Urbana, Illinois, 1960.

Schamehorn, Ernest C., "Opinions of Educators and Engineers on the Importance of Engineering Graphic Topics," unpublished doctoral dissertation, Western Reserve University, Cleveland, Ohio, 1965.

Shavlis, Wayne R., "Relative Effectiveness of the Order of Presenting Pictorial Representation and Multiview Projection in Beginning Engineering Drawing," unpublished master's thesis, California State College, California, Pennsylvania, 1965.

Shoemaker, Edwin Allen, "A Comparative Study of Two Methods of Teaching Drawing (Guide Sheet Method Versus Oral Method)," unpublished master's thesis, Ohio State University, Columbus, Ohio, 1939.

Suess, Alan Roman, "An Experimental Study Comparing the Effectiveness of Varying Degrees of Manipulation on the Directed Discovery Method of Presenting Principles of Orthographic Projection," unpublished doctoral dissertation, University of Illinois, Urbana, Illinois, 1962.

Sullivan, Frank Victor, "An Experimental Study of the Effectiveness of Two Methods of Teaching Orthographic Projection in Terms of Retention and Transfer," unpublished doctoral dissertation, School of Education, University of Illinois, Urbana, Illinois, 1964.

Trautwein, Calvin Leroy, "An Experimental Comparison of Three Methods Used to Identify Industrial Materials," unpublished doctoral dissertation, Colorado State College, Greeley, Colorado, 1962.

Twogood, Arthur P., "Teaching Fundamentals of Mechanical Drawing to Beginners by Means of Film Slides," unpublished master's thesis, Iowa State University, Iowa City, Iowa, 1931.

Wilkes, Doran F., "A Comparison of Two Methods of Teaching Engineering Drawing: Film Slides Versus the Conventional Approach," unpublished doctoral dissertation, School of Industrial Education, University of Missouri, Columbia, Missouri, 1964.

Yeager, Lowery Dale, "An Experimental Study to Determine the Value of Projectuals in Presenting Selected Units of Basic Electricity," unpublished doctoral dissertation, School of Industrial Education, Texas A & M University, College Station, Texas, 1965.