A COMPARISON OF THE EFFECTIVENESS OF TWO APPROACHES TO TEACHING ENGINEERING DRAFTING

DISSERTATION

Presented to the Graduate Council of the North Texas State University in Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF EDUCATION

By

Joe W. Walker, B.S., M.Ed.
Denton, Texas
August, 1970
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CHAPTER I

INTRODUCTION

The primary function of engineering drafting skills is the communication of ideas through graphic representation. Standardized symbols, notes, views, and arrangements are used to convey a description of the most simple, as well as the most complicated, component of every production item from the abstract thoughts of its designer to the skilled hands of its maker. A basic understanding of the drafting skills used in this medium of instruction is necessary before an idea may be fully transmitted or received through the use of drawings.

If the purpose of attaining drafting skills is to be able to produce a drawing that transmits an idea, then the teaching of such skills should be organized to constantly reflect this purpose. The teaching of the manipulative skills of drafting has been widely accepted and perpetuated as a separate entity, irrespective of the purpose of drafting as a whole. The "typical" course in engineering drafting is divided into units of study, with a working drawing assigned near the end of the semester to provide application of previously learned skills. The literature provides numerous ideas for methods of teaching within the framework of the unit approach, but guidelines for restructuring the approach are conspicuously absent.
This study was based upon the proposition that the idea communication approach to engineering drafting could prepare students to be more skillful in critical thinking, as well as assisting them to acquire more drafting knowledge than those taught by the unit approach.

Statement of the Problem

The problem of the study was a comparison of the relative effectiveness of two approaches to the teaching of engineering drafting.

Purposes of the Study

The purposes of the study were the following:

1. To determine the relative effectiveness of the idea communication approach as compared to the unit approach to teaching engineering drafting with regard to the acquisition of general drafting knowledge.

2. To determine the relative effectiveness of the idea communication approach as compared to the unit approach to teaching engineering drafting with regard to the development of critical thinking ability.

3. To determine the relative effectiveness of the idea communication approach as compared to the unit approach to teaching engineering drafting with regard to the ability to produce working drawings.
4. To determine the effect of critical thinking ability on general drafting knowledge and ability to produce working drawings.

Hypotheses

1. The group taught by the idea communication approach (experimental) will show a significantly greater mean gain score on general drafting knowledge, as measured by General Drafting: A Comprehensive Examination, than will the group taught by the unit approach (control).

2. The experimental group will show a significantly greater mean gain than will the control group from the pre-test to the post test in critical thinking ability, as measured by the Watson-Glaser Critical Thinking Appraisal, Form YM.

3. The experimental group will achieve a significantly higher mean score than will the control group on the working drawing.

4. Subjects in both groups who score above the third quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM, will score significantly higher on the second administration of General Drafting: A Comprehensive Examination than will those subjects who score below the first quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM.
5. Subjects in both groups who score above the third quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM, will score significantly higher on the working drawing than those subjects who score below the first quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM.

Background and Significance

The objectives for industrial arts have been formulated to relate to all the courses comprising the discipline. From the literature, it is found that some approaches, especially in the areas of drafting, do not appear to be consistent with all of the objectives.

A set of objectives derived by Hostetler in 1960 proposes that a problem-solving approach be instituted in industrial arts. The American Vocational Association, in a more recent publication, advocates the problem-solving objective and includes the term "critical thinking" as a learning outcome.

Although there is some controversy in the literature as to whether or not it is possible to teach problem-solving and critical thinking, the disagreement is largely one of semantics. In most research of these mental processes, the


results rely heavily upon the definitions of problem-solving and critical thinking imposed for the particular study. The terms are often used synonymously, but the Encyclopedia of Educational Research defines critical thinking as being a more limited process of decision making, based upon facts, knowledge, and assumptions. Critical thinking is often employed in the problem-solving process.  

Schmitt reports in a 1966 national survey that secondary teachers of industrial arts ranked "problem-solving skills relating to materials and processes" second in degree of emphasis out of ten purposes for the discipline. This survey, however, did not investigate the emphasis of the various purposes within each field of industrial arts.

Several writers attack the approaches used in many drafting courses and offer their suggestions for change. Auer and Rowlett condemn meaningless repetition in drafting assignments, and Wright suggests that problem-solving

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techniques would more closely emulate industrial practices than "copying line work exercise from the nearest book on engineering drawing." Tischler proposes that a conceptual approach should replace comprehensive study of engineering drafting.

In a survey of course content for college drafting, Blum indicates that beginning drafting courses in the 142 institutions contacted identified eleven specific units of study which comprise the content. They are Drawing Equipment and Materials, Sketching, Lettering, Applied Geometry, Orthographic Projection, Dimensioning, Sections and Conventions, Revolutions, Auxiliary Views, Screw Threads and Fasteners, and Pictorial Drawing. The implication is that these units were being taught as separate entities, which could be combined for practical application. This survey would indicate that the typical college-level course in drafting is taught by the unit approach, and does not exhibit evidence that a


9Robert E. Blum, "Development and Standardization of an Achievement Test for Placing College Students in General Drafting," unpublished doctoral dissertation, Graduate College, Texas A&M University, College Station, Texas, 1965, pp. 33-38.
problem-solving or critical thinking approach is being employed.

From the literature, recommendations are found that engineering drafting, as a part of industrial arts, should develop the problem-solving and critical thinking abilities of the student. The literature indicates that the typical method of teaching engineering drafting at the college level is the unit approach. The unit approach does not appear to be directed toward attainment of the problem-solving and critical thinking objective. It is suggested that an approach which strives for attainment of this objective be sought.

Definitions of Terms

For the purpose of this study, the following definitions were used.

1. **Ability to Produce Working Drawings**.—The degree of proficiency with which a student was able to supply all the information necessary for construction of an object through graphic representation as measured by the Evaluation Form for Working Drawings determined his ability to produce working drawings.

2. **Class Section**.—A group of not more than thirty-three students who met a particular class with a specified instructor composed a class section.

3. **Critical Thinking Ability**.—Critical thinking was considered to be a process whereby an individual employed mental examination of all pertinent factors and evidence
before proceeding to a logical decision. A student's critical thinking ability was reflected by his score on the Watson-Glaser Critical Thinking Appraisal, Form YM.

4. Equated Groups.—Two groups of subjects were considered to be equated when the mean score of one group did not differ significantly from the mean score of the other group on the same instrument. Individuals of two groups were not paired.

5. General Drafting Knowledge.—General drafting knowledge was considered to be a combination of factual information with understandings and applications of principles of drafting. A student's general drafting knowledge was reflected by his score on General Drafting: A Comprehensive Examination.

6. Idea Communication Approach.—The idea communication approach to teaching engineering drafting was one which utilized a problem-solving process to determine the most appropriate method of transmitting a mental image through graphic illustration.

7. Unit Approach.—A subject area was taught by units when the various facets that comprised the content were arranged so that highly related aspects of the subject were presented individually.
Limitations of the Study

The study was limited to students enrolled in Industrial Arts 1313, Engineering Drafting, at Southwest Texas State University during the 1969 Fall Semester.

Basic Assumptions

1. It was assumed that any uncontrolled variables within the study would affect the experimental and control groups equally.

2. It was assumed that the instructors involved in the study would maintain a high degree of professional integrity.

Procedure for Collecting Data

Data for the study were obtained from test scores and performance tasks of students enrolled in Industrial Arts 1313, Engineering Drafting, at Southwest Texas State University during the 1969 Fall Semester. Students were permitted to enroll in the various sections of Industrial Arts 1313 on an individual choice basis. No student was requested to change sections for purposes of participating in the study. Assignment to groups was made of entire sections only. For the purpose of the study, the test scores and performance tasks of students with previous industrial experience as draftsmen and those students who were over twenty-five years of age were excluded.

There were two instructors, each teaching one control group and one experimental group. One of the instructors
was thirty-one years old and had taught industrial arts for seven years in the public schools and three years at the college level. The other instructor was thirty-three years old and had taught industrial arts four years in the public schools and six years at the college level. Both instructors held masters degrees and had completed all the required course work for doctorate degrees.

The assignment of class sections to groups was arranged to overcome the variables of time of presentation and length of class period. The four class sections which met on Monday, Wednesday, and Friday were divided with Instructor A teaching the eight o'clock control group and the ten o'clock experimental group. Instructor B taught the one o'clock experimental group and the three o'clock control group. The two class sections which met on Tuesday and Thursday were both taught by Instructor B, with the eight o'clock section being an experimental group and the two o'clock group being a control group.

General Drafting: A Comprehensive Examination was administered to both groups during the first week of the semester. From the scores obtained on this instrument, the two groups were equated. The Watson-Glaser Critical Thinking Appraisal, Form YH, was administered to both groups during the second week of the semester to obtain mean scores on critical thinking ability. Both tests were re-administered at the end of the semester.
For the first two weeks of the semester, instruction was the same for both groups. Beginning with the third week, the control group was given instructions in seven unrelated units of drafting. The eighth unit, on working drawings, required the recall of knowledge and skills from the previous units. Each unit was coordinated with related chapters in the text and workbook.

The experimental group drew a series of carefully selected objects which necessitated the utilization of the basic concepts of drafting. Emphasis was placed on complete graphic representation of each object. The experimental group used the textbook only as a reference source and did not use the workbook.

The final assignment for both groups was to make a working drawing, which was submitted to a panel of jurors for scoring. The scores on this drawing, along with the scores of the previously mentioned tests, were used for statistical treatment.

Procedure for Treating Data

The scores obtained from the tests and the assignment task were entered on IBM cards and computations were made by

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the Data Processing Center at North Texas State University, Denton, Texas. The reported level of confidence of the hypotheses of the study was determined by standard statistical analysis.

Hypotheses 1 and 2 were tested with the analysis of covariance technique to determine if the mean gain scores for general drafting knowledge and critical thinking ability differed significantly between the control and experimental groups. The analysis of covariance technique was also employed for hypothesis 3, to determine if the two groups differed significantly on the scores of the working drawing. The Fisher $t$ test of significance was used to test hypotheses 4 and 5 to determine if the scores of students in both groups, who at the beginning of the semester scored above the third quartile in critical thinking ability, were significantly different on the working drawing and the test of general drafting ability at the end of the semester than the scores of those students in both groups who scored below the first quartile in critical thinking ability at the beginning of the semester.

**Summary**

The purpose of Chapter I has been to present an overview of the study. The statement of the problem, purposes of the study, and the hypotheses outline specifically what was investigated, while the background and significance
section offers supportive evidence of the need for the study. Only an abbreviated description of the procedures for collecting and treating data has been presented in Chapter I. These procedures are described in detail in Chapters III and IV.

Chapter II is a review of research, related literature, and previous studies relevant to the present study. Chapter V presents conclusions and recommendations resulting from the study.
CHAPTER II

REVIEW OF THE LITERATURE

The review of the literature was instituted to provide guidance for the study through investigation and presentation of research related to two approaches to teaching engineering drafting. The major areas of the literature reviewed were (1) literature concerning approaches and methods of teaching engineering drafting, (2) literature relating to problem solving, and (3) literature regarding critical thinking.

Approaches and Methods of Teaching Engineering Drafting

Numerous studies have been conducted in the area of engineering drafting. Although the subject is often called mechanical drawing, drafting, technical drafting, and engineering graphics and is taught at the junior high, high school and college levels, the content is widely accepted as being derived from the work performed by professional draftsmen. Despite the wide range of age levels for which the course is available and the diversity of activities within the profession, the results of studies conducted at one grade level, or those limited to a specific segment of the content often have significance for other grade levels or other portions of the content. For this reason, the review of the
literature was not restricted to literature dealing with college level engineering drawing or only the approaches closely resembling those of the study.

The purpose of this section is to report what the literature reveals with respect to methods and approaches to teaching engineering drafting. Although the writers and researchers have dealt with a variety of hypotheses in this area, a wide-range investigation points up many similarities.

Rowlett\(^1\) cautions teachers of drafting that they are on tenuous grounds when they assume that the completion of a specified number of drawings will result in proficiency of drafting principles, specific skills, and the application of these and technical information. One reason cited for this is the fact that students within the same class often have different needs for the knowledge and skills they hope to obtain from the course.

Auer\(^2\) charges many teachers of drafting in industrial arts with relying on copying methods. He contends that drafting should be learned through the process of conveying an idea. He describes skills in drafting as being a tool with which to communicate. A course in drafting should, Auer

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\(^1\)John D. Rowlett, "Drafting: Consultant's Clinic," *Industrial Arts and Vocational Education*, LII (May, 1963), 14.

continues, "give the student experience in the scientific method of solving problems wherein creative and critical thinking are involved in the process of carrying out design problems from idea to finished form."\(^3\)

The use of a teaching machine and a written instructional booklet was compared with conventional teaching procedures for high school students of drafting by Beck.\(^4\) Both groups completed five drafting problems, with the fifth problem being solved by conventional methods and scored by a panel of jurors. The juror's scores were significantly higher for the drawings made by the group taught with the teaching machine than those of the control group with respect to problem solving ability and manipulative skills. Almost twice as much time was required for this group to complete the fifth problem using conventional methods as was required by the control group.

Craft\(^5\) conducted a study in engineering drafting to determine the effectiveness of teaching a control group with traditional problems versus teaching an experimental group.

\(^3\)Ibid., p. 33.


with open-end design problems substituted for some of the traditional problems. The instruction for the open-end design problems was from self-instruction booklets only. The results of tests in creative ability and subject matter showed statistical significant differences in favor of the experimental group for gains in originality and ideational fluency, with no significant difference between the groups in subject matter knowledge and skills.

Hepler⁶ made an investigation of the relative effectiveness of presenting orthographic projection first, followed by pictorial representation, as opposed to teaching pictorial representation first, followed by orthographic projection. The groups were compared on informational achievement, drawing skills, ability to visualize, speed, and attitude of the student toward the subject. It was found that the group which was taught orthographic projection first, followed by pictorial representation, was superior to the group taught in the reverse order with respect to informational achievement, drawing, skill, and ability to visualize. There was no significant difference between the groups with respect to speed developed and attitude of the student toward the course.

Jacobsen⁷ utilized groups comprised of matched pairs of subjects in a comparison of competitive learning experiences as opposed to cooperative learning experiences. The pairs were matched on the basis of intelligence and technical drawing aptitude test scores. There were no significant differences between the groups with regard to use of resources, self-evaluation, motivation, acquisition of information, and development of drafting skills. The group which participated in the cooperative learning experiences was found to be significantly superior to the group which participated in the competitive learning experiences with regard to problem selection.

Moegenburg⁸ experimented with teaching a unit in engineering drafting using three methods. Two groups were taught with programmed instruction booklets which were administered differently, and the third group was taught with taped television presentations. The group taught by the video-taped television method scored significantly higher on a test of selected concepts of orthographic projection than either of

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the two groups taught by the programmed instruction method. There was no significant difference between the two groups taught by programmed instruction techniques on the test of selected concepts.

Smith\(^9\) investigated the relative effectiveness of teaching content material in four units of technical drawing. The three methods of instruction employed were programmed instruction with supervision, programmed instruction without supervision, and lecture demonstration instruction. The study revealed no significant differences among the three methods of instruction.

The purpose of a study by Sedgwick\(^10\) was to develop and test the feasibility of incorporating graphic communication, as a basic communication medium, into the general-liberal education of all students. The five-week study of eighth grade males exposed the experimental group to isometric drawing, orthographic projection, dimensioning, bar diagrams, compound bar diagrams, and graphs. No mechanical aids or instruments were used by the experimental group. They were compared with subjects who used drafting instruments in a contemporary industrial arts drafting course. Although the


researcher found no significant difference in teacher effectiveness and no significant teacher interaction with treatments, he concluded that graphic communications could be learned without jeopardizing learning of the more conventional subject matter.

Norman\(^1\) conducted a ten-week experiment to compare the effectiveness of teaching engineering drawing with a combination of free-hand and instrument drawings as opposed to the use of instruments entirely. He found that the group which experienced five weeks of free-hand drawing followed by four weeks of drawing with instruments scored significantly higher on engineering drawing tests at the end of the fifth week and tenth week than did the group which made instrument drawings for the entire period. The group taught by the free-hand-instrument combination method was found to be significantly superior on a free-hand drawing examination, and there was no significant difference between the groups on an instrument drawing test.

An experiment to determine the relative effectiveness of teaching beginning drafting by identification and analysis of elements as opposed to the conventional approach was

conducted by Schanbacher. Eighty subjects were involved for a period of twelve weeks, with the experimental group receiving instruction in isolating and analyzing certain elements in drafting, and requiring them to identify certain elements in other views.

Of eight hypotheses, a significant difference was found to exist in only one. The experimental group was superior on the number of accurately solved sketching problems. Schanbacher concluded that the approaches are equally effective or desirable.

Ellis made an experimental comparison of the use of workbooks versus the construction method of teaching drafting at the college level. Two groups of subjects were taught by the two methods with a rotation-group design. He found a significant difference favoring the workbook method with respect to the development of drafting skills, but no significant difference in informational achievement, understanding spatial relationships, student's attitude toward drafting, or the effect of measured intelligence in informational achievement.


A comparison of the use of film slides versus the conventional approach to teaching engineering drawing was made by Wilkes. The 140 subjects were paired for the experiment, which resulted in significant differences in favor of the group taught by the film slide method with respect to informational achievement, ability to visualize, quantity of work completed, student attitude, and time required for presenting instructional information. The two groups did not differ significantly in quality of work completed by the subjects.

In an attempt to ascertain the relative effect of three evaluation procedures on achievement in college level drafting, Keseman had one group evaluate all of their assignments from projected transparency solutions, the teacher evaluated one fourth of the assignments and there was no evaluation of the remaining assignments in the second group, and the teacher evaluated all of the assignments of the third group. He found that the first group required significantly less time to complete the assignments than did the other two groups. There were no significant differences found relative to

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informational achievement, skill developments, and attitude toward the course. On the basis of requiring less time for both the instructor and the student, he recommended the method of student evaluation of all of their assignments over the two other approaches.

In summary, the results of the experimental studies on methods and approaches to teaching engineering drafting reviewed in this section revealed significant differences in several areas. These differences favored the utilization of teaching machines, open-end machines problems, presenting orthographic projection before pictorial representation, video-taped television presentations, workbooks, film-slides, free-hand and instrument combination, and student self-evaluation for the milieu in which they were tested.

Problem-Solving

Educators are familiar with the term "problem-solving," although its definition is not explicit in application. The process of problem-solving has been discussed and researched for both identification and implementation.

The results of individual studies often hinge on the definition given this higher mental process and the measuring instruments that were utilized. "Problem-solving is obviously not confined to arithmetical or quantitative situations but may arise whenever the individual is confronted by an
obstacle or a task which he understands but to which he has no immediate answer in behavior."\(^{16}\)

Wright\(^{17}\) states that students of drafting should be taught with the problem-solving approach, based on the fact that industry exists and progresses through the solution of problems. He cites an example of how engineers and draftsmen worked together to solve a problem created by faulty design in a piece of farm machinery. He points out that an important step in the solution of this and many industrial problems was experimentation. Wright contends that if industrial arts in the schools imulates industry, problem-solving and experimentation must be included.

Denton\(^{18}\) scrutinized the work of Dewey and Bruner in an attempt to justify problem-solving as a theory for both learning and teaching. He concluded that it is a useful theory of learning because it contributes to a gradual reconstruction of experience and provides for interaction with the environment. Problem-solving is accepted as being an effective theory of teaching because "it is a democratic method, not

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\(^{17}\) Lawrence S. Wright, "Drawing, Problem Solving and Industry," *Industrial Arts and Vocational Education*, XLVI (October, 1956), 245.

authoritarian; it places reliance upon individual judgment, encourages a scientific approach to problems, enhances creativity and, in short, helps to produce self-reliant individuals."\(^{19}\)

A study by Haslerud and Meyers\(^{20}\) supported the postulate that "independently derived principles are more transferable than those where the principle is given to the student."\(^{21}\) The experiment involved two groups of college students who were tested on their ability to decipher coded messages and to translate messages into code. Before the first test, the control group was instructed on the system to be used in deciphering and translating into code, and the experimental group was instructed with illustrations of cryptography and encouraged to develop their own system to be used. The second test used the same codes, but the arrangement was different, necessitating transfer of the principles used in the solution of problems on the first test. The experimental group scored significantly higher than the control group on the second test.

\(^{19}\)Ibid., p. 389.


\(^{21}\)Ibid., p. 296.
Harmey\(^{22}\) found the problem solving approach to be as effective as the highly structured approach in developing subject matter competency in wood technology, metal technology, and crafts. The study involved teaching the experimental group in each of the three areas with problem solving design experiences and employing highly structured experiences with the control group in the same three areas. The experimental group scored significantly higher than the control group on a test of creative ability in wood technology and metal technology. The experimental group also scored significantly higher than the control group on a test of achievement in wood technology.

Anderson\(^{23}\) experimented with developing creative problem solving abilities in a college level general education course which dealt with industry and the consumer. Laboratory assignments were made to all groups in the form of written instructions, with the control group receiving no other treatment. Both experimental groups were provided several pages of literature designed to increase interest.


and competence in creative problem solving. One group utilized an ideation period after reading the literature, and the other group participated in the ideation session before receiving the literature. The data revealed that creative problem solving ability was significantly increased by the treatments and the experimental groups were favored, but not significantly.

Baker\textsuperscript{24} utilized the area of beginning electricity to compare the problem-solving approach to the highly structured conventional approach in providing laboratory experiences. The conventional method entailed required projects and circuit board exercises, while the problem-solving approach required individual investigation of an assigned study unit followed by the derivation and construction of projects utilizing the principles studied. Although the data revealed no significant differences between the two approaches relating to the acquisition of factual knowledge, manipulative skills, and student attitude toward the course, Baker concluded that the specific type of laboratory activity is less important than the degree of organization, formal laboratory periods are not necessary, and useful projects are generally preferred by the students.

\textsuperscript{24}Glenn Earl Baker, "A Comparison of the Problem-Solving Method of Project Construction and Conventional Methods in Teaching the Laboratory of a College Course in Beginning Electricity," unpublished doctoral dissertation, Graduate College, Texas A&M University, College Station, Texas, 1966.
Another method of teaching which is very similar to the problem-solving approach in its implementation is the directed discovery method. This method appears to be a modification of problem-solving, whereby the problem is identified by the teacher and the students are guided toward a predetermined solution with clues and hints. Being more structured than problem-solving, the transition from conventional classroom procedure is not as great to the directed-discovery method as it is to the problem-solving approach. Several studies of the effectiveness of the directed discovery method of teaching industrial arts have been conducted.

Brenner\(^2^5\) experimented with the direct-detailed versus the directed discovery methods of teaching electricity laboratory exercises. He equated two groups, each of which contained sixty subjects, on the basis of scholastic aptitude, prior knowledge of electricity, age, attitude toward electricity, and semesters of high school and college electricity completed. He found the directed discovery approach to be significantly superior to the direct-detailed approach with regard to electrical problem solving performance. There were no significant differences between the groups.

for acquisition of technical information, influencing student attitude toward basic electricity, or increasing student competency to retain cognitive content in basic electricity.

Ray\textsuperscript{26} investigated the initial learning, retention, and transfer of micrometer principles and skills when taught by the directed discovery method versus the direct and detailed instructional method. Ninth-grade male subjects were tested immediately after the treatment, one week later, and six weeks after the treatment. It was found that the methods were equally effective with respect to initial learning and one-week retention. The directed discovery method was found to be superior to the direct and detailed method with respect to retention at six weeks and in enabling students to make wide applications of materials learned to new and related situations at both one and six weeks after treatment.

Rowlett\textsuperscript{27} conducted an experimental comparison of the direct-detailed method versus the directed discovery method of teaching orthographic projection to ninth grade subjects. The groups were tested immediately after treatment, twelve days after treatment, and six weeks after treatment. The


two groups did not differ significantly on test scores in regard to initial learning of orthographic projection principles and skills. The groups taught by the directed discovery method scored significantly higher than the group taught by the direct-detailed method in terms of retention and application of orthographic projection principles and skills as measured twelve days after instruction and six weeks after instruction. The group taught by the directed discovery method also scored significantly higher than the group taught by the direct-detailed method with reference to transferring principles and skills of orthographic projection twelve days after treatment and six weeks after treatment.

An investigation by Moss compared the direct-detailed method to the directed discovery method of teaching a unit in printing. Both methods used tape recorded lectures along with visual instructional aids. The direct-detailed method presented the information in a continuous positive manner, while the directed method presented only information considered basic, followed by questions and hints to stimulate subjects' discovery of the remaining content and functional relationships. No significant differences were found between the two methods with regard to amount of initial learning, one-week transfer, or six-week retention.

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A study by Grote,\textsuperscript{29} regarding the relative effectiveness of two methods of teaching technical materials, compared the directed discovery method to the direct-detailed method of teaching eighth grade students. It was found that the direct-detailed method alone produced statistically superior initial learning with no difference in retention and transfer. When the subjects were taught by both methods, the group that had been taught by the directed discovery method first was superior in initial learning after the second instructional period, the one-week transfer tests, and retention at six weeks.

Luck\textsuperscript{30} compared the direct and detailed method with the directed discovery method of teaching automotive topics to high school industrial arts students. The subjects were equated on mental ability levels and tested on initial learning instructional materials. No significant difference was found between the two methods at any of the three intelligence levels.


A philosophical study to develop principles for guiding teachers in designing and conducting learning experiences for improving student problem-solving experiences was conducted by Ferns. A summary of the principles derived from the investigation follows:

1. The greatest gains in improving students problem-solving abilities can be affected when the teacher consciously plans learning experiences with the goal of improving problem-solving ability in mind.

2. The improvement of student problem-solving ability is best accomplished indirectly by the teacher's regulating the conditions which guide it, and providing a favorable climate for it.

3. Exposing students to direct experience in grappling with and attempting to solve real-life problems through the use of scientific or problem-solving method is the teacher's most appropriate and promising way to achieve improvement in problem-solving abilities.

4. Problem solving is both a method and objective.

5. Problem-solving method is practically synonymous with learning, and there are indications that problem-solving is generally equal or superior to other methods of learning.

6. Learning experiences should be continuous with past and future experiences, should have both active and passive elements, and should include reflective thinking.

7. In designing and selecting problem situations suitable for improving student problem-solving abilities, it is important that the teacher make the distinction between genuine problems and those which are not. The following criteria serve to define true problem situations.

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a. There should be an objective in view.
b. There should be something blocking the objective.
c. There should be awareness of the goal and blocking obstacle. There should be intellectual activity.
d. There should be a high degree of subjective identification or motivation.
e. Problem situations or both ends of a problem difficulty continuum, which range from the extremes of completely familiar . . . to puzzles . . . are less desirable problem situations than those in between and should be minimized.32

The literature may be summarized as advocating the problem-solving approach as a sound and meaningful tool of education. An impressive rationale has been developed and guidelines set forth, but the empirical research is less than encouraging. Although many studies have dealt with problem-solving, few outside the field of mathematics have actually been an attempt to test it as an approach to teaching. Of those studies which made a comparison of the problem-solving approach versus the traditional approach, the results do not provide a distinctive pattern upon which judgements may be made with regard to the effectiveness of the problem-solving approach.

The directed discovery method of instruction has received considerable attention from researchers in the field of industrial arts. The literature discloses little, if any, support for the directed discovery method as a means of increasing

32Ibid., pp. 195-197.
initial learning, however, some studies have indicated that
the advantages of this method over a more structured approach
lie in the domains of application, retention, and transfer
of acquired knowledge.

Critical Thinking

It has long been the goal of educators to develop within
their students the ability to make rational judgements based
on facts. Many attempts have been made to produce and meas-
ure this outcome in the classroom.

Critical thinking . . . is a process of
evaluation or categorization in terms of some
previously accepted standards. It is a logical
examination of data which avoids fallacies and
judgements on an emotional basis only. In a
world of conversation, admonition, newspapers,
books, and television programs, the child needs
to develop the ability to evaluate ideas, to be
critical in scientific, social, and personal
matters. This seems to involve attitude plus
knowledge of facts plus some thinking skills.33

Wallen, Haubrich, and Reid34 report a study conducted
to modify a high school history curriculum so that critical
thinking would be nurtured without affecting the acquisition
of subject content. The amount of expected gain in knowledge
of history and critical thinking was established by testing
students of the nine participating teachers the year before
the modification was made. In a summer workshop, the

33 Harris, on. cit., p. 651.
34 Norman E. Wallen, Vernon F. Haubrich, and Ian E. Reid,
"The Outcomes of Curriculum Modifications Designed to Foster
Critical Thinking," The Journal of Educational Research,
LVI (July-August, 1963), 529-534.
teachers planned the curriculum modifications, which encouraged students to critically analyze statements in the text, newspaper, and periodicals in a structured manner. The curriculum modifications were found to have no effect on mastery of content. Two different tests of critical thinking ability supplied conflicting data. The subjects taught the modified curriculum scored significantly higher than the subjects taught the original curriculum on one test and not significantly higher on the other test.

A study to evaluate the extent to which critical thinking and knowledge and understanding of science were achieved by science majors and non-science majors was conducted by Brouillette. The conclusion was drawn that critical thinking appeared to be an innate ability, unaffected by the study of science.

Edgar compared the effects of laboratory centered biology instruction versus non-laboratory instruction on critical thinking ability and student attitudes toward biology. The non-laboratory instruction method was found to be


significantly superior to the laboratory method for the improvement of critical thinking ability.

Denney\textsuperscript{37} correlated several traits of teachers and concluded that critical thinking was a product of general intelligence and psychological openness. After conducting an experiment on the effects of instruction in general semantics on critical thinking ability, Duckworth\textsuperscript{38} concluded that the teacher, as distinguished from the subject content, is a major variable on the gain in critical thinking ability.

Russell\textsuperscript{39} studied the effect of selected experiences in critical thinking on critical thinking ability and the level of achievement in electronics. The control group was taught by conventional methods, while the experimental group received exercises in critical thinking and electronics instructional material. The experimental group scored significantly higher than the control group on the test of achievement in

\begin{footnotesize}
\begin{enumerate}
\item Joseph Battersby Duckworth, "The Effects of Instruction in General Semantics on the Critical Thinking of Tenth and Eleventh Grade Students," unpublished doctoral dissertation, Graduate School, Wayne State University, Detroit, Michigan, 1968.
\item James Alvin Russell, Jr., "An Investigation Into the Changes in Critical Thinking and Achievement in Electronics as the Result of Exposure of Subjects to Specific Techniques of Critical Thinking," unpublished doctoral dissertation, Graduate School, University of Maryland, College Park, Maryland, 1967.
\end{enumerate}
\end{footnotesize}
electronics at the end of the treatment period and on the same test four weeks later. No significant difference was found for the gain in critical thinking ability between the two groups.

A longitudinal study to determine the changes in critical thinking, attitudes and values of college students from their freshman to their senior years was conducted by Lehmann. The data from a sample of 1051 students indicated that the critical thinking ability increased significantly during the four years of college. The investigation revealed that the greatest changes in critical thinking ability, values and attitudes took place during the freshman and sophomore years. The conclusions drawn from the study do not attribute the changes to formal, academic experiences alone, but suggest that dormitory discussions, new acquaintances and other informal, non-academic experiences contribute to the overall personality development.

O'Neill made an extensive investigation into teaching for critical thinking, with special attention to teacher preparation in this area. He developed a rationale for teacher education directed toward critical thinking, but

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40 Irvin J. Lehmann, "Changes in Critical Thinking, Attitudes, and Values from Freshman to Senior Years," *Journal of Educational Psychology*, LIV (June, 1963), 305-315.

found little evidence that institutions of higher education pursued this approach. The study identified a list of teacher behaviors associated with fostering critical thinking and a model of critical thinking organization.

In a study of science problem-solving ability possessed by prospective elementary teachers, Parks\(^2\) found a significant correlation between the subjects' ability to solve problems in the laboratory and their critical thinking ability. The experimental group critically analyzed five research papers in addition to the conventional laboratory work conducted by the control group. His study did not indicate a significant difference between the control and experimental groups as a result of the treatment.

A survey of the literature reveals that experiments have disclosed many properties related to and associated with critical thinking, but it offers only limited information concerning methods which foster the growth of critical thinking ability. Critical thinking has been linked with problem solving both philosophically and experimentally. In identifying and defining the two terms many similarities have been unveiled. The few studies which have dealt with the improvement of problem-solving and critical thinking abilities

through experimental methods have revealed that teaching methods and techniques which successfully improve one bear resemblance to those methods and techniques which produce desirable results in the other. A need for additional research in the area of developing critical thinking ability is stressed throughout the literature.
CHAPTER III

COLLECTION OF THE DATA

The problem of this study was a comparison of the effectiveness of two approaches to teaching engineering drafting. The experimental group was taught using an idea communication approach and the control group was taught using a "typical" unit approach. In order to implement the collection of data, the study was arranged in the following three major stages:

1. Design and Controls of the Experiment.
2. Procedures for the Control Group.

Design and Controls of the Experiment

Subjects who participated in the study were those who enrolled in Industrial Arts 1313, Engineering Drafting, at Southwest Texas State University for the 1969 Fall Semester. There were six sections, four of which met on Mondays, Wednesdays, and Fridays for a combined lecture and laboratory period of two hours each day, and two sections which met on Tuesdays and Thursdays for a combined lecture and laboratory period of three hours each day. Neither the students nor the instructors knew which sections would be assigned to the control group or the experimental group at the time of registration.
To overcome the variables of teacher differences, each instructor taught the same number of sections which were assigned to the control group as he did sections which were assigned to the experimental group. A description of the two instructors who participated in the study is presented in Chapter I.

To overcome the variable of time of presentation, one morning section and one afternoon section of the Monday-Wednesday-Friday series were assigned to the control group, with the remaining morning section and the afternoon section assigned to the experimental group. It was determined by the toss of a coin that the section taught by Instructor A at eight o'clock would be in the control group. The section taught by Instructor A at ten o'clock was then assigned to the experimental group. The same method was used to assign the one o'clock section to the control group and the section which met at three o'clock to the experimental group. These two sections were taught by Instructor B. A third toss of the coin placed the section which met at eight o'clock on Tuesdays and Thursdays in the experimental group and the two o'clock section of the Tuesday-Thursday series in the control group. Instructor B also taught both of these sections.

An information card was completed by the subjects in each group on the first day they attended class. Included in the information supplied by the students were their age and their previous drafting experience. Data from all
students who were over twenty-five years of age and all who indicated previous industrial experience as draftsmen were excluded from the study. These students remained in the classes and participated in all the activities of the class, but their scores were omitted from the data for the study.

The two groups were equated on the basis of scores achieved on General Drafting: A Comprehensive Examination, which was administered during the first week of the semester. This was accomplished statistically by using the analysis of covariance technique in testing the hypotheses related to the comparison of the experimental and control groups. The differences between the scores from the first to the second administration of General Drafting: A Comprehensive Examination were used to compute a regression equation, which was used to adjust the actual mean scores for the gain in critical thinking ability and the achievement scores for the working drawing to compensate for the original difference between the groups.

Subjects in one group were not paired with subjects of the other group, and it was not required that each group contain the same number of subjects. A total of eighty-four students were originally enrolled in the control group, and eighty-two in the experimental group. At the end of the semester, data from sixty-three subjects in the control group, and sixty-four in the experimental group were used for statistical treatment.
Four subjects were excluded from the study because of their age, and one was excluded because of previous industrial experience as a draftsman. Twenty-two subjects did not complete the course, five failed to take one or more of the pre and post tests, and seven did not turn in a working drawing.

**Description of Instruments**

**General Drafting: A Comprehensive Examination**, by Robert E. Blum, is a 140 item multiple choice test, developed in 1965. In addition to a total score, subscores are reported for the areas of drawing equipment and materials, sketching, lettering, applied geometry, orthographic projection, dimensioning, sections and fasteners, and pictorial drawings. The test is designed for freshmen college level engineering drafting and a concurrent validity coefficient of .52 for a three semester hour group is reported. The reliability coefficient for the same group is .92.

The **Watson-Glaser Critical Thinking Appraisal, Form YM**, is designed for grades nine through sixteen and adults, and supplies scores for inference, assumptions, deduction, interpretation, arguments, and a total score for the ninety-nine items. The reliability coefficient is reported as .84 from samples of both high school juniors and college "presophomores." Validity correlations are reported to range from .33 to .52 for four different classes between teacher's ratings and total scores on the test.
The third instrument used in the study was a working drawing of an automobile connecting rod and cap, which the subjects in both groups were assigned to draw two weeks before the end of the semester. These drawings were submitted to a panel of scoring jurors for grading and the average score received on each drawing was used for statistical testing.

The jury was comprised of three experienced drafting teachers from colleges and universities in Texas. All of the jury members held masters degrees, and two of them were enrolled in programs leading to the doctorate degree.

The first jury member was twenty-nine years old, had taught drafting and other industrial arts courses in the public schools for five years, and was in his second year as a drafting instructor at the college level at the time of the study.

The second jury member was thirty years old, had taught drafting and other industrial arts courses in the public schools for four years, and was in his third year as a drafting instructor at the college level. He had experience as a professional draftsman on a part-time basis over a span of several years.

The third jury member was a professional draftsman for eleven years before entering the teaching profession at the college level. He was thirty-eight years old and in his sixth year as a drafting instructor at the time of the study.
The jury members were asked to score the drawings on a prescribed evaluation form (see Appendix D) with each drawing being scored by all three jury members. Jury members did not know which drawings were those of the control and which were those of the experimental group. The mean score for each drawing was used for further computation.

The evaluation form used by the scoring jury was validated by another three member jury. This validation jury was also comprised of three experienced teachers from colleges and universities in Texas, but none of the members of the validation jury were members of the scoring jury or connected in any way with the experiment.

Two of the validation jury members had each taught more than twenty years at the college level with primary assignments in the area of engineering drafting. The other validation jury member had taught drafting and other industrial arts courses four years in the public schools, was in his seventh year at the college level and his third year as departmental chairman.

Members of the validation jury were supplied a suggested evaluation form (see Appendix A) and asked to indicate on a corresponding instrument (see Appendix B) whether they believed each item should be retained, rejected, or altered. They were asked for suggestions for improving items they had marked "Alter," and any additional items which should have been included.
Two suggestions for change were offered by one member of the validation jury. These suggestions were referred back to all three members of the jury, who indicated on a second validation form (see Appendix C) whether or not they favored making the suggested changes. The vote was unanimous to include "correct solution" in the criteria for the division heading "Accuracy of Views." There was a two to one vote in favor of listing the criteria for "Line Quality" under "Line Accuracy," reducing the number of division headings by one. Agreement of two of the three jury members was required for changes in the instrument, so both suggested changes were made.

The evaluation form contained nine division headings: neatness, scale accuracy, line accuracy, choice of views, location of views, accuracy of views, lettering, dimension adequacy, and dimension arrangement. Rating values ranging from one, unacceptable, to five, excellent, were used for each of the nine division headings. Criteria for each division heading were included on the form.

Selection of Content

To insure that the same content was presented to both groups, a careful comparison was made between the lecture material and the laboratory assignments for the control group and the lecture material and laboratory assignments for the
experimental group. The text, which was the same for both groups, was used as a source for selection of the content.

A complete list of the topics normally covered in the course was compiled by the two participating instructors. The list was expanded through the addition of sub-topics and was then divided into two parts: (1) information to be presented in lecture only, and (2) drafting processes to be developed through laboratory drawing activities.

Selection of drawings to be assigned the control group was made from the text and the workbook, with seven mimeographed worksheets supplementing the applied geometry unit. These drawings had been required in previous semesters and were considered to be typical for the course. They were compared to the list of drafting processes to be developed through laboratory activities and found to cover every topic and sub-topic on the list.

The assignments for the experimental group were actual objects which encompassed the same drafting processes as those required of the control group. The series of objects was analyzed to make certain that they fulfilled this requisite. This analysis was accomplished by studying each object carefully to determine which drafting processes were required to draw the object. The processes were noted, and checked off the list of drafting processes to be developed through laboratory drawing activities. Objects were substituted and added until every item had been checked off.
After the selection of objects to be drawn by the experimental group was made, a comparative list (see Appendix E) was compiled showing each activity to be performed by the control group and the object to be drawn by the experimental group that would entail the same drafting process. This comparative list and the list of information to be presented in lecture only were validated by an authority in the area of drafting, who was not a participant in the experiment.

The objects comprising the laboratory drawing experiences for the experimental group were arranged in order of increasing difficulty. An assignment sheet was prepared for each object to insure that the graphic representation would utilize the drafting processes indicated by the comparative list (see Appendix H).

Procedures for the Control Group

The control group was taught by a unit approach. Lectures presented information related directly to the particular unit being studied, with laboratory and outside assignments designed to provide experiences in the same areas. No attempt was made to coordinate the units until the final assignment, to make a working drawing, was presented.

The first two weeks of the semester were devoted to the use of drafting equipment. Special attention was given to familiarization and correct operation of the drafting machine. Exercises in measurement, location, angles, and line
direction were performed by the subjects, while lectures offered supplemental information on pencil usage, line characteristics and quality, techniques of handling and operating dividers and compasses, and making blue prints.

**General Drafting: A Comprehensive Examination** was administered during the first week of the semester, and the Watson-Glaser Critical Thinking Appraisal, Form YM, was administered during the second week of the semester. Total scores on these instruments were retained for statistical computation.

A unit on lettering was presented during the third week of the semester. This consisted of lectures and discussions of the various standard styles of letters and the characteristics of single-stroke vertical capitals. Laboratory assignments provided practice in making free-hand letters and numerals.

The third unit, applied geometry, required two weeks for the instructions and exercises in dividing a line into a given number of parts, constructing a hexagon, constructing ellipses, and drawing tangent lines under several different circumstances. The lectures for this unit presented the techniques of the various constructions, and the concepts of why these particular techniques were employed.

Orthographic projection was studied for a period of three weeks. It dealt with rectangular shapes, inclined surfaces, cylindrical shapes, arcs, irregular curves and
fillets and rounds in multiple-view representation. Center lines and hidden features were introduced, and line quality was stressed.

Unit five, auxiliary views, was allotted two weeks and pertained to drawing normal views of inclined surfaces. All drawings were required to include reference planes, and their location in the principal views was emphasized.

The sixth unit, pictorials, presented the methods of axonometric, oblique, and perspective representation in the lectures, although only oblique and one form of axonometric, isometric, were drawn by the subjects. Rectangular shapes, inclined surfaces, cylindrical shapes, arcs, and irregular curves were included in the problem assignments, offering a wide range of experiences during the one week devoted to the unit.

Sections and conventions were also studied for only one week. It was possible to utilize the workbook for all the assignments in this unit, which greatly decreased the time necessary to complete each problem. Full, half, broken out, rotated, removed, and assembly sections were drawn, as well as a variety of aligned features.

Unit eight, screw thread fasteners, and unit nine, dimensioning, were presented during the same week. Only one short lecture period was devoted to screw thread fasteners, but two full laboratory periods were required to complete the drawings. Two lecture periods were allocated to
dimensioning, with the workbook again being utilized to shorten the time necessary for completion of each problem. It was possible for the subjects to complete many of the dimensioning assignments as homework, because a straight edge and pencil were the only pieces of drawing equipment needed.

The final unit, working drawings, was presented the week before, and the week immediately following, the Christmas Holidays. The lectures were presented during the first week, and the second week was devoted entirely to work in the laboratory. The assignment was to make a set of working drawings of an automobile connecting rod and cap. The subjects made four blue prints of this drawing. One copy was graded by the instructor as part of their course grade, and the other three copies were retained and scored by a panel of jurors.

The Watson-Glaser Critical Thinking Appraisal, Form YM, was administered one week before the Christmas Holidays, and General Drafting: A Comprehensive Examination was administered the second week after the Christmas Holidays. Total scores on these instruments were also retained for statistical treatment.

Procedures for the Experimental Group

The experimental group participated in an idea communication approach to engineering drafting. They were presented
information only as it related to the assignment in progress at the time. The assignments to be drawn were actual objects, which with one exception were brought into the classroom where they could be handled and examined by the subjects. The text was employed only as a reference, and the experimental group did not use a workbook.

The first two weeks of the semester were devoted to the use of drafting equipment. The instruction was identical to that presented to the control group. General Drafting: A Comprehensive Examination was administered during the first week of the semester, and the Watson-Glaser Critical Thinking Appraisal, Form YM, was administered during the second week of the semester.

The experimental group studied a six-step problem solving technique during the third week of the semester. The technique included identification of the problem, analysis, assumptions, research, possible solutions, and final solution. A familiar problem, finding a parking space, was first used as an illustration. The technique was then explained as it would apply to the solution of a drafting problem. The problem was stated as "fully describe the pencil pointer in the simplest and most direct manner." The function of each part was carefully studied in the analysis. The pieces were examined to determine what they did, how they operated, how they were assembled, and how they were made. The assumption was made that persons using the finished drawing would
either produce the pencil pointer or be interested in purchasing a large quantity of them. The research involved would be to determine the material from which each part was made, and the industrial process for its manufacture. Possible solutions were sketches of various methods of illustrating the pieces and the assembled pointer. The best views, notes, and dimensions were selected from the possible solutions and used in the production of an instrument drawing for the final solution to the problem.

Since the purpose of the presentation was to illustrate the use of the technique of problem solving, the research was not carried out in detail, the possible solutions were sketched by the instructor on the overhead projector, and the final solution was not completed. The problem solving technique was emphasized to the experimental group throughout the course.

The assignment for the fourth week of the semester was to make an instrument drawing of an oilstone. The subjects were to describe the object fully, indicating its complete shape and size. They had been given no instruction at this time as to conventional methods of representation, so they were assured that there was no wrong solution. When the drawings were completed, the various methods that had been chosen were shown on the overhead projector and discussed with the class. It was emphasized that there were several ways in which the problem could be solved.
The second assignment, to make an instrument drawing of a cold chisel, was slightly more difficult, and more specific requirements concerning the methods of representation were made. Specific text references covering the introductions to orthographic projection, dimensioning, isometric drawing, inclined surfaces, and using the scale were included on the instruction sheet. Lectures on these topics were limited to explanations of the basic concepts and the specific information needed to draw the cold chisel.

Specifications of the object's use, the material from which it was made, any changes to be initiated, and the dimensions were listed on every instruction sheet. An abbreviated procedure to follow in making the drawing was included on the first two instruction sheets.

The third object, a lathe face plate, introduced circular objects, center lines, finish marks, half sections, threads, aligned features, construction of a hexagon, and oblique drawings. One week was allotted to the study of these areas and drawing the face plate. This same time allocation was made for each of the eleven objects drawn by the experimental group.

The assignment of drawing a file required a rotated section, dividing a line into a given number of parts, dimensioning a taper, and constructing an arc tangent to two lines. The wrench involved construction of ellipses, a removed section and constructing an arc tangent to another
arc and a straight line. The picture frame jig, object number six, added experiences in drawing an assembly section, an exploded pictorial, and making a parts list.

Drawing cylindrical features in orthographic and isometric, dimensioning cylinders, and constructing an arc tangent to two other arcs were presented with the assignment to fully describe a bench rammer. Plotting and drawing an irregular curve was required to draw object number eight, the wall plaque.

Assignment number nine differed from the other assignments in that it required the subjects to design a birdhouse, with certain specifications, and make a finished drawing of it. Besides allowing some creative thinking, the drawing provided experiences in illustrating construction with wood, and utilizing a broken-out section.

The drawing of a motor mount introduced auxiliary views and the location of holes. The final object to be drawn as a part of the idea communications approach was a shaft assembly. This assignment introduced decimal fractions, assembly sections, and full sections.

Two weeks before the end of the semester, the experimental group was given the same final assignment as the control group, to make a working drawing of an automobile connecting rod and cap. The Watson-Glaser Critical Thinking Appraisal, Form YM, was administered during the same week. Like the control group, the experimental group took the test, General
Drafting: A Comprehensive Examination, at the end of the semester.

Drawings made during the semester were turned in as they were completed. They were graded, the grades were recorded, and the drawings were returned to the subjects as soon as possible. Tests for the purpose of semester grade computation were administered to both groups at the discretion of the instructor. Data used for statistical treatment were the scores from both administrations of General Drafting: A Comprehensive Examination, the scores from both administrations of the Watson-Glaser Critical Thinking Appraisal, Form YM, and the average individual scores on the working drawing. Procedures for the treatment and analysis of these data are presented in Chapter IV.
CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

Introduction

The data obtained for statistical treatment for the study were related to three major areas: general drafting knowledge, critical thinking ability, and ability to produce a working drawing. General drafting knowledge was measured before and after the treatment period with General Drafting: A Comprehensive Examination. Critical thinking ability was measured before and after the treatment period with the Watson-Glaser Critical Thinking Appraisal, Form YM. Ability to produce a working drawing was measured at the end of the treatment period with a performance task of making a working drawing of an automobile connecting rod and cap.

Raw scores on the two standardized instruments and the average of three jury members' ratings on the working drawing were tabulated for each subject who participated in the study. These scores, along with an individual subject number and a control or experimental group designation number, were entered on IBM punch cards for statistical treatment by the Computing Center, North Texas State University, Denton, Texas. All five hypotheses were restated in the null form for statistical treatment.
Hypothesis 1 dealt with the mean gain scores of the group taught by the idea communication approach as opposed to the unit approach with regard to general drafting knowledge. Hypothesis 2 dealt with the mean gain scores of the group taught by the idea communication approach as opposed to the unit approach with regard to critical thinking ability. Hypothesis 3 dealt with the mean scores of the group taught by the idea communication approach as opposed to the group taught by the unit approach on their ability to produce a working drawing. Hypothesis 4 compared the scores of subjects in both groups who scored above the third quartile in critical thinking ability at the beginning of the semester with those of subjects who scored below the first quartile in critical thinking ability at the beginning of the semester on their general drafting knowledge. Hypothesis 5 compared the scores of subjects in both groups who scored above the third quartile in critical thinking ability at the beginning of the semester with those of subjects who scored below the first quartile in critical thinking ability at the beginning of the semester on their ability to produce a working drawing.

It was assumed that before the treatment period, the group taught by the idea communication approach (experimental) did not differ significantly from the group taught by the unit approach (control) with regard to general drafting knowledge. To compensate for the possibility that this could have been a false assumption, the analysis of covariance
technique was employed to test hypotheses 1, 2, and 3, with the scores obtained from the first administration of General Drafting: A Comprehensive Examination being used to compute the regression coefficient.¹

The Fisher technique was utilized to test hypotheses 4 and 5. Each of the five hypotheses was arbitrarily accepted at the .05 level of significance.

Data Related to Hypothesis 1

The mean scores of the control and experimental groups obtained from the first administration of General Drafting: A Comprehensive Examination were used as the basis for statistical allowance for the difference between the two groups. The adjusted mean gain scores from the first administration to the second administration of General Drafting: A Comprehensive Examination were used to compare the acquisition of general drafting knowledge of the two groups. Data related to the mean gain on this instrument are reported in Table I.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Pretest Mean</th>
<th>S.D.</th>
<th>Post Test Mean</th>
<th>S.D.</th>
<th>Mean Gain</th>
<th>Adjusted Mean Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>63</td>
<td>55.70</td>
<td>14.10</td>
<td>86.10</td>
<td>13.00</td>
<td>30.40</td>
<td>31.45</td>
</tr>
<tr>
<td>Experimental</td>
<td>64</td>
<td>52.00</td>
<td>15.48</td>
<td>87.95</td>
<td>11.98</td>
<td>35.95</td>
<td>34.91</td>
</tr>
</tbody>
</table>

Employment of the regression coefficient raised the mean gain score for the control group 1.05 points, and lowered the mean gain score for the experimental group 1.04 points. The adjusted mean gain scores represented the acquisition of general drafting knowledge after allowance had been made for the original difference between the two groups.

Hypothesis 1 was that the group taught by the idea communication approach (experimental) will show a significantly greater mean gain score on general drafting knowledge, as measured by General Drafting: A Comprehensive Examination, than will the group taught by the unit approach (control). The residuals of the analysis of covariance used in testing this hypothesis are presented in Table II.

| TABLE II |
| SUMMARY OF THE ANALYSIS OF COVARIANCE OF THE MEAN GAIN SCORES ON GENERAL DRAFTING: A COMPREHENSIVE EXAMINATION |
| N = 127 |

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sums of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>125</td>
<td>14976.62</td>
<td>.. ..</td>
<td>..</td>
</tr>
<tr>
<td>Within</td>
<td>124</td>
<td>14602.56</td>
<td>117.76</td>
<td>..</td>
</tr>
<tr>
<td>Difference</td>
<td>1</td>
<td>374.06</td>
<td>374.06</td>
<td>3.18</td>
</tr>
</tbody>
</table>
The analysis of covariance of the mean gain scores on General Drafting: A Comprehensive Examination did not yield the F value of 3.92 required for the .05 level of significance. Therefore, hypothesis 1 was rejected.

Data Related to Hypothesis 2

The increase in critical thinking ability, as indicated by the mean gain scores from the first to the second administration of the Watson-Glaser Critical Thinking Appraisal, Form YM, is reported in Table III.

| TABLE III |
| SUMMARY OF THE DATA RELATED TO THE MEAN SCORES FOR THE WATSON-GLASER-CRITICAL THINKING APPRAISAL, FORM YM |

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Pretest Mean</th>
<th>S.D.</th>
<th>Post Test Mean</th>
<th>S.D.</th>
<th>Mean Gain</th>
<th>Adjusted Mean Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>63</td>
<td>64.57</td>
<td>9.78</td>
<td>68.51</td>
<td>9.80</td>
<td>3.94</td>
<td>3.93</td>
</tr>
<tr>
<td>Experimental</td>
<td>64</td>
<td>66.94</td>
<td>9.36</td>
<td>70.44</td>
<td>8.93</td>
<td>3.50</td>
<td>3.50</td>
</tr>
</tbody>
</table>

The initial scores on General Drafting: A Comprehensive Examination were again utilized in the computation of the regression coefficient. Although the mean scores of the experimental group were higher than those of the control group on both administrations of the instrument, the mean gain score of the control group was greater than the mean gain score of the experimental group.
Hypothesis 2 was that the experimental group will show a significantly greater mean gain than will the control group from the pretest to the post test in critical thinking ability, as measured by the Watson-Glaser Critical Thinking Appraisal, Form YM. The residuals of the analysis of covariance used in testing hypothesis 2 are presented in Table IV.

**TABLE IV**

**SUMMARY OF THE ANALYSIS OF COVARIANCE OF THE MEAN GAIN SCORES ON THE WATSON-GLASER CRITICAL THINKING APPRAISAL, FORM YM**

\[ N = 127 \]

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>125</td>
<td>8025.34</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Within</td>
<td>124</td>
<td>8019.61</td>
<td>64.67</td>
<td>...</td>
</tr>
<tr>
<td>Difference</td>
<td>1</td>
<td>5.73</td>
<td>5.73</td>
<td>.09</td>
</tr>
</tbody>
</table>

The analysis of covariance of the mean gain scores on the Watson-Glaser Critical Thinking Appraisal, Form YM, did not yield the F value of 3.92 required for the .05 level of significance. Therefore, hypothesis 2 was rejected.

**Data Related to Hypothesis 3**

To compare the two groups on their ability to produce a working drawing, only the one average score obtained on the working drawing assignment was used for statistical
computation. Data related to the derivation of the adjusted means are reported in Table V.

**TABLE V**

**SUMMARY OF THE DATA RELATED TO THE MEAN SCORES ON THE WORKING DRAWING**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>63</td>
<td>21.03</td>
<td>4.70</td>
<td>20.94</td>
</tr>
<tr>
<td>Experimental</td>
<td>64</td>
<td>22.16</td>
<td>5.46</td>
<td>22.26</td>
</tr>
</tbody>
</table>

The initial scores on *General Drafting: A Comprehensive Examination* were again utilized in the computation of the regression coefficient. This yielded adjusted means of 20.94 for the control group and 22.26 for the experimental group.

Hypothesis 3 was that the experimental group will achieve a significantly higher mean score than will the control group on the working drawing. The analysis of covariance residuals for testing hypothesis 3 are reported in Table VI.

The obtained $F$ value did not reach the 3.92 required for the .05 level of significance. Therefore, hypothesis 3 was rejected.
TABLE VI
SUMMARY OF THE ANALYSIS OF COVARIANCE OF
THE MEAN SCORES ON THE WORKING DRAWING

N = 127

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>125</td>
<td>3262.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>124</td>
<td>3207.74</td>
<td>25.87</td>
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</tr>
<tr>
<td>Difference</td>
<td>1</td>
<td>54.74</td>
<td>54.74</td>
<td>2.12</td>
</tr>
</tbody>
</table>

Data Related to Hypothesis 4

Hypothesis 4 was that subjects in both groups who score above the third quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM, will score significantly higher on the second administration of General Drafting: A Comprehensive Examination than will those subjects who score below the first quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM. This hypothesis was tested with the Fisher t test of significance. A summary of the data related to this computation is presented in Table VII.

A Fisher t value of 3.67 was obtained, which was significant at greater than the .001 level. Therefore, hypothesis 4 was accepted.
TABLE VII

SUMMARY OF THE DATA RELATED TO THE MEAN SCORES OF THE UPPER AND LOWER CRITICAL THINKING ABILITY GROUPS ON GENERAL DRAFTING: A COMPREHENSIVE EXAMINATION

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Fisher t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper</td>
<td>32</td>
<td>91.94</td>
<td>12.65</td>
<td>* * *</td>
</tr>
<tr>
<td>Lower</td>
<td>32</td>
<td>81.41</td>
<td>9.79</td>
<td>3.67*</td>
</tr>
</tbody>
</table>

*Significant at the .001 level of confidence.

Data Related to Hypothesis 5

Hypothesis 5 was that subjects in both groups who score above the third quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM, will score significantly higher on the working drawing than those subjects who score below the first quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM. This hypothesis was also tested with the Fisher t test of significance, and a summary of the data is presented in Table VIII.

A Fisher t value of 2.00 is required for the .05 level of significance with sixty-two degrees of freedom. The obtained Fisher t value of 1.61 was non-significant at this level. Therefore, hypothesis 5 was rejected.
TABLE VIII

SUMMARY OF THE DATA RELATED TO THE MEAN SCORES OF THE UPPER AND LOWER CRITICAL THINKING ABILITY GROUPS ON THE WORKING DRAWING

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Fisher t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper</td>
<td>32</td>
<td>22.47</td>
<td>6.66</td>
<td>*</td>
</tr>
<tr>
<td>Lower</td>
<td>32</td>
<td>20.16</td>
<td>4.39</td>
<td>1.61</td>
</tr>
</tbody>
</table>

Summary

Hypothesis 1 compared the control group to the experimental group on the acquisition of general drafting knowledge. Although the experimental group showed a greater mean gain score than the control group, the F value of 3.18, as illustrated in Table IX, did not represent a significant difference and the hypothesis was rejected.

TABLE IX

SUMMARY OF THE ANALYSIS OF DATA OBTAINED IN THE STUDY

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>F Value</th>
<th>t Value</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.18</td>
<td>*</td>
<td>NS</td>
</tr>
<tr>
<td>2</td>
<td>.09</td>
<td>*</td>
<td>NS</td>
</tr>
<tr>
<td>3</td>
<td>2.12</td>
<td>*</td>
<td>NS</td>
</tr>
<tr>
<td>4</td>
<td>*</td>
<td>3.67</td>
<td>.001</td>
</tr>
<tr>
<td>5</td>
<td>*</td>
<td>1.61</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Not Significant
Hypothesis 2 compared the control group with the experimental group on the gain in critical thinking ability. The slight difference between the performance of the groups favored the control group. The analysis of covariance yielded an F value of .09, which was not significant at the .05 level. Hypothesis 2 was rejected.

Hypothesis 3 compared the performance of the control group with that of the experimental group on their ability to produce a working drawing. The mean score for the experimental group was greater than the mean score of the control group, but only enough to yield an F value of 2.12, which was not significant at the .05 level. Hypothesis 3 was rejected.

Hypothesis 4 compared the performance of the subjects with upper level critical thinking ability to the subjects with lower level critical thinking ability on general drafting knowledge at the end of the semester. As illustrated in Table IX, the obtained t value of 3.67 was significant at greater than the .001 level, in favor of the upper level ability group. Hypothesis 4 was accepted.

Hypothesis 5 was a comparison of the performance of the subjects with upper level critical thinking ability to the performance of the subjects with lower level critical thinking ability on their ability to produce a working drawing after treatment. The difference between the mean
scores favored the upper level ability group, and as illustrated in Table IX, yielded a $t$ value of 1.61. This, however, was not significant at the .05 level. Therefore, hypothesis 5 was rejected.
CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of the study was to determine the relative effectiveness of the idea communication approach to teaching engineering drafting as compared to the typical unit approach. The bases for comparison were acquisition of general drafting knowledge, critical thinking ability, and ability to produce working drawings.

Two hypotheses dealt with the mean gain scores in general drafting and critical thinking ability. Another hypothesis dealt with mean gain scores on a working drawing assignment following the treatment period. The two remaining hypotheses dealt with a comparison of subjects in the upper and lower quartiles of initial critical thinking ability with regard to general drafting ability and the ability to produce a working drawing following treatment.

Subjects registered for class sections without knowledge of the experiment, and were not placed in or assigned to other sections for purposes of participating in the study. The experimental group and the control group were comprised of three sections each.
The class sections were paired according to length of the class period and the toss of a coin designated which class section would be assigned to the control group. The other class section of the same length taught by the same instructor was assigned to the experimental group.

Two instructors participated in the study. One instructor taught one experimental class section and one control class section, while the other instructor taught two experimental class sections and two control class sections.

Both groups were given identical instruction on the use of drafting equipment for the first two weeks of the semester. During this time, the Watson-Glaser Critical Thinking Appraisal, Form YM, and General Drafting: A Comprehensive Examination were administered to both groups.

For the remainder of the semester, the control group was taught by the typical approach of a series of units of study. During the same period of time, the experimental group was taught with a series of problems which necessitated simultaneous use of information from several units. Emphasis was placed on total representation of each object for the experimental group.

Both groups were required to make a working drawing at the end of the semester. The working drawing was scored by a jury, using a prescribed evaluation form which had been previously validated by another jury. The Watson-Glaser Critical Thinking Appraisal, Form YM, and General Drafting:
A Comprehensive Examination were administered again at the end of the semester.

The analysis of covariance technique was employed to determine if a significant difference existed between the control and the experimental group with regard to acquisition of general drafting knowledge, improvement of critical thinking ability, and ability to produce a working drawing. Statistical allowance was made for the difference between the two groups on their initial drafting knowledge for the first three hypotheses. The Fisher t test of significance was employed to determine if a significant difference existed between the subjects who scored below the first quartile in critical thinking ability and above the third quartile in critical thinking ability at the beginning of the semester with regard to general drafting knowledge and ability to produce a working drawing at the end of the semester.

Hypothesis 1 stated that the group taught by the idea communication approach (experimental) would show a significantly greater mean gain score on general drafting knowledge, as measured by General Drafting: A Comprehensive Examination, than would the group taught by the unit approach (control). In testing hypothesis 1, it was found that the difference between the mean gain scores for the two groups produced an F value less than the .05 level of significance. Hypothesis 1 was therefore rejected.
Hypothesis 2 stated that the experimental group would show a significantly greater mean gain than would the control group from pretest to post test in critical thinking ability, as measured by the Watson-Glaser Critical Thinking Appraisal, Form YM. In testing hypothesis 2, the difference between the mean gain scores for the two groups yielded an F value less than the .05 level of significance. Hypothesis 2 was therefore rejected.

Hypothesis 3 stated that the experimental group would achieve a significantly higher mean score than would the control group on the working drawing. In testing hypothesis 3, it was found that the difference between the mean scores yielded an F value less than the .05 level of significance. Hypothesis 3 was therefore rejected.

Hypothesis 4 stated that subjects in both groups who scored above the third quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM, would score significantly higher on the second administration of General Drafting: A Comprehensive Examination than would those subjects who scored below the first quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM. In testing hypothesis 4, it was found that the difference between the mean scores yielded a t ratio greater than the .001 level of significance. Hypothesis 4 was therefore accepted.
Hypothesis 5 stated that subjects in both groups who scored above the third quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM, would score significantly higher on the working drawing than those subjects who scored below the first quartile on the first administration of the Watson-Glaser Critical Thinking Appraisal, Form YM. In testing hypothesis 5, it was found that the difference between the mean scores yielded a t\textsuperscript{2} ratio less than the .05 level of significance. Hypothesis 5 was therefore rejected.

Conclusions

The following conclusions were formulated from an analysis of the findings of the study.

1. With regard to general drafting knowledge, the typical unit approach to teaching engineering drafting is no more effective than the idea communication approach.

2. In the development of critical thinking ability, the typical unit approach to teaching engineering drafting is no more effective than the idea communication approach.

3. With regard to ability to produce working drawings, the typical unit approach to teaching engineering drafting is no more effective than the idea communication approach.

4. Students with higher levels of critical thinking ability attain a greater degree of general drafting knowledge than students with lower levels of critical thinking ability.
Recommendations

The following recommendations are made on the basis of the findings and conclusions of the study.

1. It is recommended that the idea communication approach be adopted by individual instructors who are considering curriculum changes in engineering drafting.

2. Research should be conducted to identify the variables related to engineering drafting which produce changes in critical thinking ability.

3. Future studies should be undertaken to determine the effects of problem-solving techniques on drafting knowledge and performance at the junior high and high school levels.

4. It is recommended that another study be conducted which compares the effectiveness of the idea communication approach in teaching engineering drafting to the unit approach with respect to students' performance in advanced drafting courses.
APPENDIX A

SUGGESTED EVALUATION FORM
FOR WORKING DRAWINGS


<table>
<thead>
<tr>
<th>Criteria</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neatness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale Accuracy</td>
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<td>Line Quality</td>
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<td>Line Accuracy</td>
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<td></td>
<td></td>
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<tr>
<td>Choice of Views</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Location of Views</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy of Views</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lettering</td>
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<td></td>
</tr>
<tr>
<td>Dimension Adequacy</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Dimension Arrangement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATING VALUES

1 - Unacceptable          4 - Above Average
2 - Below Average         5 - Excellent
3 - Average               

CRITERIA FOR DIVISION HEADINGS

Neatness - Overall appearance, organization and placement of notes, arrowhead quality, smudges, erasures.

Scale Accuracy - Selection and conformity to indicated scale.

Line Quality - Weight, contrast, and sharpness of lines.

Line Accuracy - Intersections of lines, length of dashes, center line placement, applicability of line used.

Choice of Views - Desirability in selection of views.
Location of Views - Correctness of view arrangement, placement in relation to other views.

Accuracy of Views - Adequacy of detail, conformity to standard practice, includes assemblies and pictorials.

Lettering - Adherence to conventional styles, consistency, choice of size, includes numerals.

Dimension Adequacy - Completeness of dimensions.

Dimension Arrangement - Choice of location.
APPENDIX B

DIRECTIONS FOR VALIDATION CHECKLIST

Attached to this sheet you will find a Suggested Evaluation Form for Working Drawings. Please study each division heading and its definition and state your opinion as directed below.

If it is your opinion that one of the division headings should be considered a part of the evaluation of a working drawing, place a check mark in the "Retain" column beside that division heading.

If it is your opinion that the division heading should not be a part of the evaluation of a working drawing, place a check mark in the "Reject" column beside that division heading.

If it is your opinion that the division heading or its definition could be of value in the evaluation of a working drawing, but needs some revision, place a check mark in the "Alter" column and write your suggestions for change in the space provided. Use the back of this sheet if additional space is needed.

Validation Checklist

<table>
<thead>
<tr>
<th>Division Heading</th>
<th>Retain</th>
<th>Reject</th>
<th>Alter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neatness</td>
<td></td>
<td></td>
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<tr>
<td>Scale Accuracy</td>
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<td>Line Quality</td>
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<td>Choice of Views</td>
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<tr>
<td>Dimension Arrangement</td>
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<td></td>
</tr>
</tbody>
</table>

ADDITIONS and/or SUGGESTIONS
APPENDIX C

VALIDATION OF SUGGESTED CHANGES IN SUGGESTED EVALUATION FORM FOR WORKING DRAWINGS

The following suggestions for changes on the Evaluation Form for Working Drawings were offered:

1. Line Quality - This division heading should be incorporated with the division heading Line Accuracy.
   
   Check One
   
   Change as suggested

   Leave unchanged

2. Criteria for division heading Accuracy of Views should include "correct solution."
   
   Check One
   
   Change as suggested

   Leave unchanged
APPENDIX D

EVALUATION FORM FOR WORKING DRAWINGS

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<td>Scale Accuracy</td>
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<td>Line Accuracy</td>
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<td>Dimension Adequacy</td>
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<td></td>
</tr>
<tr>
<td>Dimension Arrangement</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATING VALUES

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3 - Average

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Dimension Adequacy - Completeness of dimensions.

Dimension Arrangement - Choice of location.
Southwest Texas State University
San Marcos, Texas 78665

DEPARTMENT OF INDUSTRIAL ARTS

APPENDIX E

SAMPLE LETTER TO REQUEST VALIDATION OF EVALUATION FORM

I am in need of your assistance in validating an evaluation form for scoring working drawings. The form is to be used as a part of an experimental study in engineering drafting.

Enclosed you will find a copy of the evaluation form with an explanation of the rating values and definitions of the division headings. Along with this, you will find a validation check list, directions for its use and a return envelope.

I think you will find that the validation check list is self explanatory and will require only a few minutes of your time. Your help and cooperation will be greatly appreciated.

Sincerely,

Joe Walker, Instructor of Industrial Arts

JWW/jb
Enclosures
Thank you for assisting in the validation of the Evaluation Form for Working Drawings. Because of suggestions for revisions on the original instrument, it is necessary for me to ask your opinion again.

There were suggestions for changing two items, which are stated on Sheet # 2. Please indicate your opinion as to whether either or both of the suggested changes should be made or the form should remain unchanged, by checking the appropriate space on Sheet # 2.

Sheet # 1, the Suggested Evaluation Form for Working Drawings, is also enclosed for your convenience. Please return Sheet # 2 in the enclosed envelope.

Again, thanks for your help in this portion of my study.

Sincerely,

Joe Walker, Instructor of Industrial Arts

JWW/jb
Enclosures
APPENDIX G

DRAFTING PROCESSES TO BE DEVELOPED THROUGH
LABORATORY DRAWING ACTIVITIES

CONTROL GROUP

I. Applied Geometry

A. Divide a line into a given number of parts
B. Construct a hexagon
C. Construct a four-centered ellipse
D. Tangents
   1. Strike an arc of given radius tangent to two straight non-parallel lines
   2. Strike an arc of given radius tangent to a given arc and a straight line
   3. Strike an arc of given radius tangent to two given arcs or circles

EXPERIMENTAL GROUP

II. Orthographic projection of objects containing the following features:

A. Rectangular shapes
B. Inclined surfaces
C. Cylindrical shapes
D. Arcs
E. Irregular curves

<table>
<thead>
<tr>
<th>Control Group</th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Divide a line into a given number of parts</td>
<td>File</td>
</tr>
<tr>
<td>B. Construct a hexagon</td>
<td>Face Plate</td>
</tr>
<tr>
<td>C. Construct a four-centered ellipse</td>
<td>Wrench</td>
</tr>
<tr>
<td>D. Tangents</td>
<td>Motor Mount</td>
</tr>
<tr>
<td>1. Strike an arc of given radius tangent to two straight non-parallel lines</td>
<td></td>
</tr>
<tr>
<td>2. Strike an arc of given radius tangent to a given arc and a straight line</td>
<td>Motor Mount - Wrench</td>
</tr>
<tr>
<td>3. Strike an arc of given radius tangent to two given arcs or circles</td>
<td>Bench Rammer</td>
</tr>
<tr>
<td>A. Rectangular shapes</td>
<td>Oil Stone</td>
</tr>
<tr>
<td>B. Inclined surfaces</td>
<td>Cold Chisel</td>
</tr>
<tr>
<td>C. Cylindrical shapes</td>
<td>Bench Rammer</td>
</tr>
<tr>
<td>D. Arcs</td>
<td></td>
</tr>
<tr>
<td>E. Irregular curves</td>
<td>Wall Plaque</td>
</tr>
</tbody>
</table>
F. Hidden features  Bird House - Motor Mount
G. Center lines  Bench Rammer
H. Fillets and rounds  Face Plate

III. Oblique and isometric drawings of objects with the following features:
A. Rectangular shapes  Cold Chisel
B. Inclined surfaces  Cold Chisel
C. Cylindrical shapes  Bench Rammer
D. Arcs  Wrench
E. Irregular curves  Wall Plaque

IV. Dimensioning
A. Dimension lines  Cold Chisel
B. Extension lines  Cold Chisel
C. Leaders  Motor Mount
D. Notes  Face Plate
E. Figures  Picture Frame Jig
F. Common fractions  Picture Frame Jig
G. Decimal fractions  Shaft Assembly
H. Finish Mark  Face Plate
I. Drawing to scale  Bench Rammer
J. Size dimensions  Cold Chisel
K. Location dimensions  Motor Mount
L. Dimensioning arcs  Wrench
M. Dimensioning curves  Wall Plaque
N. Rounded ends  Wrench
O. Cylindrical objects

P. Holes

Q. Tolerance dimensions

V. Screw threads and fasteners

   A. ASA regular thread symbols
   Picture Frame Jig

   B. Specifications of standard features
   Picture Frame Jig

VI. Sections and Conventions

   A. Full
   Shaft Assembly

   B. Half
   Face Plate

   C. Broken out
   Bird House

   D. Rotated
   File

   E. Removed
   Wall Plaque

   F. Assembly
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VII. Auxiliary Views

   Motor Mount
APPENDIX H

INSTRUCTION SHEETS

Instruction Sheet #1

Title: Oilstone

Assignment: Make an instrument drawing of the Oilstone. The drawing should describe the object fully, indicating its full shape and size. Keep the drawing simple; avoid duplication of information.

Specifications: This Oilstone is a natural abrasive material cut from novaculite rock and used to sharpen edge-cutting tools, such as wood chisels, plane irons and lathe tools. It is referred to as Soft Arkansas Bench Stone, and measures 8" x 2" x 1".

Drawing Procedure: Make a freehand sketch on graph paper experimenting with various methods and views of how to best illustrate the Oilstone. Eliminate unnecessary views and dimensions. When you have decided upon what you consider the best solution, make an instrument drawing of it on the printed border tracing paper. It should then be blueprinted and turned in with your final sketch and the original instrument drawing. Place the blueprint on top, the instrument drawing next, and the sketch last. Staple in the upper left corner.
Title: Cold Chisel

Assignment: Make an instrument drawing of the Cold Chisel. Include orthographic views with dimensions and an isometric view. Make the drawing one-half actual size.


Specifications: The model is made of wood, however the material specifications space in the lower left-hand corner should indicate that the Cold Chisel is made of tool steel. The Cold Chisel is 9 1/2" long overall, with 3/8" x 45 degree chamfer around the back edge. The inclined surfaces begin 6 1/2" from the chamfer and have an included angle of 22 degrees. The point is an included angle of 60 degrees.

Drawing Procedure: Sketch the object freehand on graph paper until you have selected what you consider the best and simplest method of representation. This sketch should
look exactly like your instrument drawing except that it is a freehand drawing. Make an instrument drawing, blueprint, and turn in both, along with your sketch.
Instruction Sheet #3

Title: Face Plate

Assignment: Make an instrument drawing of the Face Plate. Include finish marks, a half section of the threaded portion, and aligned holes in section. Use orthographic views with dimensions and an oblique.

Specifications: The Face Plate is used to hold a piece of wood on the head stock spindle of a wood lathe while it is being turned (shaped). It screws on the spindle and wood screws are inserted through the six holes into the wood. A common product turned on the lathe using a face plate is a wooden bowl.

The Face Plate is made of cast aluminium with a machine finished face. The three outer holes are equally spaced (120 degrees apart) on a 5" diameter center line. They are 5/32" in diameter with a 1/16" minimum depth countersink. The three holes are equally spaced on a 3" diameter center line. They are 1/4" diameter with a 1/16" minimum depth countersink. The outside of the threaded portion should be changed from round to hexagonal, 1 3/4" across the flats, so that a wrench may be used in removing the Face Plate from the lathe spindle. The internal threads are Unified National Coarse, class 2, left hand, 1 1/8" major diameter, 7 threads per inch.
Instruction Sheet #4

Title: File

Assignment: Make an instrument drawing of the File. In the orthographic views, include a rotated section and dimensions. Make an oblique drawing of the File.

Specifications: The File is made of tool steel, the blank is forged to shape, the teeth are cut, and it is hardened by heat treating.

The File is 12 1/2" overall, 15/16" at its widest point tapering to 3/4" thick from the point to the heel. The heel is the widest part of the File, or the point at which the tang begins. The tang is the portion which is to be inserted into a handle when the File is in use.

The tang tapers in thickness from 5/32" to 1/8", in width from 3/8" to 1/8", with 1/4" radii at the heel and a 1/16" radius on the end. The tang is 2 1/2" long to the heel. It is 9/16" from the heel to the closest end of the first tooth.

The teeth are 65 degrees to a line down the center of the File from the center of the point to the center of the tang. There are 52 teeth per inch, which are inclined so that they cut when the File is pushed forward. The forward edge of the tooth is upward and to the left at 75 degrees to the surface of the File and the
back edge is upward to the right at 45 degrees when the point of the File is to the right.

Instruction Sheet #5

Title: Wrench

Assignment: Make a technical sketch and an instrument drawing which fully describes the Wrench. Use the four-center approximate method of constructing the ellipses. Make a removed section of the handle.

Specifications: The Wrench head is elliptical, with a major diameter of 2 1/8" and a minor diameter of 1 3/4". The machined sides of the head form a smaller ellipse with 2" major and 1 1/2" minor diameters. The jaw opening is 7/8" major and 19/32" minor diameter partial ellipse at the back. The head is 1/4" thick with a 1/16" radius on the edge.

The handle is offset at 15 degrees. It is 7/8" wide at the widest point, and joins the head with tangent radii of 9/16" and 17/64". It is 7/32" thick in the middle, tapering tangent to a 1/2" radius there and tangent to a 1/16" radius on both edges. The end of the handle has 5/16" radius, the center of which is 5 1/2" from the center of the largest ellipse. A 1/16" radius is formed where the wide surface of the handle joins the head.

The Wrench is made of tool steel, which has been drop forged to shape, with a slight excess of metal left for machining the sides and jaws of the head.
   Pp. 105-126: 5.11, 5.12, 5.13, 5.14, 5.28, 5.29, 5.30,
                   5.34, 5.35, 5.36, 5.37, 5.38, 5.45, 5.46. P. 236: 8.7.
   Pp. 289-296: 10.1, 10.2, 10.3, 10.8, 10.9, 10.10, 10.17.
Instruction Sheet #6

Title: Picture Frame Jig

Assignment: Make a technical sketch and an instrument drawing of the Picture Frame Jig. Include all dimensions on the orthographic drawing. Make an assembly section and an exploded pictorial drawing. Include a parts list.

Specifications: The Picture Frame Jig is used to hold four-piece frames while the glue dries in the miter joints at the corners. This operation requires two of the jigs, which are pulled together with a handscrew or "C" clamp. All five wooden pieces are 2" wide and 15/16" thick, with 9/32" holes in the center. The long pieces are 18" long with 17 equally spaced holes. The center connecting piece is 5" long with the holes 1" from each end. The two corner blocks are 2 1/8" long with an 89 degree notch. The holes are 3/4" from the back edge of the corner blocks. All the rounded edges have 3/8" radii. The pieces are fastened together with 1/4" x 2 1/2" round head machine screws.

Instruction Sheet #7

Title: Bench Rammer

Assignment: Make a technical sketch and an instrument drawing of the Bench Rammer. Dimension the orthographic views and make an isometric pictorial.

Specifications: The Bench Rammer is made of soft wood (in this case, white pine) and is used to pack the moist sand around the pattern of an object to be cast.

The overall length is 13 1/2". The large cylindrical part is 3 7/8" in diameter and 4" long. The small cylindrical end is 2 15/16" in diameter and 4 1/4" long. The handle is 1 1/2" in diameter at the largest point. The handle has a 5" radius tangent with 3/8" radii on each end. The 3/8" radii are also tangent with the ends of the cylindrical end portions. All corners are rounded with 1/8" radii.

Instruction Sheet #8

Title: Wall Plaque

Assignment: Make a one-view orthographic drawing which shows the shape of the Wall Plaque and a partial section view showing the shape of the edge.

Specifications: The Wall Plaque is made of walnut, with the edges shaped with a router. The radius for the router cut is 3/8" and begins 1/16" below the face of the plaque. The outline of the Wall Plaque is symmetrical. That is, the left has the exact reverse shape as the right half. To plot the outline of the left half, number the 1/8" lines on a piece of graph paper, with zero being at least 5" from the left side of the paper, and numbering toward the left. Zero will be the center line. The center line should run parallel to the long side of the graph paper, and should also be numbered at 1/8" intervals from bottom to top.

Use the following chart to locate points along the contour of the Wall Plaque. Example: 2 ---- 2 1/2 -- 84 1/4. Move two 1/8" spaces to the left of the center line and follow this line up 2 1/2 spaces. Mark this point, follow the same line up 84 1/4 spaces, and mark the second point. These points will be on the edge of the left hand side of the outline. Move left two more
spaces (to line 4) and up 4 3/4 spaces from zero for one point, and up 83 1/2 spaces from zero for the next point.

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38 \[ 63 \, 64 \frac{1}{2} \]
Instruction Sheet #9

Title: Bird House

Assignment: Design and make a working drawing of a Bird House that will accommodate four families of birds. Utilize a broken-out section in the drawing. Make a pictorial drawing which shows the Bird House mounted as it will be used.

Specifications: Accommodations for each family of birds must be separate from the others and have an outside entrance. The Bird House may be any size and any shape. It is to be constructed of wood, with the method of mounting indicated.

Be sure that the dimensions indicate the size of each piece of material to be used.
Instruction Sheet #10

**Title:** Motor Mount

**Assignment:** Make a technical sketch and an instrument drawing, complete with dimensions and isometric of the Motor Mount.

**Specifications:** The Motor Mount is made of 1/2" x 3" mild steel. It has two 3/8" holes on one end, with a 1/2" and two 1/4" holes on the other end. It is bent at a 29 degree angle, forming a 1 1/8" radius on the outside of the bend. From the center of the outside curve to the end containing the two holes is 2 1/2". From the same point, it is 2 5/8" to the other end of the Motor Mount.

The centers of the 3/8" holes are 11/16" and 1 13/16" from the end and 2 3/16" and 3/16" from one side. The centers of 1/4" holes are 2 5/16" and 13/16" from the same side and 1 13/32" and 23/32" from the opposite end. The center of the 1/2" hole is 1 1/2" from the same side and 1 5/16" from the end.

Title: Shaft Assembly

Assignment: Make a detail drawing of the shaft, housing, and flange, using decimal fractions. Make a full section drawing, complete with parts list. Make an exploded pictorial drawing of the unit.

Specifications: The flange is 2 1/4" in diameter, 3/8" thick on the edge and 9/16" thick near the center. The inside face is 7/8" in diameter with a 45 degree bevel starting at that point. The 1/4" VMC threaded holes are equally spaced on a 1 1/2" diameter center line. Change the flange so that it contains three of these threaded holes, rather than four. The flange has a PN2, medium drive force fit on the shaft. It is made of SAE 1040 steel. All surfaces are machine finished.

The shaft is 4 5/8" long with a 5/8" base size diameter. The ends have a 3/32" radius on the corners. The flange fits 1/2" from the end, and the bearing is 1 3/8" from the same end. It is made of cold rolled mild steel, SAE 1040, which has been heat treated. All surfaces are machine finished.

The bearing is a standard part. It is a New Departure, number 1313, needle bearing. It is 1 5/8" long, with a base size diameter of 1 1/8". It has a 1/32" radius groove, 1/32" deep around the center. The
housing is made of cast iron. Part of the housing has been cut away, and will not be shown on the drawing. The front end of the housing has a machined surface, joined by a chamfered edge on the inside, which is 30 degrees to the axis of the hole. The large edge of the chamfered surface has a diameter of 1 1/4". Behind this are two surfaces into which the bearing fits with a FN1 light drive force fit. The front surface is 11/32" long and the back surface is 17/32" long. There is a space 9/16" long with a diameter of 1 3/16" between the two bearing surfaces. Behind the second bearing surface is a 5/8" x 1 7/16" diameter bore, into which have been drilled two holes on opposite sides of the cylindrical opening. This is a change from three holes on the model. The holes are 1/4" diameter drilled toward the center of the bored portion at an angle of 45 degrees. There is a 45 degree chamfer 1/16" long connecting the bore hole with back surface which has been machined. The outside of the housing has a diameter of 1 19/32" at the front and connects the parts that have been cut away with a 3/8" radius 1 1/24" from the front edge. Behind the 3/16" thick cut away portion, the housing has a 1/8" radius fillet and is 1 3/4" in diameter. The overall length of the housing is 2 7/32".
Instruction Sheet #12

Title: Connecting Rod

Assignment: Make a complete working drawing of the Connecting Rod. Include a detail drawing of each piece, complete with dimensions and necessary views, an exploded pictorial assembly, and a parts list. The drawing is to be made on 11" x 17" bordered paper.

Specifications: The Connecting Rod is made of manganese alloy steel. It is forged and machines, with honed journals.

The distance between the centers of the journals is 6 5/8", with a .010 tolerance. The overall length of the rod and cap is 9 1/8". The smaller journal has a nominal size diameter of 1" and an RC5 medium running fit. The larger journal also has an RC5 medium running fit with a nominal diameter of 2 5/16".

The small hole in the end of the Connecting Rod is 1/8" in diameter with a 45 degree chamfer 1/16" deep. It is centered on the 1 1/4" x 13/16" machined surface.

The portion between the journals is 1 1/16" wide with a 2 1/2" radius tangent to the side and to a 1 9/32" radius from the center of the large journal. The other end of this portion joins the small journal with a 1 3/8" radius tangent to the side and to an arc of 13/16" radius from the center of the small journal. This
portion is 5/8\" thick at the edges and 3/16\" thick in the center, with 1/16\" fillets and rounds.

The small journal end is 1 1/4\" thick and the larger journal end is 1\" thick. The machined surface on the end of the cap is 1 11/16\" x 13/16\", has 1/8\" and 1/2\" radii fillets, and is 1 5/8\" from the journal center. The elliptical machined surfaces on the edge of the larger journal are 19/32\" x 13/16\" and are 3 1/2\" apart. The machined surface on the outside of the small journal is 5/8\" long and tapers from 1/4\" to 3/16\". It is 1 21/32\" from the matching surface on the opposite side of the journal. The machined rim around the small journal has a diameter of 1 3/8\".

The machined surface around the large journal is 1/8\" wide with a 1/32\" radius on the inside and a 1/16\" fillet on the outside. Four reinforcing areas are equally spaced around the journal, each with a 5/16\" radius, the center of which is 1 11/32\" from the center of the journal. The outside fillet around these reinforcements are also 5/16\" radii.

The cap is held on the Connecting Rod with two bolts 2 1/2\" long, not including the head. The head is 9/16\" across the narrow dimension with 1/2\" arcs cutting the 3/4\" diameter. It has a 45 degree chamfer. The head is 7/32\" thick. The shank has a 3/8\" diameter for
1 5/16” where 30 degree chamfer tapers to a diameter of 11/32”. Three-eighth inch by 24 UNF threads extend 13/16” from the end of the bolt. A standard hexagonal nut is used.

The centers of the bolt holes are 2 13/16” apart. The 13/32” holes in the cap are 1 1/16” long and have a 23/32” spot face on the lower side. The holes in the rod are 25/64” in diameter, with a 15/32” counter bore 1/8” deep on the lower end, and a 23/32” spot face on the upper side. The hole and counter bore have a combined length of 31/32”. The inside of the large journal has two 1/8” notches 7/32” from the side of the rod and 5/32” from the opposite edge but same side of the cap. The notches are 1/16” deep at the parting line and extend 5/16” around the journal.
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