ABSTRACT

SCALES, ALICE YOUNG. The Effect of Learning Style, Major, and Gender on Learning Computer-aided Drawing in an Introductory Engineering/Technical Graphics Course. (Under the direction of Dewey A. Adams and Barbara M. Kirby)

This correlational descriptive study examined factors that might affect students' achievement in learning computer-aided drawing and engineering/technical graphics concepts in introductory classes at North Carolina State University. The study involved 38 subjects enrolled in introductory classes that combined the teaching of computer-aided drawing and technical graphics. The three dependent variables used in the study were CAD project grade, CAD posttest score, and final course grade. The seven independent variables examined were gender, learning style, major, student classification, final exam grade, final exam with the posttest score removed, and pretest score. Subjects' learning styles were established by the Group Embedded Figures Test, which measures field-dependence and field-independence. Kendall's Tau B correlations and multiple linear regression models were used in the analysis of the data. The α used for statistical significance was .05.

Analysis of the data revealed that the research subjects were primarily field dependent, and exactly half of them had prior drafting experience. Subjects in the study represented 19 different majors. Eighteen students were from engineering programs and 20 from non-engineering programs. Females in the sample reported a lower level of computer experience and less prior drafting experience than males.

For the total sample, statistically significant correlations were found between the project grade and the final grade with the project score removed, learning style and the final exam grade with the project score removed, computer experience and gender, and the final

exam grade and gender. Correlations were found between gender and the final exam grade with the posttest score removed and between learning style and the final exam with the posttest score included. For females, a statistically significant relationship was found between prior drafting experience and the project grade; this was the strongest correlation found in the study. For males, statistically significant relationships were found between learning style and final exam grade, learning style and the final exam grade with the posttest removed, the project grade and the final grade with the project score removed, the project grade and the pretest score, and the pretest and posttest score.

Three multiple linear regression models were created as part of the study, two as predictors of computer-aided drawing achievement and one as a predictor of achievement in learning the course content. Model 1 used the final project grade as its dependent variable to measure CAD achievement. The independent variables used in this model were gender, the pretest score, and major. The model's R^2 was 0.31 ($p = 0.005$). Model 2, which used the posttest score as its dependent variable, was the second measure of CAD achievement. The independent variables used in this model were the pretest score, the Group Embedded Figures Test score, and the final exam grade with the posttest score removed. Its R^2 was 0.19 ($p = 0.056$). Model 3 used the final course grade as its dependent variable to measure achievement in learning the course content. The independent variables included in this model were gender, the Group Embedded Figures Test scores, and student classification. The R^2 for this model was 0.21 ($p = 0.043$).

The Effect of Learning Style, Major, and Gender on Learning Computer-aided Drawing in an Introductory Engineering/Technical Graphics Course

By

ALICE YOUNG SCALES

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Chair of Advisory Committee

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DEDICATION

I would like to dedicate this dissertation to the people who inspired me. My parents, Kathryn and Talmage Young, believed in me and gave me the courage to pursue this degree. My father taught me to reach for excellence. Dad, I wish you were here. My mother taught me persistence and to see beauty in the things and people around me.

I also dedicate this dissertation to my husband, Glenn, and my children, Emily and David. They allowed me time to accomplish this, believed that I would get it done, and provided the love and understanding I needed to keep going.

Finally, I dedicate this dissertation to my sister, Gloria. I have always looked up to her and have always been impressed with her ability and drive for excellence.

BIOGRAPHY

Alice Kathryn Young Scales was born in Fitzgerald, Georgia on December 2, 1947. Moving to Raleigh, North Carolina in 1957, she graduated from Needham B. Broughton High School in 1965. After graduating from high school, she attended Campbell College and North Carolina State University. She received her Bachelor of Science in Science Education with a Concentration in Biology from North Carolina State University in 1969. She taught Science in Johnston County, North Carolina before taking a position at Wake Memorial Hospital as an In-service and Continuing Education Instructor for non-nursing personnel.

After marrying, she returned to public school teaching in the Wake County Public Schools in 1977. There she taught Industrial Arts and Occupational Exploration at the Middle Grades level. While still teaching for Wake County, she completed her Master of Education Degree in Industrial Arts Education in 1983. She was presented the Young Educator Of the Year Award by the North Carolina Association of Educators in 1982.

Employed by North Carolina State University in 1988 as a Lecturer in the Graphic Communications Program, she was appointed the Coordinator of the program in 1994. While at NCSU, she has conducted research in the areas of visualization and AutoCAD instruction through web-based tutorials.

She is a member of the Phi Kappa Phi, Epsilon Pi Tau, Phi Kappa Delta, and Omicron Tau Theta honor societies as well as the American Society for Engineering Education.

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Chapter 1

INTRODUCTION

Eighty percent of the manufacturing gross national product passes through computer-aided drawing, computer-aided manufacturing, or computer-aided engineering systems (Connolly, 1998). In industry, computer-based drawing has become the standard because it has advantages over traditional hand-drawing. Computer-based drawings are quicker to produce, are more precise, can be retrieved and edited, and can be drawn in ways not possible by hand techniques. They can also be linked to other software and machines to perform computer-aided manufacturing (CAM), finite element analysis, and computer numerically controlled (CNC) manufacturing (Bertoline, 1993; Bidanda, Shuman, & Puerzer, 1992; Connolly, 1998; Teske, 1992). As computers moved into manufacturing and engineering design, they also moved into the field of technical graphics. The introduction of computers into technical graphics in industry is changing the standards that define how technical graphics are represented (Gorska, 1998); therefore, the domain of engineering/technical graphics education must include computer-based graphics if students are provided with the tools they need in their careers. According to Baxter (1998), companies now expect entry-level engineers to be able to create and document computer models of engineering designs.

A few institutions of higher education began including computer instruction in engineering/technical graphics courses as early as the 1980s, and its inclusion has gained momentum. The move to computer-aided drawing (CAD) has led some engineering/technical graphics programs to abandon teaching students manual instrument drawing. Many institutions instruct students to use a range of computer drawing programs that include computer-aided drawing (CAD) and 3-dimensional constraint and non constraint-based modeling software (Baxter, 1998; Connolly, 1998; Gorska, 1998; Nee; 1998; Wiebe, 1998). According to a survey conducted in the Fall of 1998 that investigated teaching practices in the field of engineering/technical drawing, 92.8 percent of the respondents indicated that some form of computer-aided drawing is being taught at their institutions. Also, two of their top concerns were staying abreast of software and hardware changes and the quality of graphics instruction in technical graphics programs (Clark & Scales, 1999).

Since computers in engineering/technical graphics are here to stay, there is a need to find ways to fully integrate computer instruction into classes in an efficient and effective manner (Chipman, 1993). In order to create effective computer learning activities and design courses that deliver computer instruction along with engineering/technical graphics concepts to student with different characteristics, research must be conducted (Lee, 1993). The need to develop effective instructional techniques to teach computer software in graphics classes will continue to grow as other computer graphics software becomes part of the curricula of most institutions of higher education (Bertoline, 1993). Some institutions already include instruction in computer-aided manufacturing, computer rendering, computer simulation, finite element analysis, and desktop publishing. To develop instruction that effectively teaches this type of software, instructors need information based on research. However, an examination of the literature reveals that limited research exists on factors that affect students' achievement in learning to use technical graphics software and technical graphical concepts together.

Teaching technical computer graphics classes not only requires teaching students the function and use of computer commands, but also how to apply geometric concepts, to develop strategies for modeling objects, and to function in 3-dimensional space. Computer graphics instruction integrated into graphics classes must allow students to quickly master the software and utilize it to produce graphical drawings and simulations (Mohler, 1997).

At North Carolina State University (N. C. State), engineering and technology students take introductory engineering/technical drawing classes that include computer-aided drawing instruction. Teachers at N. C. State use a variety of methods to incorporate this instruction into their classes. Presently they include a combination of tutorials delivered through the World Wide Web, class demonstrations, CAD homework assignments, and a final CAD project. The web tutorials are the core of the CAD instruction. This method of delivering CAD instruction has several advantages. Unlike earlier versions of computer assisted instruction (CAI), on-line tutorials are available to students at any time and eliminate instructional material duplication costs. The use of web-based instruction permits instructional designers to develop flexible instruction that integrates text and graphics as well as sound and animation (Benyon, Stone and Woodroffe, 1997; McManus, 1996; Shneiderman, 1997). The web tutorials and other teaching strategies used at N. C. State for CAD instruction are consistent with recommendations by Lee (1993).

Research demonstrates that matching learning styles with teaching styles has an effect on student achievement (Ayerman, 1993; Davidson, 1990; Dunn & Dunn, 1987;

Grimes, 1995; Matthews, 1996; O'Neil, 1987; Smith & Renzulli, 1984). Wooldridge (1995) stated that the learning style concept is the most important concept to influence education in years because it goes to the core of what it means to be a person. He also stated that matching learning styles with teaching styles is logical and offers a framework for organizing instruction for the diversity among students. Because instructors tend to use teaching styles that match their learning style, students with learning styles that do not match the instructor's are at a disadvantage (Charkins, O'Toole & Wetzel, 1985; Dunn, Beaudry & Klavas, 1990; Dunn & Dunn, 1985; Wooldridge, 1995). Identifying the predominant mode of learning in classes and being aware of differences in learning modes are important to serving students in a class. Davidson (1990) suggested that students' knowledge of their learning style could even have an effect on their achievement.

The importance of research on learning styles has been voiced by a number of individuals. Sims & Sims (1995) stated:

> It should be evident to those responsible for teaching and training that an increased understanding and use of learning style data can provide them with important information. Most importantly, each teaching or training endeavor will have learners with disparate learning style preferences and a variety of learning strengths and weaknesses that have been developed through earlier learning experiences, analytical abilities, and a host of other preferences they bring with them (p. 193).

Students' interest and confidence in using computers may be related to their ability to learn computer-aided drawing in technical graphics courses. Gattiker (1990) and Shashaani (1997) concluded that females and males differ in their computer experience and confidence to master computer skills. In studies that have examined computer skill development, experience, and attitudes, females were shown to have less experience, less confidence, and a greater fear of computers than males.

The only study that investigated CAD instruction was completed by Lee in 1993. Lee's study looked specifically at predictors of student achievement after using self-paced AutoCAD tutorials, but the tutorials used for the study were designed to teach the software commands without reference to graphical concepts. Lee concluded that the levels of prior computer experience, prior exposure to AutoCAD in high school, and attitudes toward the tutorial were significant predictors of achievement in learning AutoCAD. He did not find learning style to be a predictor of the subjects' achievement. Guster (1986), on the other hand, found that learning style did relate to achievement in high school drafting classes. A search of the literature failed to locate research that examines the effect of learning style, major, and gender on mastering CAD along with course content in engineering/technical graphics classes at the higher education level.

Research on the Effect of Instructional Media

One widely used method for instructing students in computer graphics and CAD is software instructional tutorials (Parson, 1997). Software tutorials are not new and are frequently included with software documentation in either printed or as multimedia form. Tutorials allow students to move at their own pace and to repeat lessons. They do not require the course instructors to be actively engaged in normal teaching, which frees them to work with students who need additional assistance. Well-designed tutorials can be a very efficient form of instruction (Lee, 1987).

A method of delivering software tutorials is through the World Wide Web. This form of tutorial delivery is becoming common and is predicted to grow (Ibrahim & Franklin, 1995; Jacobson & Levin, 1998; Parson, 1997; Smith, Newman & Parks, 1997). Although research on instructional technology has been carried out for approximately 90 years, there is little evidence that the type of media used to deliver instruction has any effect on learning. It has been demonstrated that the design of instructional material, regardless of the media through which it is presented, has a greater effect on learning (Parson, 1997; Russell, 1997; Thompson, Simonson & Hargrave, 1996). Research that has examined the effect of media and learning styles on achievement has largely found that no real interactions exist (Ayerman, 1993; Cordell, 1990). In this study, the media used to deliver tutorials to students should not have had an effect on learning AutoCAD and was not examined.

Purpose of the Study

Students in introductory Graphic Communications courses at N. C. State come from different backgrounds and have different prior experiences. It has been observed in these classes that some students are less successful than others in developing the skills they need to use AutoCAD to produce acceptable models and drawings and in understanding the graphic concepts taught in the course. Although strategies used at N. C. State are fairly common for programs of this type (Clark & Scales, 1999), there is a need to examine factors that might affect the achievement of students in learning computer-aided drawing and the engineering/technical course concepts in these classes. This descriptive, correlational study explored the relationship between learning styles, major, prior computer experience, prior drafting experience, student classification, and gender on achievement in learning to use the computer-aided drawing package known as AutoCAD and the concepts of technical graphics in introductory classes of engineering/technical graphics at N. C. State.

Research Questions

The research questions used in this study included the following:

1. What pattern of learning styles exists for students who enroll in introductory engineering graphics classes?
2. Is there any relationship between a student's learning style and his or her achievement in learning computer-aided drawing programs in classes of introductory engineering graphics?
3. Is there a relationship between a student's prior computer experience and his or her achievement in learning computer-aided drawing in classes of introductory engineering graphics?
4. Is there any relationship between a student's major and his or her achievement in learning computer-aided drawing programs in classes of introductory engineering graphics?

5. Is there a relationship between a student's gender and his or her achievement in learning computer-aided drawing programs in classes of introductory engineering graphics?
6. Is there a difference in the prior computer experience based on a students' major in classes of introductory engineering graphics?
7. Is there a difference in the prior computer experience of individuals based on their gender in classes of introductory engineering graphics?
8. Is there a difference in the learning styles of students in different majors among students enrolled in introductory engineering/technical graphics courses?
9. What percentage of students entering introductory engineering graphics classes at N. C. State have prior drafting experience?
10. Does previous drafting experience have any relationship to a student's achievement in learning CAD in classes of introductory engineering graphics?
11. Does previous drafting experience have any relationship to a student's achievement in learning course content in classes of introductory engineering graphics?
12. Is there a relationship between a student's gender and his or her achievement in learning course content in classes of introductory engineering graphics?
13. Is there a relationship between a student's learning style and his or her achievement in learning course content in classes of introductory engineering graphics?

Assumptions and Limitations

Assumptions

1. The classes selected for participation in the study were introductory classes, and the students enrolled in the classes were assumed to have limited experience with computer-aided drawing programs and the course content.

Limitations

1. The sample was limited to whole classes in order to eliminate teacher effects, which did not allow the selection of a random sample of research participants.
2. After the information on students in the sample was collected, it was noted that a large portion of the students was from the Civil Engineering Program. This was due to the specialized engineering/graphics courses are that taught at N. C. State for specific engineering programs. For this reason, Mechanical, Aerospace, and Industrial Engineering students are underrepresented in the classes that were sampled.

Definition of Terms

Some definitions and/or background information for terms used in this study are provided in the following:

1. Boolean Operation — A computer-aided drawing term for operations that either combine (union) two or more three-dimensional solid shapes or remove (subtract) one or more three-dimensional solid shapes from others to create a more complex object.

2. Computer-Aided Drawing (CAD) — Engineering drawings created on a computer so they appear as one-dimensional drawings or as three-dimensional solid objects.
3. Engineering/technical graphics — Drawings created for ideation, problem solving, or documentation of engineered and manufactured objects.
4. Learning Style — An individual's typical mode for processing information and perceiving, thinking, problem solving, and remembering (Keefe, 1979).
   —Field-Dependent Learner - A cognitive style identified by the Embedded Figures Tests. Individuals with this cognitive style process information globally and relate elements to the context in which they are contained (Witkins, Oltman, Raskin & Karp, 1971; Witkins, Moore, Goodenough & Cox, 1977).
   —Field-Independent Learner - A cognitive style identified by the Embedded Figures Tests. Individuals with this cognitive style process information analytically and have the ability to isolate individual elements from the context in which they are contained (Witkins et al., 1971).
5. Primitive — A computer representation of a simple three-dimensional solid object (box, cone, cylinder, or wedge) that can be combined or removed from other three-dimensional shapes to create a complex three-dimensional computer representation of an object.
6. Two-dimensional drawing — Drawing confined to the dimensions of height and width.
7. Solid model — A computer drawing that represents an object as a three-dimensional shape with its width, height, and depth oriented along X, Y, and Z axes.

Summary

Dissertation information will be provided for the remainder of the study in following order: Chapter 2 will examine the previous research and literature related to this study, Chapter 3 will provide a description of the study's design and methodology, Chapter 4 will provide a description of the research results, and Chapter 5 will provide a discussion of the results and recommendations.

The focus of this study was on the effects of students' major, gender, student classification, prior computer experience, prior drafting experience, and learning style on achievement in learning computer-aided drawing and the concepts of technical graphics in an introductory engineering/technical graphics class at N. C. State. The nature of the study required the use of intact classes taught by the same instructor, which limited the number of students in the sample. Key research questions centered on factors that might affect student achievement in introductory engineering/technical graphics classes that include instruction in computer-aided drawing. These factors need to be identified before future research in this area can be designed and effective instruction in this area can be created and evaluated.

Chapter 2

LITERATURE REVIEW

Introduction

Experiments in the literature that address the subject of learning styles, prior computer experience, prior drafting experience, and gender and their relationship to achievement in learning computer-aided drawing and graphics content are extremely limited or absent. No study was found that addresses all of these concepts together. In this chapter, several studies that relate to issues involved in this study will be discussed. The research and papers described are those that relate to learning styles, achievement, gender and computer skill development, computer instruction, and drafting instruction.

Theoretical Model

Garton, Spain, Lamberson, and Spiers (1999) presented a model, used by Dunkin and Biddle, as a guide to the study of teaching and learning. A modified version of this theoretical model is shown in Figure 1. This model illustrates how learner and teacher characteristics and behaviors interplay during instruction and affect students' ability to gain knowledge, skills, and attitudes from participation in an introductory engineering/technical graphics course that includes computer-aided drawing instruction. The model serves as a theoretical framework for this study. However, only the Context Variables (Learner) are examined in this study.

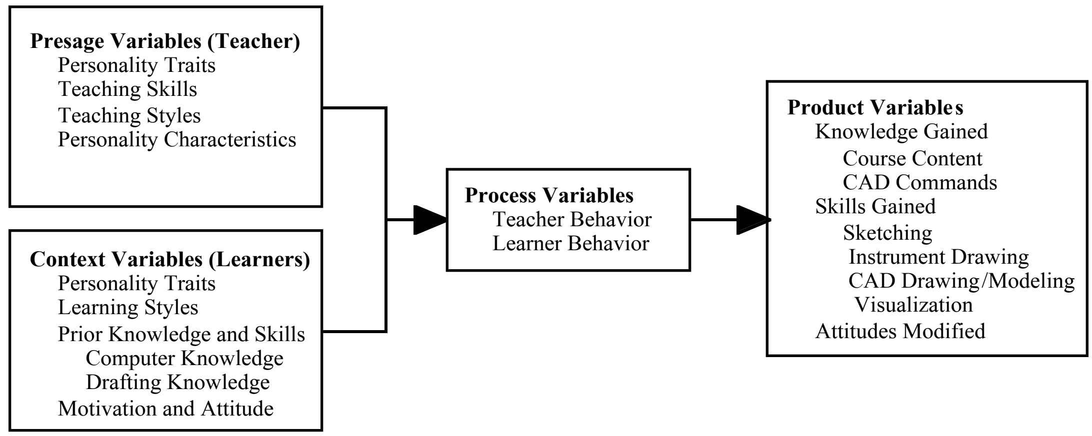

Figure 1. Theoretical Learning Model

Learning Styles

Learning style research began in the 1940s, and since then some 19 to 21 cognitive constructs have been created (Curry, 1983; Thompson & Melancon, 1987). The term learning style became widely used in the 1970s when research in this field gained popularity (Dyer, 1995; Morgan, 1997). Learning style instruments are numerous and include the Witkins' Group Embedded Tests, Dunn and Dunn's Learning Style Inventory, Gregorc's Style Delineator, Kolb's Learning Style Inventory, and Myers-Briggs Personality Inventory (Ayersman, 1993; Curry, 1983; Henson & Borthwick, 1984). Lee (1993) quoted Schmeck as defining learning styles as "a predisposition on the part of a student's approach to learning regardless of the specific demands of the learning task" (p. 29).

According to Morgan (1997), the study of learning styles began with research into learning theory by psychologists. The concept of psychological differentiation was first introduced by Warner in 1957 and preceded the term cognitive style. Warner theorized that the biological development of all humans followed a path from a global pattern to one that was differential, articulated, and hierarchically integrated. He stressed that developmental changes in humans advance systematically, taking advantage of early stages of growth. In Warren's view, children proceed through systematic qualitative changes that begin with an undifferentiated global relationship between the individual and the environment. As the biological structures grow, the child becomes more independent or differentiated, and more efficient at creating cooperative interactions between the underlying subsystems.

Although learning styles have been demonstrated to change during the development of an individual, by young adulthood learning styles have become stable and are persistent (Haaken, 1988; Hashway & Duke, 1992; Miller, Alway & McKinley, 1987; Sims & Sims, 1995; Witkins et al., 1971) According to Kolb (1981), learning style development is due to hereditary factors, previous experience, and the needs of the present learning environment. Researchers believe that learning outcomes are related to a number of interacting variables including age, intelligence, personality, social experience, and motivation (Lee, 1993).

Learning Style Classifications

The vast number of learning style constructs creates confusion when examining previous research in this field. Many constructs have been criticized for lack of adequate research support before being published for use. Another difficulty involves the inability to relate one learning style model to another when comparing study results. This difficulty dilutes the strength of the research, could be the cause of conflicting results, and creates conflicting messages when applying research results to instruction (Curry, 1990; O'Neil, 1990).

Because of the difficulty involved in grasping the relationship between models, Curry (1983) examined the underlying concept of several learning style constructs and developed a classification system for 10 models. The constructs she included in her system were limited to those for which meaningful data had been collected and reported and validity and reliability had been established. Her system divided learning styles into three classifications: instructional preference, information processing, and cognitive personality. Curry likened these to layers of an onion with the instructional preference models on the outer layer, the information processing models in the middle layer, and the cognitive personality models at the core.

The instructional preference models include Frideman and Stritter, Rezler, and Grasha-Reichmann. Instructional preferences are in the layer that interacts most directly with the learning environment. Examining the most observable learning behavior, instructional preference tests have in common their reference to the individual's choice of an environment in which to learn, the individual's expectations, the teacher's expectations, and other external features.

The information processing models, in the middle layer of the onion, concern the individual's approach to assimilating information. Models that Curry classifies under this category are Kolb, Tamir, Elstein and Molidor, and Schmeck and Ribich. All of these models examine the concept of an individual's preference for working at a certain pace and on material of his or her choosing, as opposed to material chosen by the instructor or peers.

These models are concerned with the degree a learner wishes to structure and participate in his or her own learning.

Cognitive personality models, at the innermost layer of the onion, are defined by Curry as the individual's approach to adapting and assimilating information. Models falling under this category include Witkins, Myers-Briggs, and Kagan. Although all of these share an examination of an individual's approach to adapting and assimilating information, they do not deal directly with the individual's interaction with the environment. They are concerned with the underlying and relatively permanent personality dimension. They also reflect the most stable element of the individual, particularly when compared to instructional preferences that can change to suit the needs of the learning situation and subject matter being learned (Curry, 1983).

Witkins' Field-Independent and Field-Dependent Cognitive Styles

One of the oldest, most researched, and most recognized of the cognitive style constructs is that of field-dependence and field-independence (Thompson & Melancon, 1987). This concept has been researched by Herman A. Witkins and others since the 1940s (Claxton & Ralston, 1978; Hashway & Duke, 1992; Morgan, 1997; Witkins et al., 1971; Witkins et al., 1977). These cognitive styles relate to a learner's use of an analytical or global approach to learning, which Witkins referred to as field-independent and field-dependent, respectively.

The original research in this area utilized body positioning and rod/frame equipment to determine if individuals could place their body or a rod in a vertical position. In these tests a physical frame that was not aligned to vertical was placed in front of the participant as his or her only visual reference. Participants were then asked to align the rod or their body vertically. These tests determined that some individuals were able to align elements vertically independent of the frame, and others would align elements with the frame. Later tests used a simpler arrangement where individuals were asked to find a simple shape in a more complex figure. The embedded figure tests measure how well an individual can isolate specific elements within a more complex figure. Analyses of the data obtained by these tests demonstrate that individuals exist along a continuum from one extreme to the other (Witkins et al., 1971; Witkins et al., 1977).

According to this bi-polar construct, field-independent learners do not rely on the learning environment for references. They are able to isolate the essential element from the whole. In learning situations, they prefer to work alone without extensive direction. They are exploratory by nature, tend to be introspective, and are not oriented to the social context. They have an internal structure that enables them to analyze data without outside information (Doyle & Rutherford, 1984; Morgan, 1997; Witkins et al., 1971; Witkins et al., 1977).

In contrast, field-dependent individuals are social, outgoing, friendly, and oriented towards people. They are less able to isolate elements from the context in which they are presented and have difficulty distinguishing parts of a task from the whole. They prefer cooperative learning situations and take clues from social situations (Doyle & Rutherford, 1984; Morgan, 1997; Witkins et al., 1971; Witkins et al., 1977).

The tendency to become field-dependent or field-independent has been demonstrated to be partially related to environment. For instance, cultures with strong authoritarian family arrangements tend to have more field-dependent individuals (Morgan, 1997).

Gender seems to have less impact on field preferences. Although Witkins' research suggested that more females than males are field-dependent (Witkins et al., 1971), recent research has failed to substantiate his conclusion and indicates that the proportion of field-dependent and field-independent individuals in each gender is about equal (Haaken, 1988; Cooperman, 1980). Haaken (1988) suggested that Witkins may have overinterpreted his findings to be consistent with the prevailing stereotypes of women held at the time of the construct's development.

Although there is little evidence that gender affects whether an individual is field-dependent or field-independent, gender differences do exist. It is known, for instance, that females are more verbally precocious than males, and males seem to have superior visual-spatial perception. However, some researchers contend that the difference between female and male spatial ability is related to their different experiences as they grow up (Jones, 1986).

Field-Neutral Characteristics

There are researchers who believe that individuals should be classified into more categories than field-dependent and field-independent. Witkins actually espoused a continuum rather than a discrete dichotomy for his construct (Witkins et al., 1977).

However, a number of researchers, in order to use the Group Embedded Figures Test (GEFT) scores as a dichotomy, remove individuals from their data who fall in the midrange between field-dependent and field-independent. Unfortunately, this eliminates research data and creates an artificial dichotomy that does not provide information on individuals who are neither one extreme or the other.

To eliminate this difficulty and still provide a discrete classification system, Dyer (1995) added a third category to Witkins' construct that he referred to as field-neutral. Dyer's inclusion of a field-neutral classification was based on work by Garton and Raven in 1994. They contended that there was a learning style that existed between the two extremes of field-independent and field-dependent. In Dyer's study, which involved high school students enrolled in Agriculture classes, he used the Group Embedded Figures Test as the learning style instrument. After administering this test, he observed and interviewed the subjects to further classify them by learning style. These observations and interviews lead him to support Garton's and Raven's assertion that three styles existed. Dyer found that individuals with scores in a range from 0 to 8 had field-dependent characteristics, individuals with scores in a range from 12 to 18 had field-independent characteristics, and individuals with scores in a range from 9 to 11 had some characteristics of both.

His work indicated that field-neutral individuals require some "hint" of structure to perform well in educational endeavors. Although usually intellectual and logical, their school grades frequently fail to indicate it. They perceive and absorb information abstractly, but must convert it to a concrete form for use. They are deductive learners, interpersonally oriented, and do not like excessive rules. They like to work in calm environments with few distractions. They like authority in a classroom setting, but prefer independent study. This mixture of characteristics makes field-neutral individuals unique from their field-dependent and field-independent classmates.

Learning Styles and Achievement

The literature is not conclusive on the existence of a relationship between learning styles and student achievement (Curry, 1983, 1990; MacNeil, 1980). Developing a clear picture of this relationship is complicated by the array of learning style instruments and the limited information that relates learning style instruments to each other.

Research on achievement and learning style has provided several insights into the way that field-dependent and field-independent learners differ in their learning environment needs. The practical implications of this are directly related to student achievement in various learning environments (Jones, 1986; Liu & Reed, 1994). Many studies have shown that field-independent individuals, for example, out perform field-dependent individuals in higher education settings (Liu & Reed, 1994; Smith & Standal, 1981; Witkins et al. 1977) The literature also suggested that students entering colleges and universities are predominately field-dependent (Wooldridge, 1995). Witkins et al. (1977) indicated that field-dependent individuals have a disadvantage in learning situations because they need more explicit instructions when performing problem-solving tasks. They also suggested that field-dependent learners are less likely to do as well in math and science because of the way in which these subjects are taught.

In 1993, Lee examined multiple predictive elements related to achievement in learning CAD, one of which was learning style. This work was centered on the use of self-paced, embedded tutorials for AutoCAD known as the Teaching Assistant for AutoCAD Release 11. The primary question being studied was whether AutoCAD tutorials used in industry to train adult learners could be successfully used to provide instruction for architectural students as an independent study course. The population under study was students enrolled in ARCH 301, Independent Study AutoCAD Workshop, in the School of Architecture at the University of Illinois.

The tutorials used in the study were embedded, which is a form of computer-aided instruction (CAI) where the instruction is integrated into the program the tutorials are designed to teach. These embedded tutorials provided training on the function and use of the commands in AutoCAD. Because they were written for individuals in industry, instructions in drawing standards and concepts were not included. The tutorial designers assumed that individuals using the tutorials would already have a background in this area.

A total of 30 students participated in the study, which examined 12 predictors of achievement in learning AutoCAD. The predictors examined were interest, relevance, expectancy, satisfaction, level of computer experience, attitude towards computers, attitude towards the tutorial, study time, learning styles, AutoCAD exposure in high school, recent CAD experience, and concurrent AutoCAD experience. Students in the study were allowed to work at their own pace during the course. At the end of the semester they were given a posttest on AutoCAD functions, two different questionnaires, and the Kolb Learning Style Inventory.

The Kolb Learning Style Inventory tests for four abilities: concrete experience (CE), reflective observation (RO), active experimentation (AE), and abstract conceptualization (AC) (Kolb, 1981). According to Kolb, these four abilities form the opposing ends of two separate dimensions (abstract/concrete and active/reflective). From these abilities, Kolb formulated four distinct learning styles known as the converger, the diverger, the assimilator, and the accommodator. The Learning Style Inventory is used to determine an individual's preferred style of receiving and organizing information. However, Kolb noted that individuals may use any one of these styles if the situation warrants (Ayersman, 1993; Lee, 1993).

The first questionnaire used in the study was given to the students prior to their use of the tutorials. This questionnaire was designed to collect information about the students' previous computer experience, attitude toward computers, and motivation. The second questionnaire gathered student feedback on the presentation of the tutorials. The researcher used student observations to determine where misunderstanding of learning sequences occurred. In addition, he surveyed experts in AutoCAD to solicit their opinions on appropriate teaching techniques that should be used for AutoCAD instruction. At the end of the study, a multiple regression analysis was performed on the data. The results of the study indicated that, of the 12 predictors of achievement, only the level of experience in computer use, prior exposure to AutoCAD in high school, and attitude toward the tutorials were significant predictors of CAD achievement. Learning style was not found to be a predictor.

Another study that examined learning style and achievement related to computer instruction was conducted by Sexton, Raven, and Newman in the Spring of 1998 at Mississippi State University. The primary intent of the study was to determine to what extent different teaching methods and learning styles influenced agriculture students' achievement in a computer applications course. The course was taught as a combination of lectures, demonstrations, self-paced hypermedia-based laboratories, and class assignments.

The population in the study consisted of 15 female and 28 male agricultural students at Mississippi State University enrolled in two sections of ASS 4203/6203, Applications of Computer Technology to Agricultural and Extension Education. This was a required course for several majors in the College of Agriculture and Life Sciences. The control group consisted of one section of the course that limited the number of students to an enrollment of 17. The treatment group consisted of the second section of the course that allowed a student enrollment of 26. The course was organized into 16 modules and included units on an introduction to computers, word processing, spreadsheets, the Internet, and presentation packages. Each learning module consisted of a lecture, a demonstration, and a laboratory exercise that was followed by a graded lab assignment.

The students in the control group met two days a week, and each student had access to a computer during class time. The first class meeting each week was devoted to lectures and class demonstrations. The second class meeting was reserved for laboratory assignments. The instructor was available to provide individual help to students during laboratory sessions.

Instruction for students in the treatment group used the same 16 modules, but only met once a week. During this class meeting they received the same lectures and demonstrations provided the control group, but laboratory assignments were completed outside of class. The instructor or a graduate teaching assistant was available in the computer laboratory 25 hours a week to help students with assignments.

Students in the study were given the Group Embedded Figures Test (GEFT) to determine their learning styles. A total of 14 homework assignments was assigned to students during the course. Assignments included in the homework score were a word processing project, a spreadsheet project, a World Wide Web project, presentation projects, and a comprehensive lab practical. The two measures used to address authentic learning were the time it took students to complete the lab practical and the score on a final problem on the lab practical. The programs used for the lab practicals were Microsoft PowerPoint 97 and Corel Presentations 7.0.

A factorial multivariate analysis of variance was used to test the null hypotheses. The researchers concluded that there was not a significant difference in the achievement of the control and treatment groups or the field-dependent and field-independent learners.

Still another study that examined learning style and how it related to performance in a computer applications course was conducted by Davidson, Savenye, and Orr (1992). Their research examined learning styles and achievement with achievement measured by the final exam and final course grades. The Gregorc Style Delineator self-assessment instrument for identifying and quantifying learning styles of adults was used as the learning style instrument. This instrument consists of ten sets of four words that an individual ranks in order. Based on the score of the rankings, four basic learning style abilities are identified. A score of 27 or higher in a category identifies the dominant ability. These styles are Abstract Random (AR), Abstract Sequential (AS), Concrete Random (CR), and Concrete Sequential (CS).

According to this construct, Concrete Sequential (CS) learners are by nature methodical, deliberate, and instinctive in their thinking. They are also pragmatic and finely tuned in to their physical senses. CS learners prefer step-by-step conventional instruction. They learn best in situations that present information in an orderly and efficient manner.

Abstract Sequential (AS) learners prefer abstractions, thoughts, and symbols that correspond to the concrete, reality-based world. They are sequential learners, but prefer rich images and lots of detail. They are able to analyze and separate relevant from irrelevant information in order to grasp key ideas. They are highly verbal and prefer stimulating, orderly, and quiet learning situations. They also prefer clearly organized and lean presentations and a quiet atmosphere in which to learn.

Abstract Random (AR) learners experience reality through emotions, imagination, and feelings. They are subjective learners and base many perceptions on intuition and the senses. They see the essence of ideas and build themes as they work through information randomly. They learn best by receiving information in an unstructured manner and prefer group discussions and sensitive-rich environments.

Concrete Random (CR) learners use the physical world as a laboratory to investigate ideas. They are capable of examining, disassembling, and changing the information presented to them. They make intuitive leaps without being able to explain the steps used to reach their conclusions. They learn best in a stimulus-rich environment where they can explore ideas and express opinions. They work well independently or in small groups (Sexton, Raven & Newman, 1998).

The study used two sections of the computer applications course. These sections were taught by two different instructors who used similar pedagogical methods to instruct students. Except for the instructor, the syllabus, course content, outlines, time schedule, textbook, related instructional materials, and evaluation criteria for the projects and exams were the same. The study examined the relationships among learning styles and each performance measure. A total of 68 subjects participated in the study. Analysis of the data revealed that learners with high abstract sequential abilities had higher performance scores for computer applications skills and knowledge on their midterm exam, received higher scores on the second project, received higher scores on the final exam, scored more total points, and had higher scores on the final grade than did learners with low abstract sequential ability. Individuals with high abstract random scores showed significant negative correlations between their learning style scores and their midterm exam grade. Negative correlations for this group was also found between their final exam grade, the total points they scored, and their final grade. Students with a high abstract random score also demonstrated a higher score and a trend towards significance on their project 2 score when compared to learners with low abstract random scores.

A study conducted by Smith and Standal (1981) that matched learning style to a particular study technique seemed to demonstrate that a link between achievement and learning style could exist. In this study, the researchers were looking for a method to help community college students improve their comprehension of textbook reading assignments. The study techniques they investigated involved teaching students to visually map or paraphrase the salient parts of passages from the students' textbooks. The study used 144 subjects, 52 males and 92 females. Subjects in the study were enrolled in one of six sections of an introductory psychology course. Two sections were used as a control group (n = 41), two sections were taught to map text passages (n = 44), and two sections were taught to paraphrase text passages (n = 59).

The learning style instrument used was the Group Embedded Figures Test. Based on their scores on this test, students were placed into categories of field-dependent, field-independent, or neither. Subjects who scored in the top third of the scores on the GEFT were classified as field-independent, subjects who scored in the bottom third of the scores on the GEFT were classified as field-dependent, and subjects who scored in the middle third of the scores on the GEFT were considered neither. Data from the subjects who scored in the middle third on the GEFT were not used in the data analyses, although these subjects fully participated in the study.

For 10 weeks, students in the two treatment groups received 15 to 20 minutes of training in either mapping or paraphrasing during the Tuesday and Thursday class meetings. Total training time amounted to about 6.5 hours. The training material consisted of short passages of 200 words or less taken from the textbooks used in the course. At the end of the 10-week session, students were given Form B of the Descriptive Test of Language Skills (DTLS)—Reading Comprehension. This 30-minute test uses 15 passages that are followed by two to four comprehension questions. A total of forty-five questions is on the test. Fifteen of these assess the ability to understand main ideas, 13 assess the ability to understand direct statements, and 17 assess the ability to make inferences.

The data were analyzed with a t test and two-way analysis of variance using the students' scores on the reading comprehension test as the dependent variable. Results of the analysis showed that the treatment groups did no better on the comprehension test than the control group. However, the researchers found a relationship between learning style and student performance on reading comprehension with field-independent subjects performing better than field-dependent subjects. Similar results have been demonstrated in other studies (Witkins et al., 1977).

Teaching Style, Learning Style, and Achievement

In recent years, a major area of research has been the relationship among teaching styles, learning styles, and student achievement; however, research in this area is still inconclusive. In 1980, MacNeil reported that the numbers of studies that supported and failed to support the concept that matching teaching styles to learner styles improves student achievement were about equal. In more recent research, a larger percentage of studies seems to support a positive relationship between these variables (Wooldridge, 1995).

A study of achievement in Economics Education, conducted at Purdue University in the Spring of 1982, examined 600 students and 20 teachers to see if a link between teaching and learning style could be demonstrated (Charkins, O'Toole & Wetzel, 1985). As a measure of learning style, the researchers used the Grasha-Reichmann Learning Styles Questionnaire (RGLSQ). This instrument places individuals into three learning style categories: dependent, collaborative, and independent. The researchers used the same questionnaire to classify instructors participating in the study. Control groups were not part of the research design.

According to the Grasha-Reichmann learning style construct, dependent learners generally prefer a teacher-directed and highly structured course, collaborative learners prefer a discussion class with a high degree of student interaction, and independent learners like to influence the content and structure of the class. In this study, student scores were compared to teacher scores in order to determine the degree of conflict between the teaching and learning style.

The study used a general learning and attitude model that was based on work by McKenzie and Staff, Bloom, Allison, Manahan, and others (Charkins, O'Toole & Wetzel, 1985). The models were:

Achievement = F(Ability, Attitude, Effort, Quality of Instruction)

Attitude = F(Ability, Achievement, Effort, Socioeconomic Factors, Quality of Instruction)

The researchers added to this model the independent variable of a teaching/learning-style link. As a measure of each student's ability, the researchers used the student's Scholastic Aptitude Test (SAT) score. As a measure of each student's knowledge of economics, they used the Test of Understanding College Economics (TUCE).

From the linear regression model for achievement in economics, the researchers found the following statistically significant components: the expected grade, SAT verbal score, the student's pre-TUCE score, and the absolute value of the difference between a dependent instructor's teaching-style score and a dependent learner's learning-style score. From the linear regression model for attitude, the researchers found the statistically significant components included the expected grades, hours students studied for the course, the student's pre-attitude-toward-economics score, the percentage of change in TUCE score, and the absolute value of the difference between a dependent instructor's teaching-style score and a dependent learner's learning-style score.

The researchers in this study concluded that there was a link between learning style, teaching style, and student gains in understanding economics. They also found that the greater the deviation between a student's learning style and a teacher's teaching style, the less positive the student's attitude towards economics (Charkins, O'Toole & Wetzel, 1985).

In another study that examined learning and teaching styles by MacNeil (1980), he failed to find a relationship between the two. MacNeil's study began with a sample of 72 students, who volunteered to participate, from a group of students enrolled in courses offered by the Recreation Education Program at a Big Ten university during the Spring Semester of 1979. He used the Group Embedded Figures Test to determine the student's learning style. After giving students this test, he eliminated students who scored 13 (the student's median score) from the sample. He then defined students who scored from 1-12 as field-dependent and students who scored from 14-18 as field-independent. This left a sample size of 64, 32 field-dependent students and 32 field-independent students. These students were randomly assigned to one of the experimental groups or the control group, with the restriction that the number of field-dependent and field-independent students be equally apportioned.

The instructor style was classified into three different categories: discovery, expository, and no treatment. MacNeil defined the discovery teacher style as one that is student-centered. Teachers with this teaching style use discussion, group projects, role-playing, self-paced worksheets, and group problem-solving as their dominant modes of instruction. He defined the expository teacher style as one that is teacher-centered. Teachers with this teaching style predominately use lectures, teacher demonstrations, and a large degree of instructor guidance in their teaching. The no treatment (control group) was used to reflect the baseline of receiving no instruction. This group was only given the Group Embedded Figures Test.

The study treatment consisted of five one-hour competency-based group instructions designed by the researcher. For each treatment group the instructional materials were identical. The instructors involved in the study were three graduate level teachers who received four hours of instruction by the researcher to prepare them to teach in the different teaching styles. In addition, the student instruction sessions were attended by the researcher to closely monitor the instructors' adherence to their assigned teaching style and the instructional content.

The two levels of learning style and the three levels of instructor style were used to form a 3 X 2 factorial design. The change in student performance was determined by the Behavior Modification Achievement Test (BMAT), which was an instrument designed by the researcher. This test consisted of fifty objective questions drawn directly from the objectives of the instructional unit's competency list. The estimated reliability for the

BMAT of 0.95 was determined by the Spearman-Brown Prophecy Formula. The BMAT was used as both a pretest and posttest in the study.

An assessment, which primarily focused on a validation of the instructional styles, was performed to evaluate the success of the manipulation of the independent variables in the study. This assessment, in the form of a questionnaire given to the 42 students in the treatment groups, asked the students a series of questions. The questions related to the flow and sequencing of critical information in the course and the level of guidance provided by their instructor.

The results of the study indicated that instruction had a significant effect on the learning performance of the treatment groups when compared to the control group, but there was not a significant difference in the change in learning performance between the treatment groups. The results suggest the subject matter and the instrument used by the researcher may not have been difficult enough to reveal a difference in the groups. Another contributing factor could have been that the instructors used in the study were field-dependent (MacNeil, 1980).

Gender Differences in Computer Training

A number of studies suggest that there is a difference in males' and females' achievement and attitudes related to computer use. Females on the whole demonstrate less interest in computers, less confidence in their abilities to use computers, and lower achievement when using computers (Arch & Cummins, 1989; Chen, 1986; Francis, 1994; Ogletree & Williams, 1990; Shashaani, 1993; Shashaani, 1997; Voogt, 1987). Examination of the literature revealed that these differences seem to have persisted over the years even with an increase in computer use in public schools and private homes.

In a California statewide assessment of computer literacy between the years of 1982 and 1983, Fetler (1985) examined sixth-grade and twelfth-grade boys and girls. In his study, Fetler used a test designed by specialists from the public school system, universities, and industry. The test, the Survey of Basic Skills, assessed instructional objectives in the area of computer literacy as well as attitudes towards computer technology and relevant computer experiences. The test questions for the six-graders were a subset of the test questions for the twelfth-graders, and multiple versions of these tests were prepared for the study. The twelfth-grade part of the study included 87 schools and had an estimated return rate of 88%. Each of the 430 cognitive test questions was answered by approximately 200 students, each of the 13 attitude questions was responded to by approximately 1,200 students, and the background questions were responded to by approximately 4,800 students. For the sixth-grade part of the study, the Survey of Basic Skills was administered to 293,717 students. Test forms were assigned randomly with each school receiving approximately the same number of each form. Each question related to computers was given to an average of 7,343 students with a non-response rate between 4 and 6%.

In both halves of the study, Fetler found that the sixth-grade and twelfth-grade boys outpaced the girls in computer literacy. The in-depth analysis of the data revealed that under three headings (performance, attitudes, and experience) the twelfth-grade boys outperformed girls in every major objective area except one. That objective, which failed to show statistical significance, was related to computer interactions. The boys demonstrated strengths in the areas of computer functions and uses, impact on life, hardware, and computer science problem solving.

The sixth-grade boys demonstrated a superior performance over the girls except in the use of systematic procedures, which was a subset of problem-solving and not directly related to computer skills and abilities. The sixth-grade boys showed particular strength in the areas of vocabulary, system components, history, and simple programs.

In the area of attitudes towards computers, the twelfth-grade boys and girls differed significantly on two statements. The girls were more likely to believe that computers slowed down and complicated business operations and computers could not make mathematics more interesting.

The sixth-grade boys' and girls' attitudes differed on more issues than the twelfth-grade students. The sixth-grade girls were less likely to see that computer skills could help someone get a better job, that someday most things would be run by computers, and that computers could make mathematics more interesting. The girls also appeared to have a less positive attitude towards computers than the boys.

In the examination of computer experience, more twelfth-grade boys than girls reported they learned about computers from having them in their home, learned about them from friends, and learned about them from video games. Similar results were found for the sixth-grade students. Although the boys and girls who had taken computer courses had similar levels of computer experience through course work, more of the girls reported they had no computer experience. The girls also reported they had less access to computers at school and video games at home. The researcher hypothesized that the girls' computer performance would be lower because they had fewer computer experiences than the boys.

In a study with college students (Ogletree & Williams, 1990), gender was again examined in relationship to attitudes and aptitudes related to computers. Students used in this study were enrolled in two sophomore-level human sexuality classes at a central Texas university. The sample consisted of 47 men and 78 women. During the first class, students completed a questionnaire on their computer backgrounds and demographics. After completing the questionnaire, they were asked to respond to a slightly modified version of the Bem Sex Role Inventory (BSRI), which measures an individual's degree of masculine and feminine characteristics, and the Computer Attitude Scales. During the same class, students completed a modified version of the Self-Efficacy Questionnaire and the Computer Aptitude Test adapted by Dambrot et al. The Computer Aptitude Test asked students to rank their self confidence and ability to complete five computer programming tasks, complete five computer science courses, and use the computer for five personal projects. The five-point Likert scale used by the instrument ranged from: "not at all confident/can't do" to "completely confident/can do."

When surveyed, approximately 85% of the participants indicated that they did not currently own a computer, and about 63% indicated that their family did not own a computer. Only 34% indicated that they used a computer more than an hour a week.

Initial comparisons by gender found similar results as previous studies. Analysis of the data on the Computer Attitude Scale revealed that the males demonstrated a more positive attitude towards computers and a greater confidence in using computers than did the females. However, when certain characteristics were controlled in an analysis of covariance, gender had less impact on computer achievement. In the analysis, four computer experience variables and two sex-typing variables were entered as covariates in the following order: personal computer ownership, family computer ownership, current level of computer usage in hours per week, number of different kinds of computer courses taken, Bem Sex Role Inventory measure of masculinity, and Bem Sex Role Inventory measure of femininity. The results of this analysis revealed that individual computer ownership was associated with a more positive computer attitude and a high self-efficacy score. The level of computer use was associated with each of these variables and with better attitudes towards computers and higher expectations for succeeding in computer courses, while BSRI femininity was negatively associated with these expectations of success. In this analysis, gender was significant only for computer attitudes.

The study also found a correlation between BSRI masculinity and computer attitude and self-efficacy. For males, current computer usage was significantly correlated with the attitude and self-efficacy measures; for females, current computer usage was significantly related to attitude and aptitude measures.

BSRI femininity and masculinity were not significantly correlated with any of the computer experience variables for the either males or females. While owning a computer was significantly correlated with current computer usage for the males, the correlation for the females was not significant and negative.

In a study conducted by Shashaani (1997) in 1993, females still demonstrated that they were less secure than males in their ability to use computers. Even with students' greater exposure to computers in public school, little seems to have changed. In her study, Shashaani used a sample of 202 undergraduate students (87 males and 115 females) at a private urban university in Pittsburgh. These students were enrolled in seven sections of a required introductory computer science course, "Elements of Computer Science." Approximately 50% of the course used hands-on instruction in the use of several programs, and the other 50% was on computer theory.

The instrument, used as a pretest and posttest to measure attitudes, utilized a Likert-type scale. The items on this instrument related to computer attitudes were grouped into four categories: computer liking (six items), computer confidence (seven items), computer usefulness (six items), and computer stereotypes (four items). Both positive and negative wording were used in the test items.

Data on computer experience were collected by gathering information on the computer courses the students took in high school, frequency of computer use in high school, home computer ownership, and the primary user of the home computers. Demographic information was also collected on the participant's age, sex, and academic status.

The results of the study showed a significant relationship between gender and three components of the pretest. The males scored higher than the females on enjoying learning about computers, enjoying working with computers, and considering computers exciting. The results also indicated the females were more uncomfortable with computers and feared them more than the males. Analysis of the data further revealed that the females generally believed computers were hard to learn, and they had less confidence in dealing with computers.

Questions related to computer experience showed that the males had more experience with computers than the females. Fifty-eight % of the males said they had prior computer experience, compared to 40 % of the females. More of the males than the females reported they had taken computer courses in high school. Also, for the males and females who had taken computer courses in high school, the males had taken a larger number of courses. The males also had taken more courses related to programming, spent more hours in the school's computer labs, and had more computers at home. Of the students who reported that they used computer at home, approximately 70% were male and only 25% female (5 % were not identified as male or female). The study found statistically significant relationships between computer use, a positive attitude towards computers, and confidence in ability to work with computers. Positive correlations were found between a student's prior experience with computers, interest in computers, confidence in his or her ability to work with computers, belief that the genders were equal in computer ability, and belief that computers are useful to the individual and society. Other positive correlations were found between attitudes towards computers, taking computer-related courses, and using computers in high school. Smaller positive correlations were found between computer ownership and liking computers and between computer ownership and confidence in using computers.

When the students were asked if their parents, particularly their fathers, believed that computers are more appropriate for males than females, the majority of them agreed with the statement. For the males, a positive correlation was found between their parents' perceived view that computers were mostly for males, their interest in computers, and their confidence in their ability to use computers. For the females, a negative correlation was found between their parents' perceived view that computers are more appropriate for males, their interest in computers, and their confidence in their ability to use computers.

Both the males and females had positive correlations between their parents' encouragement to use computers, their interest in computers, their self-confidence in their ability to use computers, and their belief that computers were beneficial in their daily lives.

At the end of the one semester course, the researcher found that the males and females tended to demonstrate a better attitude towards computers. The final course grades for the females were not affected by their lack of confidence in learning and working with computers or by their lower interest level. Although the females still perceived computer science as more difficult to learn and feared computers more than the males, they performed better in the course.

Learning Style and Drafting

A single study carried out by Guster (1986) examined learning style, attitude towards drafting, and drafting performance in high school classes in a Missouri high school. In this study, the researcher found a statistically significant relationship between learning styles and achievement in learning drafting. The study sample consisted of six intact classes taught by two instructors, which provided a sample size of 167 individuals. All of the students involved in the study were male.

The researcher created six multiple linear regression models to examine the data. As a measure of attitude (pretest and posttest), Guster used an instrument known as A Scale to Measure Attitude Toward Any School Subject (SMATSS). To measure drafting achievement, he used an instrument known as The Drawing: Cooperative Industrial Arts Tests (DCIAT). To measure the students' cognitive style, he used the Group Embedded Figures Test. In three of the models the GEFT scores were treated as a continuous variable, and in the other three it was treated as a dichotomous variable. To create the dichotomous variable, Guster divided the scores on the GEFT (0-18) into thirds. Students who scored in the highest third on this test were classified as field-independent, students who scored in the lowest third were classified as field-dependent, and students who scored in the middle third were removed from the data to minimize error when the data were converted to a dichotomous variable.

During the first week of class, the students were administered the SMATSS as a pretest to measure their attitude towards drafting. On the following day, they completed the DCIAT as a pretest of their drafting achievement. Two days later they were given the GEFT as a measure of their cognitive style. Posttests for the SMATSS and DCIAT were completed during the last week of instruction in the same order as the pretests.

Guster's models 1 and 2 examined the students' exit scores for attitude towards drafting and their cognitive styles. Three variables—age, entering attitude toward drafting, and entering drafting achievement—were used as covariates. In model 1 the GEFT scores were used as a continuous variable, while controlling for the confounding variables. In model 2 the GEFT score was used as a dichotomous variable, again controlling for confounding variables. The results showed no significant relationships in either model at the .05 level.

Guster's models 3 and 4 examined the relationship between drafting achievement and cognitive styles. Model 3 treated the GEFT score as a continuous variable, and model 4 treated the GEFT score as a dichotomous variable with age, entering attitude toward drafting, and entering drafting achievement again used as covariates. In both models, a relationship between cognitive style and drafting achievement was found, which indicated that a high score on the GEFT (field-independent) predicted a high score on drafting achievement.

Models 5 and 6 examined the relationship of the end-of-course grades and student cognitive styles. Again, model 5 used the GEFT score as a continuous variable, while model 6 used it as a dichotomous variable with the same covariates used in the earlier models. The multiple linear regression models for both models 5 and 6 found a statistically significant relationship between GEFT scores and final course grades. Again, the results indicated that the field-independent students received higher end-of-course grades than the field-dependent students.

Summary

The literature on learning styles related to this study showed a mixture of results, but tends to indicate that there probably is a relationship between learning styles and student achievement. While the jury still seems to be out on the relationship between student learning style, teaching style, and achievement, it is a promising area for investigation.

A problem with the literature on learning styles is that the variety of learning style instruments and constructs makes it difficult to draw conclusions from the body of work in this field. With no clearly established relationship between these instruments and constructs, direct comparisons between studies are problematic.

In the area of computer experience and confidence in using computers, the literature indicate that males demonstrate a superior level of experience and confidence when compared to females. However, it is noteworthy that, even with lower levels of computer experience and confidence, females manage to achieve as well or even better than their male counterparts in basic computer courses.

The lack of research on factors related to learning computer-aided drawing and technical/engineering graphics concepts together makes this a fertile ground to explore. It is hoped that this study will shed light on this subject.

Chapter 3

METHODOLOGY

Introduction

The review of the literature suggested that there were several factors that could possibly influence the achievement of individual students in learning computer-aided drawing and course content in engineering/technical graphics classes at N. C. State. The methods discussed in this chapter were designed to explore the effect of some of these factors.

Significance of the Study

This study is significant because it examined factors that affect achievement in courses that combine the teaching of engineering/technical graphics concepts and computer-aided drawing. The literature is void of research contributing to this area of inquiry.

Purpose of the Study

The purpose of the study was to determine if certain student characteristics affect achievement in learning computer-aided drawing and technical graphics when taught together. These characteristics include learning style, major, computer experience level, gender, student classification, and prior drafting experience. By determining some of the factors limiting student achievement, faculty in the Graphic Communications Program at N. C. State would be provided evidence to aid them in evaluating and modifying instruction.

Design of Study

The study was designed as a descriptive correlational study (Borg & Gall, 1989) and used three dependent variables and seven independent variables. The subjects were from intact classes. Because it was a descriptive study, a control group was not used. The independent variables in the study were student major (engineering, non-engineering), student classification (freshman, sophomore, junior, senior), student learning style as measured by the Group Embedded Figures Test, an AutoCAD pretest, gender, prior computer experience, the final exam grade, the final exam grade with the posttest score removed, and prior drafting experience. The dependent variables were the student score on the final project, the student score on the 10 questions that formed the AutoCAD portion of the final exam (posttest), and the final course grade.

Population and Sample

The target population for the study included students enrolled in introductory classes of engineering/technical graphics. The classes also provided instruction in the use of AutoCAD Release 14 at N. C. State in the Spring of 1999. The sample consisted of two sections of GC 120, Foundations of Graphics, which includes instruction in AutoCAD. Because of the nature of course assignments, whole classes were used. The sections chosen to participate in the study had the same instructor to eliminate the instructor effect. There were three criteria for the selection of the classes:

1. Each section was taught by the same instructor.
2. The instructor had taught the course at least once prior to the semester in which the research was conducted.
3. The instructor had prior experience in teaching AutoCAD.

The anticipated sample size was 48 (24 students in each section of GC 120); however, due to a lower enrollment in one section, the beginning sample size was only 43. During the semester, subject attrition reduced the sample size to the 38 subjects used in the study analyses.

Instrumentation

The Group Embedded Figures Test

The instrument used to measure student learning style was the Group Embedded Figures Test (GEFT). One of several tests that measure an individual's ability to isolate stimuli within complex fields, the Group Embedded Figures Test is the most widely used test developed by Witkins et al. Unlike other tests designed for this cognitive style construct, this test is group administered. The Group Embedded Figures Test is an adaptation of the original Embedded Figures Test designed to be administered to single individuals (Thompson & Melancon, 1987; Witkins et al., 1971).

Individuals taking the Group Embedded Figures Test are asked to find a simple line figure in a more complex line figure and overdraw it. The test consists of two practice items and 18 test items grouped into two sets of nine. The time limit for completing the first set is two minutes, and the time limit for completing the second is five minutes. Problems in the second set are more complex than those in the first. Norms for the test were established using college men (N =158) and women (N = 242) from an eastern liberal arts college. Males in this group had a mean of 12.0 (SD = 4.1) and the females a mean of 10.8 (SD = 4.2). The slight difference in the means of the males and females was statistically significant to a p-value of <0.005. The group used to establish the GEFT test norms closely matches the age range of the subjects in this study. The Spearman-Brown prophecy formula was used to establish reliability. The reliability estimate for the GEFT is 0.82 for both males (N = 80) and females (N = 97) (Witkins et al., 1971).

Tutorials

During the Summer and Fall of 1998, six tutorials were created for AutoCAD Release 14 (see Appendix D). The tutorials were designed to be delivered to students through the World Wide Web and were first used in two sections of GC 120 in the Second Summer Session of 1998. Using the input from these students, the content of the tutorials was revised. These refined tutorials were then used by ten introductory Graphic Communications (GC) classes in the Fall of 1998, and further refinements were made.

Questionnaire

The questionnaire that subjects were asked to complete at the beginning of the study supplied data and information for a number of variables along with the subjects' demographics (See Appendix C). The demographic information included the subjects' names, identification numbers (for temporary verification), course section numbers, gender, and current classifications (Freshman, Sophomore, Junior, or Senior). Other information gathered through the questionnaire included the students' majors (or the major they intended to pursue if currently enrolled in the Freshman College), level of prior computer experience, how they had obtained their computer experience, if they had prior drafting experience, and the computer courses they had taken. Under the heading of computer courses, they were also asked to identify the course level (middle school, high school, community college, or university) and course length.

Pretest and Posttest

Prior to the study, a pretest and posttest were created to test students' knowledge of AutoCAD commands and their functions. The 10 question pretest on AutoCAD was developed by the researcher and tested for content validity, face validity, and accuracy by expert members of the Graphic Communications Faculty at N. C. State and a set of four students who had taken the GC 120 course. Students selected for this review panel were limited to those who took the course during the 1998 Fall Semester when AutoCAD Release 14 was used in the GC 120 course. The pretest was designed to be similar to the posttest, and both sets of questions were selected from a bank of AutoCAD questions created by the Graphic Communications' faculty.

As a measure of students' knowledge of AutoCAD commands, a 10 question portion of the final exam was used as the posttest. These questions were reviewed by instructors in the Graphic Communications program for accuracy and face validity, and had been used for four semesters and four summer sessions as part of the course's final exam. Using the split-half method, a reliability estimate was obtained for the posttest of 63% (Gronlund, 1981).

Research Procedure

The research was conducted during the 1999 Spring Semester. Two sections of GC 120 (Foundations of Graphics) were selected before the semester began and asked to participate in the study. Prior to the semester, the researcher met with the instructor of the course and agreed on the types of instructional activities to be used to teach CAD and the other course content. They also agreed that identical activities would be used in both sections of the course. During the first week of the semester, the researcher attended each class section, explained the research to the students, and asked the students to volunteer to participate in the study. During the second week of the semester, prior to any AutoCAD instruction, the researcher again attended the class sections and administered the 10 question AutoCAD pretest, the research questionnaire, and the Group Embedded Figures Test (GEFT).

For the remainder of the semester, participants in the classes proceeded through the course normally. Instruction in the use of the AutoCAD software for these sections included the six tutorials for AutoCAD Release 14, class demonstrations, and in-class and homework assignments. The AutoCAD instruction was designed to parallel the main course content so students were prepared for CAD assignments that required knowledge of the concepts of technical graphics for successful completion. Instruction in the other course content was delivered as lectures, class demonstrations, and in-class and homework assignments. The GC 120 course included units on hand lettering, the metric scale, manual drawing equipment, geometric constructions, isometric pictorials, multiview drawings, sections, auxiliaries, dimensions, manufacturing processes, and working drawings. Throughout the course, visualization exercises were used to improve students' ability to mentally picture, rotate, and project representations of objects.

The homework and in-class AutoCAD activities began with a simple 2-dimensional drawing using only horizontal and vertical lines and then advanced to drawings involving complex geometry (See Appendix D). A pair of two-dimensional drawings was assigned to students to complete during class or as homework along with the first and second AutoCAD Tutorials. Students then completed a simple three-dimensional solid model in class and were assigned to complete the third, fourth, and fifth AutoCAD Tutorials for homework. These tutorials involved the construction of three-dimensional solid models. Next, students were asked to complete a second, more complex solid model as a homework assignment. Finally, students were assigned the last tutorial on dimensioning a multiview drawing, which they first converted from a solid model. The last AutoCAD assignment was the final project (see Appendix E). The project assignment was to create a complex three-dimensional solid model in AutoCAD, convert it to a multiview drawing, add a titleblock, and dimension it according to the standards established by the American National Standards Institute (ANSI). The project was designed to provide the students with an experience in constructing a working drawing like those used in industry. At the end of the semester, the instructor provided the researcher with the students' grades on the final project, final exam, the posttest, and the course.

Analysis Methods

Two methods of analysis were used in the study. A nonparametric analysis procedure, Kendall's Tau B, was used to correlate the variables. In addition, appropriate variables were included in three linear regression models. Model 1 examined the ability of certain independent variables to predict project scores, Model 2 examined the ability of certain independent variables to predict scores on the posttest, and Model 3 examined the ability of certain independent variables to predict the final course grade. A p-value of .05 or less was used in the analysis of the data to indicate statistical significance. The data were analyzed using the JMP™ statistical analysis program Version 3.1 (SAS, 1995).

Dependent Variables

Three dependent variables were used in the analysis of the data: the score on the posttest, the final project grade, and the final course grade. The AutoCAD posttest score was derived from 10 questions on the students' final exam that tested students' knowledge of AutoCAD commands. The final project, assigned towards the end of the semester, was created as a solid model in the computer and then converted to a multiview drawing. The multiview drawing had to be a working drawing with appropriate views, dimensions and notes, and placed inside a properly labeled titleblock. The posttest and final project were used to examine different aspects of using CAD. The posttest primarily provided a measure of students' knowledge of the names and functions of the commands in AutoCAD. The final project grade provided a measure of students' ability to use the commands and apply appropriate strategies for producing a drawing in AutoCAD. The final course grade, the third dependent variable used in the study, provided a measure of achievement in learning overall course content. The final course grade was based on the homework assignments, two quizzes, a final exam, attendance, and the final project grade.

Independent Variables

The independent variables used in the study included gender, major, student classification, the pretest score, the posttest score, learning style, the final exam grade, and the final exam grade with the posttest questions removed. The variable of gender was classified as females (1) and males (2). Majors were combined into two categories of non-engineering (1) and engineering (2). For the Kendall's Tau B correlations, the independent variable of computer experience was categorized as: none (1), some experience (2), fairly experienced (3), and very experienced (4). The category of none (1) was not selected by the subjects and, therefore, was not used in the correlations. For the multiple linear regression models, the computer experience categories were combined into some and fairly experienced (1) and very experienced (2). For the correlations, the variable of student classification used the categories of freshmen (1), sophomores (2), juniors (3), and seniors (4). For the multiple linear regressions these categories were combined into freshmen and sophomores (1) and juniors and seniors (2).

Multiple Linear Regression Models

Two multiple linear regression models were created to predict students' achievement in computer-aided drawing. Model 1 used the students' project grade as the dependent variable, and Model 2 used the students' score on the AutoCAD portion of the final exam as a posttest. Before creating the multiple regression models, backwards stepwise regressions were performed to examine the effect of several independent variables. The variables used in the stepwise regression models were either anticipated to have an effect on the dependent variables by the researcher or were found to have a correlation with the dependent variable by the Kendall's Tau B analyses.

Model 1 used the dependent variable of project grade as a measure of achievement in learning computer-aided drawing. During the stepwise regression procedure, the independent variables examined for the final model included gender, major, student classification, the Group Embedded Figures Test score, posttest score, prior computer experience, and prior drafting experience. After performing the stepwise regression, the variables retained for the final model were gender, pretest score, and major (engineering or non-engineering).

Model 2 used the posttest score as its dependent variable, which was the second measure of CAD achievement. During the stepwise regression procedure, the independent variables examined for inclusion in the final model were the pretest score, the Group Embedded Figures Test score, prior drafting experience, the final exam grade with the posttest score removed, the project grade, student classification, and gender. Following the stepwise regression, the independent variables retained for the final model were the pretest score, the Group Embedded Figures Test score, and the final exam grade with the posttest score removed.

Model 3 used the final course grade, to measure achievement in learning technical graphics, as its dependent variable. The independent variables examined by the stepwise regression for the final model were gender, major, student classification, pretest score, Group Embedded Figures Test score, prior computer experience, and prior drafting experience. Based on the stepwise regression, the final formula retained the independent variables of gender, Group Embedded Figures Test score, and student classification.

Summary

This chapter has described the methodology used in the study. A correlational descriptive study, this research used three dependent variables and seven independent variables. Analysis of the data was completed using Kendall's Tau B non parametric analyses and three multiple linear regressions. The results of these analyses will be discussed in the following chapter.

Chapter 4

FINDINGS

Introduction

This chapter provides a description of the data collected during the study and the results of the data analyses. It includes the demographic information, the results of the Kendall's Tau B correlations, and an examination of three multiple linear regression models designed to predict students' achievement in learning computer-aided drawing and course content.

Description of the Study Sample

Thirty-eight students participated in the research study, eight females and 30 males. The number of males and females in the sample was typical for the GC 120 (Foundations of Graphics) classes.

Students in the study represented all levels of student classification from freshmen to seniors and included four freshmen, 20 sophomores, eight juniors, and six seniors. The engineering and technology curricula that require this course recommend that it be taken during the sophomore year. Therefore, the large proportion of sophomores enrolled in the sample was normal for this course.

Students in the sample were from 19 different majors. The largest number of students from a single major was ten from Civil Engineering. Eighteen of the students were enrolled in engineering programs and 20 in non-engineering programs (see Table 1). The nearly equal division between engineering and non-engineering students was typical for this course. GC 120 is required for many engineering and technical majors and can be used to fulfill one of N. C. State's general education course requirements (GER). Because of its GER designation, students from a larger variety of majors enroll in GC 120 than would be otherwise expected.

Table 1

Majors of Students in the Study Sample (N=38)

Major	Number of Students
Civil Engineering	10
Agricultural and Environmental Technology	4
Technology Education	4
Mechanical Engineering	3
Civil Construction Management	2
Engineering Undesignated	2
Chemical Engineering	1
Biological Science Undesignated	1
Computer Science	1
Environmental Engineering	1
Environmental Science	1
Geology, Marine Science Concentration	1
Information Systems	1
Multidisciplinary Studies	1
Pulp and Paper Technology	1
Psychology	1
Textile Engineering	1
Technology: Poultry Science	1
Wood Products	1

Males and females in the sample were almost equally distributed between engineering and non-engineering programs. Fourteen males and four females were enrolled in engineering programs, and 16 males and four females were enrolled in non-engineering programs (see Table 2).

Table 2

Engineering and Non-Engineering Majors by Gender (N=38)

Major	Females	Males	Total
Engineering	4	14	18
Non-Engineering	4	16	20
Total	8	30	38

Analyses of the Correlations Between Variables

Kendall's Tau B, a nonparametric statistical procedure, was used to correlate the variables in the study. Several significant correlations were found, but only one strong relationship. According to Borg and Gall (1989), Pearson's correlation values between 0.20 and 0.35 indicate slight relationships, and correlation values above 0.65 indicate a strong relationship. They also state that correlation values around 0.5 can be used for making some predictions.

Variables used in the correlations for this study included the project grade, final exam grade, the final exam grade with the posttest score removed, the pretest score, the posttest score, student classification (1 = freshmen, 2 = sophomores, 3 = juniors, 4 = seniors), prior drafting experience (1 = no, 2 = yes), Group Embedded Figures Test score, gender (1 = males, 2 = females), prior computer experience (2 = some experience, 3 = fairly experienced, 4 = very experienced), major (non-engineering = 1, engineering = 2), and final course grade.

Final Project Grades

One of the two dependent variables used in the analysis of the data to measure achievement in learning computer-aided drawing was the final project grades. The project assignment required students to use AutoCAD to construct a three-dimensional model that was then converted to a multiview drawing with appropriate standards and dimensions. The mean of the final project grade for the total sample was 88.81 (SD = 9.75), the mean for the 30 males was 91 (SD = 7.35), and the mean for the eight females was 80.6 (SD = 13.47). The data, shown in Table 3, indicate that the project grades were slightly negatively correlated with gender (τ_b = -0.346, p = 0.018). The correlation's negative sign resulted from the lower project grades of the females when compared to those of the males. A correlation found between the project grade and the final grade with the project grade removed (τ_b = 0.366, p = 0.003) suggested that achievement in the general course content may be related to achievement in learning CAD. A slight, but non significant, relationship was also found between the project grade and pretest score (τ_b = 0.220, p = 0.093), which suggested that students who scored well on the pretest probably had prior AutoCAD experience.

Table 3

Correlation of Project Grade and Other Variables:

Total Sample (N=38)

Variables	Kendall's Tau	Probability
Project and Pretest	0.220	0.093
Project and Posttest	0.070	0.596
Project and Final Exam	0.136	0.268
Project and Final Grade Minus Project	0.366	0. 003
Project and Major	0.184	0.210
Project and Student Class	0.066	0.632
Project and Drafting Exper.	0.151	0.304
Project and Computer Exper.	0.166	0.232
Project and GEFT	0.008	0.948
Project and Gender	-0.346	0.018

An examination of the correlation analyses between project grade and other variables for the females in the study (see Table 4) revealed a statistically significant correlation. This correlation was between the project grade and the females' prior drafting experience ($\tau_b = 0.707$, $p = 0.039$). The mean of the project grades for the females (N = 2) with prior drafting experience was 92.5 (SD = 3.54), and the mean of the project grades for the females (N = 6) without drafting experience was only 75 (SD = 14.14). For the females without prior drafting experience, the project grades ranged from a low of 50 to a high of 85. Fairly large, but not statistically significant, correlations for the females were also found between the project grade and the variables of student major ($\tau_b = 0.561$, $p = 0.102$) and student classification ($\tau_b = -0.490$, $p = 0.127$). The negative value for the correlation between the project grade and student classification was an indication that the highest project grades received by females in the study were earned by a freshman and sophomore, whereas the lower project grades were earned by three sophomores, one junior, and two seniors.

Table 4

Correlation of Project Grade and Other Variables:
Females Only (N=8)

Variables	Kendall's Tau	Probability
Project and Pretest	0.057	0.865
Project and Posttest	-0.286	0.358
Project and Final Exam	-0.232	0.441
Project and Final Grade Minus Project	0.386	0.199
Project and Major	0.561	0.102
Project and Student Class	-0.490	0.127
Project and Drafting Exper.	0.707	0.039
Project and Computer Exper.	-0.158	0.645
Project and GEFT	0.392	0.216

Examination of the same correlations for males as a group (see Table 5) found slight significant correlations between the variables of project grade and the final grade with the project grade removed (τ_b = 0.332, p = 0.017) and the project grade and the pretest score (τ_b = 0.339, p = 0.023).

Table 5

Correlation of Project Grade and Other Variables:

Males Only (N=30)

Variables	Kendall's Tau	Probability
Project and Pretest	0.339	0.023
Project and Posttest	0.149	0.323
Project and Final Exam	0.049	0.726
Project and Final Grade Minus Project	0.332	0.017
Project and Major	0.153	0.359
Project and Student Class	0.212	0.176
Project and Drafting Exper.	-0.039	0.813
Project and Computer Exper.	0.071	0.652
Project and GEFT	-0.025	0.866

Posttest Score

The second dependent variable used in the analysis of the data to measure achievement in learning computer-aided drawing was the posttest score. This was a subset of the final examination that contained questions on the AutoCAD commands. The mean of the posttest scores for the total study sample was 7.63 (SD = 1.36), the mean of the posttest scores for the males was 7.63 (SD = 1.37), and the mean of the posttest scores for females was 7.62 (SD = 1.04). Table 6 summarizes the correlations between the posttest scores and other variables for the whole sample. The largest correlation was found between the posttest and pretest scores (τ_b = 0.228, p = 0.084) and was not statistically significant.

Table 6

Correlation of Posttest Scores and Other Variables:

Total Sample (N=38)

Variables	Kendall's Tau	Probability
Posttest and Pretest	0.228	0.084
Posttest and Exam Minus Posttest	0.044	0.726
Posttest and Final Grade	0.128	0.294
Posttest and Major	0.031	0.834
Posttest and Student Class	0.060	0.661
Posttest and Drafting Exper.	-0.044	0.764
Posttest and Computer Exper.	0.077	0.580
Posttest and GEFT	-0.122	0.344
Posttest and Gender	-0.030	0.840

Table 7 summarizes the correlations between the posttest scores and other variables for the females. For the females, two fairly large correlations were found between the posttest score and prior computer experience (τ_b = 0.516, p = 0.129) and the posttest score and the exam grade with the posttest score removed (τ_b = 0.491, p = 0.099), but these correlations were not significant.

Table 7

Correlation of Posttest Scores and Other Variables:

Females Only (N=8)

Variables	Kendall's Tau	Probability
Posttest and Pretest	-0.277	0.402
Posttest and Exam Minus Posttest	0.491	0.099
Posttest and Final Grade	0.189	0.527
Posttest and Major	-0.050	0.883
Posttest and Student Class	-0.087	0.784
Posttest and Drafting Exper.	0.000	1.000
Posttest and Computer Exper.	0.516	0.129
Posttest and GEFT	-0.128	0.684

Table 8 provides a summary of the correlations between the posttest scores and other variables for the males. The only significant correlation found was between the pretest and posttest scores ($\tau_b = 0.316$, $p = 0.034$).

Table 8

Correlation of Posttest Scores and Other Variables:

Males Only (N=30)

Variables	Kendall's Tau	Probability
Posttest and Pretest	0.316	0.034
Posttest and Exam Minus Posttest	-0.019	0.897
Posttest and Final Grade	0.142	0.310
Posttest and Major	0.054	0.748
Posttest and Student Class	0.092	0.556
Posttest and Drafting Exper.	-0.036	0.830
Posttest and Computer Exper.	-0.006	0.970
Posttest and GEFT	-0.119	0.419

Final Grade

The last dependent variable used in the study was the final course grade. This grade was based on graded homework, practice homework, two quizzes, a final exam, attendance, and the final project. Table 9 summarizes the correlations between the final course grade and other variables for the total sample. It indicates that a significant correlation was found between the final course grade and the final exam grade ($\tau_b = 0.444$, $p = 0.0001$). Slight, but non significant, correlations were also found between the final grade and gender ($\tau_b = -0.263$, $p = 0.053$), the final grade and drafting experience ($\tau_b = 0.228$, $p = 0.093$), and the final grade and major ($\tau_b = 0.227$, $p = 0.096$). The negative value of the correlation between the final grade and gender was an indication that the females in the sample had lower course grades than the males.

Table 9

Correlation of Final Grade and Other Variables:

Total Sample (N=38)

Variables	Kendall's Tau	Probability
Final Grade and Pretest	0.110	0.366
Final Grade and Final Exam	0.444	0.0001
Final Grade and Major	0.227	0.096
Final Grade and Student Class	0.053	0.680
Final Grade and Drafting Exper.	0.228	0.093
Final Grade and Computer Exper.	0.068	0.600
Final Grade and GEFT	0.148	0.215
Final Grade and Gender	-0.263	0.053

For the females as a group (see Table 10), a fairly large, but non significant correlation was found between the final grade and prior drafting experience ($\tau_b = 0.546$, $p = 0.096$).

Table 10

Correlation of Final Grade and Other Variables:

Females Only (N=8)

Variables	Kendall's Tau	Probability
Final Grade and Pretest	0.157	0.622
Final Grade and Final Exam	0.143	0.621
Final Grade and Major	0.284	0.387
Final Grade and Student Class	-0.206	0.503
Final Grade and Drafting Exper.	0.546	0.096
Final Grade and Computer Exper.	-0.146	0.655
Final Grade and GEFT	0.322	0.288

When examining the males as a group (see Table 11), the final course grade was found to be significantly correlated with the final exam grade ($\tau_b = 0.416$, $p = 0.002$).

Table 11

Correlation of Final Grade and Other Variables:

Males Only (N=30)

Variables	Kendall's Tau	Probability
Final Grade and Pretest	0.187	0.175
Final Grade and Final Exam	0.416	0.002
Final Grade and Major	0.250	0.105
Final Grade and Student Class	0.168	0.247
Final Grade and Drafting Exper.	0.100	0.517
Final Grade and Computer Exper.	0.011	0.939
Final Grade and GEFT	0.171	0.209

Prior Computer Experience

The questionnaire given to the subjects at the beginning of the semester asked them to rank their previous computer experience under one of the following categories: none (1), some experience (2), fairly experienced (3), or very experienced (4). Subject responses to this question ranged from some experience (2) to very experienced (4). The mean of the prior computer experience scores for the total sample was 2.92 (SD = 0.78). The females as a group reported a lower level of prior computer experience than the males (See Table 12). Their mean was 2.36 (SD = 0.51), and the males' was 3.06 (SD = 0.78).

Table 12

Frequency of Computer Experience (N=38)

Level of Experience	Females Freq.	Males Freq.	Total Freq.
None (1)	0	0	0
Some (2)	5	8	13
Fairly Experienced (3)	3	12	15
Very Experienced (4)	0	10	10

An examination of the means for computer experience by student classification revealed that sophomores reported the highest level of computer experience and seniors the lowest. The mean for each student classification was: freshmen = 2.75, sophomores = 3.15, juniors = 2.86, and seniors = 2.33. When examining computer experience by major, the engineering students as a group reported they had more experience. The mean for engineering majors was 3.11 (SD = 0.68), and the mean for non-engineering majors was 2.75 (SD = 0.85).

Table 13 summarizes the correlations between prior computer experience and other variables for the total sample. The analysis of the data found a significant correlation between prior computer experience and gender (τ_b = -0.344, p = 0.027). The negative value for this correlation was due to the females' lower level of reported computer experience when compared to the males.

Table 13

Correlation of Computer Experience and Other Variables:

Total Sample (N=38)

Variables	Kendall's Tau	Probability
Computer Exper. and Pretest	0.084	0.544
Computer Exper. and Final Exam	0.060	0.647
Computer Exper. and Major	0.230	0.139
Computer Exper. and Student Class	-0.217	0.134
Computer Exper. and GEFT	0.041	0.764
Computer Exper. and Gender	-0.344	0.027

Table 14 summarizes the correlations between prior computer experience and other variables for the females in the sample. Six females indicated that they had some experience with computers and two that they were fairly experienced. The analysis of the data found a fairly large correlation between their prior computer experience and pretest scores (τ_b = -0.430, p = 0.242); however, the p-value of this correlation was fairly large. Except for the two females who had scores of seven and eight, all of the females in the sample scored six on the pretest. The females who scored higher than six also reported that they only had some experience with computers, which accounted for the negative sign on the correlation between prior computer experience and the pretest score.

Table 14

Correlation of Computer Experience and Other Variables:

Females Only (N=8)

Variables	Kendall's Tau	Probability
Computer Exper. and Pretest	-0.430	0.242
Computer Exper. and Final Exam	-0.049	0.882
Computer Exper. and Major	0.258	0.495
Computer Exper. and Student Class	0.113	0.749
Computer Exper. and GEFT	0.165	0.634

The correlations between prior computer experience and other variables for the males in the sample are summarized in Table 15. It indicates that slight but non significant correlations were found in the analysis of the data between their prior computer experience and the variables of major (τ_b = 0.241, p = 0.170), student classification (τ_b = -0.303, p = 0.065), and pretest score (τ_b = 0.202, p = 0.197).

Table 15

Correlation of Computer Experience and Other Variables: Males Only (N=30)

Variables	Kendall's Tau	Probability
Computer Exper. and Pretest	0.202	0.197
Computer Exper. and Final Exam	-0.068	0.646
Computer Exper. and Major	0.241	0.170
Computer Exper. and Student Class	-0.303	0.065
Computer Exper. and GEFT	0.093	0.547

Prior Drafting Experience

When the subjects were asked if they had prior drafting experience on the research questionnaire, the responses indicated that exactly 50%, 17 males and two females, had. Table 16 provides a summary of the correlations between prior drafting experience and other variables for the total sample. It shows that slight, but non significant, correlations existed between the students' prior drafting experience and the variables of gender (τ_b = -0.258, p = 0.116), final exam grade with the posttest removed (τ_b = 0.237, p = 0.087), the Group Embedded Figures Test scores (τ_b = 0.232, p = 0.107), and the final exam grades (τ_b = 0.225, p = 0.102). The negative correlation between prior drafting experience and gender was an indication that a larger percentage of males, compared to the females, had prior experience.

Table 16

Correlation of Drafting Experience and Other Variables:

Total Sample (N=38)

Variables	Kendall's Tau	Probability
Drafting Exper. and Pretest	0.134	0.362
Drafting Exper. and Final Exam	0.225	0.102
Drafting Exper. and Final Exam Minus Posttest	0.237	0.087
Drafting Exper. and Major	0.000	1.000
Drafting Exper. and Student Class	-0.152	0.324
Drafting Exper. and GEFT	0.232	0.107
Drafting Exper. and Gender	-0.258	0.116

Table 17 summarizes the correlations between prior drafting experience and other variables for the females in the study. The largest correlations were between prior drafting experience and major ($\tau_b = 0.577$, $p = 0.127$) and between prior drafting experience and the Group Embedded Figures Test scores ($\tau_b = 0.492$, $p = 0.155$), but these correlations were not significant.

Table 17

Correlation of Drafting Experience and Other Variables:

Females Only (N=8)

Variables	Kendall's Tau	Probability
Drafting Exper. and Pretest	0.240	0.513
Drafting Exper. and Final Exam	0.109	0.739
Drafting Exper. and Final Exam Minus Posttest	0.000	1.000
Drafting Exper. and Major	0.577	0.127
Drafting Exper. and GEFT	0.492	0.155

When the same data for males were examined (see Table 18), the largest correlation found was between prior drafting experience and the Group Embedded Figures Test score ($\tau_b = 0.219$, $p = 0.180$); this correlation and was not significant.

Table 18

Correlation of Drafting Experience and Other Variables:

Males Only (N=30)

Variables	Kendall's Tau	Probability
Drafting Exper. and Pretest	0.184	0.266
Drafting Exper. and Final Exam	0.164	0.295
Drafting Exper. and Exam Minus Posttest	0.198	0.208
Drafting Exper. and Major	-0.126	0.498
Drafting Exper. and GEFT	0.219	0.180

Group Embedded Figures Test Scores (GEFT)

The students' scores on the Group Embedded Figures Test ranged from two to 18, with a mean of 14.65 (SD = 4.04) and a median of 15.5. The interquartile range was from 13.75 to 17.25; the sample distribution was skewed to the left (see Figure 2). The mean of the males' GEFT scores was 14.53 (SD = 4.17), and the mean of the females' scores was 15.125 (SD = 3.75).

As seen in Figure 2, the stem and leaf diagram of the distribution of the GEFT scores, the majority of the students' scores ranged from 12 to 18, and the mode was 18. Using Dyer's (1995) classification system, which added a field-neutral category to Witkins' field-dependent and field-independent construct, the sample contained four field-dependent students (three males and one female), zero field neutral students, and 34 field-independent students.

Stem	Leaf	Count
18	000000000	9
17	00000000	8
16	00	2
15	000000	6
14	0000	4
13	000	3
12	00	2
11		
10		
9		
8	0	1
7		
6		
5	0	1
4		
3	0	1
2	0	1

Figure 2. Stem and leaf diagram of the score distribution for the Group Embedded Figures Test.

Table 19, which provides a summary of the correlations between the Group Embedded Figures Tests scores and other variables for the total sample, shows that the GEFT scores were correlated with the final exam grades ($\tau_b = 0.299$, $p = 0.013$) and the final exam grade with the posttest scores removed ($\tau_b = 0.367$, $p = 0.003$). A scatter plot of the GEFT scores and exam grades with the posttest removed shows a slight linear pattern, although the points are widely dispersed around the line (see Figure 3).

Table 19

Correlation of Group Embedded Figure Test Score and Other Variables:

Total Sample (N=38)

Variables	Kendall's Tau	Probability
GEFT and Pretest	0.138	0.282
GEFT and Final Exam	0.299	0.013
GEFT and Exam Minus Posttest	0.367	0.003
GEFT and Major	0.138	0.335
GEFT and Gender	0.094	0.513

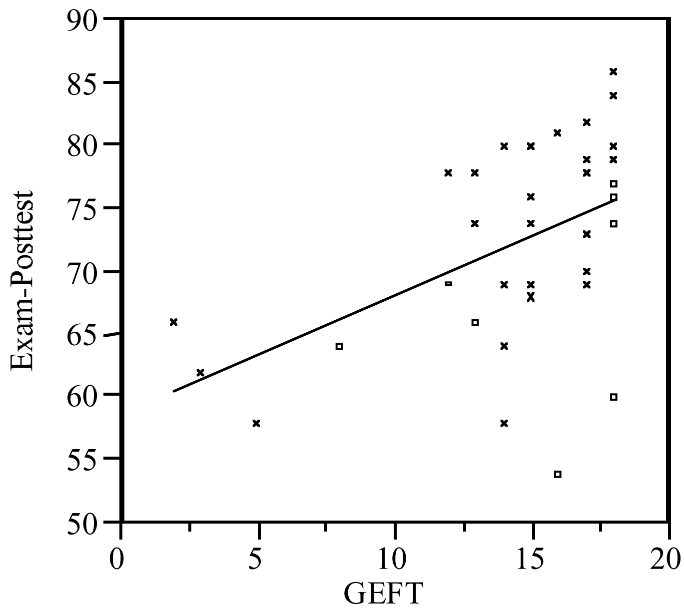

Figure 3. Scatter plot of the relationship between GEFT score and exam grade with the posttest score removed (N=38)

Table 20 summarizes the correlations between the females' Group Embedded Test Figure Scores and the variables of pretest score, final exam grade, final exam grade with the posttest score removed, and major. Fairly large, but non significant, correlations were found between their GEFT scores and pretest scores ($\tau_b = 0.473$, $p = 0.161$) and between their GEFT scores and major (engineering or non-engineering) with a τ_b of 0.586 ($p = 0.091$).

Table 20

Correlation of Group Embedded Figure Test Score and Other Variables: Females Only (N=8)

Variables	Kendall's Tau	Probability
GEFT and Pretest	0.473	0.161
GEFT and Final Exam	0.242	0.425
GEFT and Exam Minus Posttest	0.322	0.288
GEFT and Major	0.586	0.091

Table 21 summarizes the relationship of the Group Embedded Figures Test scores and the same variables for the males. The two significant relationships found when analyzing the data were between the GEFT scores and the final exam grades (τ_b = 0.407, p = .003) and between the GEFT scores and the exam grades with the posttest scores removed (τ_b = 0.447, p = 0.001).

Table 21

Correlation of Group Embedded Figure Test Score and Other Variables: Males Only (N=30)

Variables	Kendall's Tau	Probability
GEFT and Pretest	0.095	0.514
GEFT and Final Exam	0.407	0.003
GEFT and Exam Minus Posttest	0.447	0.001
GEFT and Major	-0.024	0.882

Pretest Scores

The pretest, to test the students' prior knowledge of AutoCAD, was given to students before they received instruction in AutoCAD. Students could score a total of ten points on this test. The students' scores on the test ranged from three to nine with a mean of 5.94 (SD = 1.48). The mean on this test for the females was 6.37 (SD = 0.74), and the mean for the males was 5.8 (SD = 1.62).

Gender

Table 22 summarizes the correlations between gender and other variables for the total sample. The analysis of the data revealed slight but significant relationships between gender and the variables of final exam grade (τ_b = -0.330, p = 0.016) and the final exam grades with the posttest score removed (τ_b = -0.298, p = 0.031). Their negative values indicate that the females received lower grades than the males on both the exam and the exam with the posttest score removed.

Table 22

Correlations Between Gender and Other Variables:

Total Sample (N=38)

Variables	Kendall's Tau	Probability
Gender and Pretest	0.153	0.296
Gender and Final Exam	-0.330	0.016
Gender and Exam Minus Posttest	-0.298	0.031
Gender and Major	0.027	0.869

Student Classification

Table 23 indicates that no significant correlations were found between the variable of student classification and the variables of pretest score, final exam grade, and the final exam grade with the posttest score removed.

Table 23

Correlations Between Student Classification and Other Variables:

Total Sample (N=38)

Variables	Kendall's Tau	Probability
Student Class and Pretest	-0.039	0.778
Student Class and Final Exam	-0.050	0.700
Student Class and Exam Minus Posttest	-0.020	0.880

Final Exam Grades with the Posttest Score Removed

For the total sample, no significant correlations were found between the exam grade with the posttest score removed and the variables of pretest score and student major (see Table 24).

Table 24

Correlations Between the Exam Grade Minus the Posttest Score and Other Variables: Total Sample (N=38)

Variables	Kendall's Tau	Probability
Exam Minus Posttest and Pretest	-0.096	0.437
Exam Minus Posttest and Major	0.075	0.588

For the females (see Table 25), a moderately large correlation was found between the exam grade with the posttest score removed and the variable of pretest score (τ_b = 0.367, p = 0.250), but its p-value was well above statistical significance.

Table 25

Correlations Between the Exam Grade Minus the Posttest Score and Other Variables: Females Only (N=8)

Variables	Kendall's Tau	Probability
Exam Minus Posttest and Pretest	0.367	0.250
Exam Minus Posttest and Major	0.000	1.000

When examining males as a group, no significant correlations were found between the final exam grade with the posttest removed and the variables of pretest score and student major (see Table 26).

Table 26

Correlations Between the Exam Grade Minus the Posttest Score and Other Variables: Males Only (N=30)

Variables	Kendall's Tau	Probability
Exam Minus Posttest and Pretest	-0.111	0.429
Exam Minus Posttest and Major	0.082	0.602

Multiple Linear Regression Models

During the study, three models were created to look at student achievement, two for achievement in learning computer-aided drawing and one for achievement in learning the course content. For their dependent variables, Model 1 used the project grade, Model 2 used the posttest score, and Model 3 used the final course grade. In developing the multiple regression models, the information from the Kendall's Tau B analyses and backwards stepwise regressions were employed to identify the variables for the final models. Possible interactions between variables were also examined to see if the models could be improved, but no significant interactions were found. For the multiple linear regressions, two independent variables were modified, student classification and prior computer experience. The student classifications were combined into two categories of 1 (freshmen and sophomores) and 2 (juniors and seniors). The prior computer experience ratings were combined into two categories of 1 (some experience and fairly experienced) and 2 (very experienced). The category of none was eliminated since it was not selected by any of the subjects.

Project Model

The stepwise regression for the project model (Model 1) looked at the independent variables that might have had a relationship to the project grade. These variables included gender (1 - males, 2 - females), pretest score, major (1 - non-engineering, 2 - engineering), student classification (1 - freshmen and sophomores, 2 - juniors and seniors), Group Embedded Figures Test score, final exam grade, prior drafting experience (1 - no, 2 - yes), and posttest score. Table 27 summarizes the effect tests when all of these variables are placed in a model, and Table 28 summarizes this model's fit.

Table 27

Model 1 (Project Grade) - Effect Tests for Variables Considered for Use in the Model (N = 38)

Source	DF	Sum of Squares	F Ratio	Prob.>F
Gender	1	721.45255	9.3965	0.0047
Pretest	1	127.20990	1.6568	0.2082
Major	1	138.20198	1.8000	0.1901
Student Class	1	66.24045	0.8627	0.3606
GEFT	1	37.74374	0.4916	0.4888
Exam Grade	1	40.53211	0.5279	0.4733
Drafting Exper.	1	5.52459	0.0720	0.7904
Posttest	1	22.28923	0.2903	0.5941

Table 28

Model 1 (Project Grade) - Summary of Fit With Variables Before Stepwise Regression Procedure Performed (N = 38)

RSquare	0.367754
RSquare Adj.	0.193341
Root Mean Square Error	8.762355
Mean of Response	88.81579

Table 29 provides a history of the stepwise regression with the change in R^2 as these variables were removed from the model. The variables were removed from the model by starting with the variable that had the least significant correlation with the project grade, while controlling the others. Variables were removed until the independent variables that remained all had a p-value of 0.15 or less.

Table 29

Model 1 (Project Grade) - Stepwise History (N = 38)

Step	Parameter	Action	Sig. Prob.	Seq. SS	RSquare
1	Drafting Ex.	Removed	0.7904	5.524587	0.3662
2	Posttest	Removed	0.5438	28.05279	0.3582
3	Class	Removed	0.3330	70.51274	0.3382
4	GEFT	Removed	0.3389	68.63749	0.3187
5	Exam Grade	Removed	0.5325	28.92691	0.3105

Based on the stepwise regression, the independent variables used in the final version of Model 1 (project grade) were gender, pretest score, and major (engineering or non-engineering). Table 30 summarizes the final model's fit, Table 31 summarizes the model's parameter estimates, and Table 32 provides the model's Analysis of Variance.

Table 30

Model 1 (Project Grade) - Summary of Fit for Final Model (N = 38)

RSquare	0.310494
RSquare Adj.	0.249655
Root Mean Square Error	8.450969
Mean of Response	88.81579

Table 31

Model 1 (Project Grade) - Parameter Estimates for Final Model (N = 38)

Term	Estimate	Std Error	t Ratio	Prob.>|t|
Intercept	86.799942	7.434604	11.68	<.0001
Gender	-11.40167	3.401663	-3.35	0.0020
Pretest	1.6428794	0.949645	1.73	0.0927
Major	4.1033636	2.761346	1.49	0.1465

Table 32

Model 1 (Project Grade) -Analysis of Variance Test for Whole Model (N = 38)

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	1093.4690	364.490	5.1035
Error	34	2428.2416	71.419	Prob.>F
C Total	37	3521.7105		0.0050

The coefficient of multiple determination (R^2) for Model 1 was 0.310, which indicates the proportion of the variation in the project grades that can be explained by the predictive power of the independent variables of gender, pretest score, and major (engineering or non-engineering). The predictive power of this model was relatively good and the p-value for the final model's fit was 0.005, well below the p-value established for statistical significance in the study. The multiple linear regression formula for this model was:

Predicted Y = 86.80 - 11.40X_1 + 1.64X_2 + 4.10X_3 (X_1 = gender, X_2 = pretest score, X_3 = major)

An examination of the data for the partial correlations revealed that only gender had a statistically significant p-value. The independent variables of pretest score and major were not significant in the model, but had p-values below 0.15.

Posttest Model

Model 2 used the dependent variable of the posttest score. The stepwise regression examined the independent variables of pretest score, Group Embedded Figures Test score, prior drafting experience (1 - no, 2 - yes), exam grade with the posttest score removed, project grade, prior computer experience (1 - some experience and fairly experienced, 2 - very experienced), major (1 - non-engineering, 2 - engineering), student classification (1 - freshmen and sophomores, 2 - junior and seniors), and gender (1 - males, 2 - females). Table 33 summarizes the effect tests for these variables when they were all placed in the model, and Table 34 summarizes the fit for a model with all of these variables included.

Table 33

Model 2 (Posttest Score) - Effect Tests for Variables Considered for Use in the Model (N=38)

Parameter	DF	SS	F Ratio	Prob.>F
Pretest	1	11.045000	5.9421	0.0214
GEFT	1	6.090211	3.2765	0.0810
Drafting Exper.	1	1.590245	0.8555	0.3629
Exam Minus Post	1	4.378789	2.3557	0.1360
Project	1	0.630311	0.3391	0.5650
Computer Exper.	1	0.130827	0.0704	0.7927
Major	1	0.269103	0.1448	0.7065
Student Class	1	0.043113	0.0232	0.8800
Gender	1	0.001885	0.0010	0.9748

Table 34

Model 2 (Posttest Score) - Summary of Fit With Variables Before Stepwise Regression Procedure Performed (N = 38)

RSquare	0.243055
RSquare Adj.	-0.00025
Root Mean Square Error	1.363371
Mean of Response	7.631579

Table 35 provides the history of the stepwise regression and shows the change in R^2 as variables were removed from the model based on their effect test. Again, only independent variables with a p-value of 0.15 or less, with the other variable held constant, were left in the model.

Table 35

Model 2 (Posttest Score) - Stepwise History (N = 38)

Step	Parameter	Action	Sig. Prob.	Seq. SS	RSquare
1	Gender	Removed	0.9748	0.001885	0.2440
2	Student Class	Removed	0.8770	0.04373	0.2433
3	Computer Exper.	Removed	0.7359	0.201312	0.2404
4	Major	Removed	0.6809	0.290769	0.2362
5	Project	Removed	0.5028	0.754895	0.2252
6	Drafting Exper.	Removed	0.2761	1.982233	0.1964

Table 36 summarizes the final model's fit, Table 37 summarizes the model's parameters, and Table 38 provides the model's Analysis of Variance. The independent variables used in the final model were pretest score, GEFT score, and final exam grade with the posttest removed.

Table 36

Model 2 (Posttest Score) - Summary of Fit for Final Model (N = 38)

RSquare	0.196412
RSquare Adj.	0.125508
Root Mean Square Error	1.27557
Mean of Response	7.631579

Table 37

Model 2 (Posttest Score) - Parameter Estimates for Final Model (N = 38)

Term	Estimate	Std. Error	t Ratio	Prob.>|t|
Intercept	3.7741623	2.246502	1.68	0.1021
Pretest	0.3526768	0.145956	2.42	0.0212
GEFT	-0.126328	0.061523	-2.05	0.0478
Exam-Post	0.0496353	0.031129	1.59	0.1201

Table 38

Model 2 (Posttest Score) - Analysis of Variance Test for Whole Model (N = 38)

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	13.521437	4.50715	2.7701
Error	34	55.320668	1.62708	Prob.>F
C Total	37	68.842105		0.0565

The coefficient of multiple determination (R^2) for Model 2 was only 0.196, which is the portion of the variation in the posttest scores that can be explained by the predictive power of the pretest score, the Group Embedded Figures Test score, and the final exam grade with the posttest score removed. Model 2 did not have the same level of predictive power for the posttest score that Model 1 had for the project grade. The p-value for the model's fit was 0.056, slightly above the established level for statistical significance. The model obtained from the multiple regression analysis provided the following formula:

Predicted Y = 3.77 + $0.35X_1$ - $0.13X_2$ + $0.05X_3$ (X_1 = pretest score, X_2 = GEFT score, X_3 = exam minus posttest grade)

The table listing partial coefficients with other variables held constant (see Table 37) revealed that two independent variables, the pretest scores (p = 0.021) and the GEFT scores (p = 0.048), were statistically significant in this model, but the p-value of the exam grade minus the AutoCAD questions was not.

Final Course Grade Model

Model 3 used the final course grade as its dependent variable. The backwards stepwise regression for this model looked at the independent variables of pretest score, Group Embedded Figures Test score, prior drafting experience (1 - no, 2 - yes), prior computer experience (1 - some experience and fairly experienced, 2 - very experienced), major (1 - non-engineering, 2 - engineering), student classification (1 - freshmen and sophomores, 2 - junior and seniors), and gender (1 - males, 2 - females). Table 39 summarizes the effect tests for these variables when they were all placed in a model, and Table 40 summarizes this model's fit.

Table 39

Model 3 (Final Course Grade) - Effect Tests for Variables Considered for Use in the Model (N=38)

Source	DF	SS	F Ratio	Prob.>F
Gender	1	127.19406	3.2655	0.0808
GEFT	1	73.99928	1.8998	0.1783
Class	1	57.13222	1.4668	0.2353
Major	1	52.80922	1.3558	0.2534
Pretest	1	10.44804	0.2682	0.6083
Drafting Ex.	1	19.27002	0.4947	0.4873
Computer Ex.	1	11.46953	0.2945	0.5914

Table 40

Model 3 (Final Course Grade) - Summary of Fit With Variables Before Stepwise Regression Procedure Performed (N = 38)

RSquare	0.354762
RSquare Adj.	0.229877
Root Mean Square Error	4.699878
Mean of Response	71.27132

Table 41 provides the stepwise regression history showing the change in R^2 as variables were removed from the model.

Table 41

Model 3 (Final Course Grade) - Stepwise History

Step	Parameter	Action	Sig. Prob.	Seq. SS	RSquare
1	Pretest Score	Removed	0.6083	10.44804	0.2646
1	Computer Ex.	Removed	0.5726	12.36635	0.2568
2	Drafting Ex.	Removed	0.4392	22.84779	0.2426
3	Major	Removed	0.2479	50.91529	0.2108

After completing the stepwise regression, the three variables left in the final model were gender, the Group Embedded Figures Test score, and student classification. Table 42 provides the summary of the fit for Model 3, Table 43 the model's parameter estimates, and Table 44 the model's Analysis of Variance.

Table 42

Model 3 (Final Course Grade) - Summary of Fit for Final Model (N = 38)

RSquare	0.210826
RSquare Adj.	0.141193
Root Mean Square Error	6.099915
Mean of Response	84.79184

Table 43

Model 3 (Final Course Grade) - Parameter Estimates for Final Model (N = 38)

Term	Estimate	Std. Error	t Ratio	Prob.>|t|
Intercept	79.482384	5.565844	14.28	<.0001
Gender	-4.739248	2.432044	-1.95	0.0596
GEFT	0.4276866	0.248455	1.72	0.0943
Class	3.4253462	2.027521	1.69	0.1003

Table 44

Model 3 (Final Course Grade) - Analysis of Variance Test for Whole Model (N = 38)

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	337.9705	112.657	3.0277
Error	34	1265.1048	37.209	Prob.>F
C Total	37	1603.0754		0.0427

The R^2 for Model 3 was 0.211, which meant that the independent variables explained approximately 21 percent of the variability in the final course grade. The multiple linear regression formula for the final model was:

Predicted $Y = 79.48 - 4.74X_1 + 0.43X_2 + 3.43X_3$, ($X_1$ = gender, X_2 = GEFT score, and X_3 = student classification).

Table 43, listing partial coefficients with other variables held constant, reveals that none of the independent variables was statistically significant in this model. The p-value for gender, however, was only slightly above .05 ($p = 0.059$). The Group Embedded Figures Test scores ($p = 0.094$) and student classification ($p = 0.100$) had p-values that were higher, but still small enough to be included in the model.

Summary

The analysis of the data in this study found that the majority of the students were field independent, half of them had previous drafting experience, and the number of engineering and non-engineering students were almost equal. The study also found a number of significant correlations between variables, but the only strong correlation was between prior drafting experience and project grade for the females. The final multiple linear regression model for the project grade (Model 1) contained the variables of gender, pretest score, and major. The model for the posttest (Model 2) included the independent variables of pretest score, Group Embedded Figures Test score, and the final exam grade with the posttest score removed. The model for the final course grade (Model 3) included the independent variables of gender, the Group Embedded Figures Test score, and student classification.

Chapter 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

For the Graphic Communications Program at N. C. State and other programs like it that teach computer-aided drawing as part of their introductory classes, information is needed so that appropriate teaching methods can be created to instruct students in the use of computer-aided drawing (CAD) programs and course content. This research has attempted to answer some questions related to the factors affecting students' achievement in these areas. The results of the study provided some answers, but it also raised new questions and indicated new directions for research. This chapter will discuss the results of the study, speculate on the possible causes of the results, attempt to draw some conclusions, and make several recommendations.

The Study Research Questions

In order to review the findings of the study, the research questions will be discussed one at a time.

Research Question #1 — What pattern of learning styles exist for students who enroll in introductory engineering graphics classes?

Based on Dyer's (1995) classification system, the majority of the students in the study sample were field-independent. Thirty-four out of the 38 subjects had scores in the upper half of the possible scores for the Group Embedded Figures Test (GEFT) and would be classified as field-independent by Witkins' cognitive style construct (Witkins et al., 1971; Witkins et al., 1977). The fact that the majority of the students participating in the study were in engineering programs, or programs that were technical in nature, could explain the distribution of the GEFT scores. According to Witkins et al. (1977), students tend to select majors that are appropriate to their cognitive styles.

Research Question #2 — Is there any relationship between a student's learning style and his or her achievement in learning computer-aided drawing programs in classes of introductory engineering graphics?

The analysis of the data indicated that no relationship seemed to exist between learning style and learning computer-aided drawing. When the Kendall's Tau B analyses were performed, no significant correlations were found between the students' Group Embedded Figures Test scores and either of the two measures of achievement in AutoCAD.

Research Question #3 — Is there a relationship between a student's prior computer experience and his or her achievement in learning computer-aided drawing in classes of introductory engineering graphics?

The analysis of the data for the total sample, the females, and the males found no evidence of a relationship between prior computer experience and achievement in learning computer-aided drawing.

Research Question #4 — Is there any relationship between a student's major and his or her achievement in learning computer-aided drawing programs in classes of introductory engineering graphics?

For the total sample, a relationship between student major and computer-aided drawing was not found for either measure of CAD achievement. Likewise, relationships between these variables were not found for the males in the sample. However, analysis of the data for the females revealed a possible relationship between their majors and project grades, but not between their majors and posttest scores. Although the p-value for this correlation was slightly above the statistically significant level set for the study of <.05 and the number of females in the study was limited, this is a relationship that should be examined further.

Research Question #5 — Is there a relationship between a student's gender and his or her achievement in learning computer-aided drawing programs in classes of introductory engineering graphics?

There seemed to be a slight relationship between gender and project grades, but not between gender and posttest scores. A slight negative correlation was found for these variables that indicated that the females' project grades were lower than the males'. Likewise, the multiple linear regression model that used the project grade as its dependent variable found gender had a significant effect on the prediction of the project grade.

Research Question # 6 — Is there a difference in prior computer experience based on a student's major in classes of introductory engineering graphics?

On the self-reported rating system for computer experience, students could rate their experience level as one of the following: none (1), some experience (2), fairly experienced (3), or very experienced (4). The analysis of the data indicated that engineering students had slightly more prior computer experience than the non-engineering students in the sample.

Research Question #7 — Is there a difference in the prior computer experience of individuals based on their gender in classes of introductory engineering graphics?

A slight difference in prior computer experience between the genders was found in the analysis of the data. The Kendall's Tau B analysis found a statistically significant negative correlation between these variables, which indicated that the females reported a lower level of computer experience than the males.

Research Question #8 — Is there a difference in the learning styles of students in different majors among students enrolled in introductory engineering/technical graphics courses?

Analysis of the data did not find a relationship between learning styles and major (engineering or non-engineering) for the total sample or for the males. However, a relationship was found between these variables for females. Although its p-value was slightly above .05, it is a relationship that should be examined closer.

Research Question #9 — What percentage of students entering introductory engineering/technical graphics classes at N. C. State have prior drafting experience?

Analysis of the data on prior drafting experience found that exactly half of the students in the sample had prior experience before enrolling in the GC 120 course. This was a much higher than anticipated. The data also indicated that a larger proportion of the males, when compared to the females, had previous drafting experience.

Research Question #10 — Does previous drafting experience have any relationship to a student's achievement in learning CAD in classes of introductory engineering graphics?

For the total sample and the males, a relationship was not found between either of the measures of achievement in computer-aided drawing and prior drafting experience. For the females, a relationship was also not found between the posttest scores and prior drafting experience, but one was found between the project grades and prior drafting experience. This correlation coefficient was the strongest statistically significant correlation observed during the study.

Research Question #11 — Does previous drafting experience have any relationship to a student's achievement in learning course content in classes of introductory engineering graphics?

For the total sample, only a slight relationship was found in the data between prior drafting experience and achievement in learning course content as measured by the final course grade.

Research Question #12 — Is there a relationship between a student's gender and his or her achievement in learning course content in classes of introductory engineering graphics?

A slight relationship was found between gender and achievement in learning the course content that indicated the final grades of the females in the sample were lower than those of the males.

Research Question #13 — Is there a relationship between a student's learning style and his or her achievement in learning course content in classes of introductory engineering graphics?

No relationship between learning style and the final course grade was found from the analysis of the data. However, slight relationships for the whole sample, males, and females were found between learning style and the variables of final exam grade and final exam grade with the posttest score removed. This suggests that there actually may be a connection between learning style and achievement in learning the overall course content.

The Multiple Linear Regression Models

The multiple linear regression models were included in the study to see if student achievement in learning computer-aided drawing and the course content could be predicted by factors investigated in the study. Models with good predictive abilities can indicate which students are more likely to have difficulty in certain areas of the course content.

Models 1 and 2 both examined CAD achievement, but each model looked at different types of computer-aided drawing (CAD) skills. The project measured students' ability to use the CAD software and the posttest measured the students' ability to learn the names and functions of the program's features. Model 1, for the project grade, included the independent variables of gender, pretest score, and major. These variables explained approximately 31 % of the variability in the project score, and the whole model's ANOVA test was statistically significant. Model 2 for the posttest grade included the variables of pretest scores, Group Embedded Figures Test scores, and final exam grades with the posttest score removed. This model only explained approximately 19 % of the variability in the posttest grade, and the ANOVA test for the whole model had a p-value slightly above .05.

Of the two models that examined achievement in learning computer-aided drawing, the project grade model (Model 1) has the greatest potential for use as a predictive tool. The independent variables in this model can be assessed at the early stages of a course and allow instructors to identify students who may have potential difficulty learning CAD. The three independent variables in the posttest model (Model 2) only include two that can be assessed at the beginning of a course. As a measure of CAD achievement, the posttest is not as valuable as the project. However, Model 2 provides an interesting insight into the relationship between certain variables. Since the posttest was primarily a measure of rote knowledge, the fact that the final exam with the posttest score removed was an independent variable in this model illustrates that the students who performed well on both of these measures probably were able to memorize information easily.

It is interesting that both Model 1 and 2 included the pretest score as an independent variable. This probably indicated that some students had prior experience with the AutoCAD program or a program similar to it. This would have provided these students with some advantage in learning CAD in the GC 120 course. It is also worthy of note that gender played a role in the formula for predicting the project grade, but not the posttest score. This could be due to the different aspects of CAD achievement that these two models measured.

The third model, for the final grade, included the independent variables of gender, Group Embedded Figures Test score, and student classification. These variables can be assessed at the beginning of the course. Although it only explained 21 % of the final grade, the model could be used to identify students who might have difficulty learning the course content.

This model again contained the independent variable of gender and demonstrates the difficulty that the females as a group had with the course work when compared to the males. Learning style also is a variable in this model and Model 1, which further indicates that learning style may have some effect on student achievement in the course.

Discussion

The study results both support and fail to support the modified theoretical learning model used by Garton, Spain, Lamberson, and Spiers (1999). Although learning style affected student achievement in learning computer-aided drawing and course content, other characteristics failed to demonstrate an effect. For instance, learning style seemed to have had an effect on student achievement in learning the course content as measured by the final exam, but their prior knowledge of drafting and computers did not.

When examining the findings of the study, there are some things of note, but only one strong relationship was found. When the Kendall's Tau B correlations were performed, most of the larger correlations found were related to the females or gender, but many of these had p-values that were slightly above statistical significance due to the number of females in the study. With only eight females out of 38 subjects, it is inappropriate to draw any real conclusions from these correlations. The data suggest that females may have a lower level of prior drafting experience than males before entering introductory engineering/technical graphics classes at N. C. State. The data suggest that females have less computer experience than males in these classes. The data suggest that females do not do as well as males on the final project. The data suggest that all three of these could be connected in some fashion. The data on females is intriguing, but the sample size is too small to draw conclusions, although the results point to areas for additional research.

The data also indicated that there was not a difference in the posttest scores for males and females. This is of interest since the posttest and the project measure different computer-aided drawing skills. The final project required a deeper understanding of the CAD program for successful completion. It tested students' ability to use the CAD software, work in three-dimensional space, and apply appropriate strategies in completing a working drawing. The posttest simply measured students' recall of the names of the AutoCAD commands, their functions, and program features.

The large difference in the males' and females' project grade means was not anticipated by the researcher. Unfortunately, the lower project grade mean for the females could be due to one or a combination of factors examined in the study. These include a poorer understanding of the computer-aided drawing program, a lower level of previous drafting experience, or a lower level of previous computer experience. It is also possible that other factors, not examined in this study, may have caused or contributed to the difference. For instance, females typically have lower visualization skills, which could have affected the project grade.

In traditional engineering/technical graphics, working drawings like the final projects were created as two-dimensional, line-drawn multiviews. This type of drawing requires a high degree of visualization skill to produce. Previous research indicates that college-age males typically have stronger visualization skills than females (Kalichman, 1988; Nordvik & Amponsah, 1998; Parolini, 1994), which gives males an edge when creating multiviews. A multiview drawing requires an individual to create views of the object as if the object's sides are projected onto the surfaces of a glass box that surrounds it. The challenge for the individual creating a traditional multiview drawing is that the object must be seen in the "mind's eye" as projections before it can be drawn. In this form of drawing, visualization of complex surface intersections and hidden features are difficult for individuals with low visualization skills.

Some researchers believe that the difference in the visualization skills of males and females may be due to the differences in their experiences as they are growing up (Fennema & Sherman, 1977). Support for this theory comes from the fact that males and females have about the same level of visualization skill as young children, but that the visualization skills of females tend to be lower than males when they reach their teens. In a study by Deno (1995), he found that a difference existed in the patterns of experiences between males and females in college engineering graphics classes. He also found a correlation between the types of experiences students had growing up and their scores on spatial visualization tests.

In introductory engineering/technical graphics courses at N. C. State, students no longer construct final projects as two-dimensional, line-drawn multiviews. They construct the projects as three-dimensional computer models, and the CAD program extracts the multiviews from the models. Unlike two-dimensional, line-drawn multiviews, models resemble "real" objects when viewed by students on the computer screen. Solid models are constructed by using Boolean operations to combine or subtract simple objects (boxes, cylinders, etc.) and/or extrusions of two-dimensional shapes to form a more complex object. The construction of a computer model is reminiscent of building an object from solid materials. Experience with students since the projects have been constructed as models seemed to indicate that students found model construction far easier than traditional multiviews. It also seemed that that students did not need strong visualization skills in order to create them (Crittenden, 1999). The females' lower project grades could indicate that their CAD achievement was lower than males', but it could also indicate that their lower visualization skills were still a handicap even when they created models. A possible explanation for this could be related to the type of experiences that females and males have in childhood. Experiences assembling and disassembling objects probably aid in building computer graphics models, and there is some evidence that females do not have as much experience as males doing this (Deno, 1995).

Other factors that could have accounted for, or contributed to, the differences in the mean of the project grades for males and females were the females' lower levels of computer and drafting experience. The females in the sample reported that they had less computer experience than males, and only two of the eight females had prior drafting experience before enrolling in the class. Some correlations were found between these variables and the females' project grades. The correlation coefficient between prior drafting experience and project grade for the females was the strongest one found in the data analyses. It would seem to be the best explanation for this difference; however, there is a difficulty in accepting either the prior drafting experience or the prior computer experience as an explanation for the females' lower project grades. This difficulty arises because these same associations were not found in the males. It would seem unlikely that a lower level of prior computer and drafting experience would have an effect on the project grades of the females and not on the project grades of the males.

The students' ratings of their previous computer experience may actually reflect the students' confidence in their ability to use computers rather than the level of their experiences since the computer experience score was based on a self-reported rating. If the data on computer experience are considered separately, there is a noticeably lower prior computer experience mean for the eight females than the 30 males in the sample. Although the literature indicated that females usually have less computer experience than males, females in the sample were majoring in technical and engineering programs and listed similar computer activities and backgrounds as the males on the research questionnaire they completed at the beginning of the study. Their enrollment in these programs meant that they were from a select group, and their characteristics were expected to differ from the general female population. Levine and Donitas-Schmidt (1997) cited a study by Busch, conducted in 1995, in which he concluded that the only difference between males and females is their self-confidence and interest in computers. A number of studies have indicated that because females tend to view computers as primarily a male domain they are less confident in their computer abilities when compared to males (Arch & Cummins, 1989; Chen, 1986; Francis, 1994; Ogletree & Williams, 1990; Shashaani, 1993; Shashaani, 1997; Voogt, 1987). In two studies, however, lower confidence and experience did not impact on females' achievement in learning to use computers. Although they had less experience and confidence in their ability to use computers than their male counterparts, Gattiker (1990) and Shashaani (1997) found in their studies that the females performed better than the males in computer training courses.

It should be stated that caution must be taken in reaching conclusions based on the results of the correlations conducted using Kendall's Tau B in this study. When large numbers of correlations are computed between variables, approximately five percent of them will be found to be significant due to type I errors when the α is set at .05 (Agresti & Finley, 1986). Although the analysis finds significance, no association may actually exist. With the number of variables correlated in this study, this could explain some of the correlations that were found. Only by continuing to examine the relationship of these variables can it be determined if these correlations really exist.

A number of relationships that were not related to the research questions were explored during the analysis of the data. One of these was the relationship of learning styles and final exam grades. In analyzing the data on the males, a correlation was observed between the students' final exam grades and their GEFT scores. Since three of the four subjects who scored at eight or below on the GEFT were male, it is not surprising that the correlation was strongest when the data on the males were analyzed separately. However, slight correlations were also observed in the data for the whole sample and females. Even stronger correlations for the whole sample, the males, and the females were found when the GEFT scores were correlated with the final exam after the posttest score was removed. These findings suggest a connection could exist between students' achievement on the technical graphics content of the course and the students' cognitive styles as measured by the Group Embedded Figures Test. These findings support the findings of Guster (1986), who found a relationship between GEFT scores and achievement for males in drafting classes in a high school. A larger sample size might shed light on this relationship. If it exists, it could provide engineering graphics instructors with a tool to identify students who might have difficulty learning technical graphics concepts and content.

Another observation made during the analysis of the data was that the Group Embedded Figures Test scores of females and males in the sample did not differ. This agrees with research that indicates the proportion of males and females who are field-dependent and field-independent are essentially equal (Haaken, 1988; Cooperman, 1980). However, since the subjects used in the study were predominately from engineering and technical programs, they do not represent the general population, and the number of females in the sample was quite small. Therefore, this observation is merely interesting, but not very meaningful.

Although females and males are about equally distributed in their cognitive styles, there is some evidence that the subset of GEFT problems solved correctly by males and females differs. In a study conducted by Loo (1982), he compared students' scores on the GEFT for 173 females and 93 males between the ages of 18 and 24. Using cluster analysis, Loo examined the problems solved by females and males. His analysis found a difference in the problem subsets most often solved by each gender. He suggested that this difference might be due to a difference in the strategies employed by females and males to solve the problems.

Recommendations

Recommendations for Further Study

One of the greatest benefits of this study is that it points to a number of areas that should be researched further. A need still exists to conduct a more comprehensive study that answers questions related to student achievement in learning computer-aided drawing and course content at N. C. State; therefore, this study should be repeated with a larger sample size and with some changes in the procedures and instruments. A larger sample size could validate and shed additional light on the findings that were observed in this limited study. Likewise, an increase in the number of questions on the pretest and posttest could provide a better measure of students' knowledge of AutoCAD commands and procedures.

Still further studies should be made on the possible link between learning style and the students' achievement in the engineering graphics classes. If this association was substantiated, it could become a diagnostic tool to identify students who might have difficulty in grasping the concepts in the class. It also would allow the course instructors to more closely examine the characteristics of students who struggle with the content of the course. They could then make instructional modifications that accommodate these students.

Another area that warrants further investigation relates to the type of errors students make on the final projects. An analysis of these errors would provide information that could be used in eliminating instructional shortcomings and determining if the difficulties students have with the projects relate mostly to the CAD program or to the concepts in engineering graphics.

An examination of the characteristics of females enrolled in introductory classes in the Graphic Communications courses is particularly warranted. It is still not known whether the difference in the means for the reported levels of computer experience of the females and males was due to an actual difference in experience or a difference in confidence. Answering this question could shed light on why more females seem to have greater difficulty in the practical aspects of using the CAD program to create the project and less difficulty correctly answering the posttest questions.

Although a large number of research studies have been conducted on gender and spatial ability, the change from constructing engineering drawings in two-dimensions to modeling them in three-dimensions requires a reexamination of visualization and gender issues. Whether females, when they are compared to males, are still handicapped by their lower visualization skills when they create solid models is a question that needs answering. Since the field of engineering graphics is moving towards solid modeling as a standard, it is an important issue. Related research that examines the relationship of experiences assembling and disassembling objects to an individual's ability to model objects using computers might shed further light on this question. If a relationship exists between these, then interventions could be designed to improve a student's ability to construct computer models.

Recommendation for Practice

Based on this research study, several recommendations can be made for instructors in the field of engineering/technical graphics at the higher education level. The first recommendation relates to females and computer use. Research indicates that females have less experience or less confidence in their ability to use computers when learning computer-aided drawing programs. Research also indicates that increased use of computers affects an individual's confidence in using them (Shashaani, 1997). Therefore, additional computer exercises may be needed to provide females with increased opportunities to interact with computers and software. These experiences should be designed to provide females with additional practice in creating solid models, in improving their visualization skills, and in functioning in three-dimensional computer space.

The second recommendation relates to students' learning styles. Although students who enroll in introductory classes are predominately field-independent, this study indicated that field-dependent students who enroll in the classes do not achieve as well as their field-independent classmates. More attention should be paid to identifying these students, understanding their needs, and designing instruction that is appropriate for these learners.

The last recommendation is that instructors need to help students develop an understanding of the strategies that are needed to create solid three-dimensional models in computer-aided drawing software. Knowledge of the names and functions of the commands are not enough to ensure that a student can use the software to create a model successfully. As the shift towards parametric modeling programs occur in industry and education, students' understanding of modeling strategies will become increasing important.

Summary

The relative newness of large-scale instruction in computer-aided drawing as part of introductory engineering/technical graphics courses has not provided time to study the effect of instructional practices on achievement in these courses. This study has provided information that can be applied to designing other investigations in this area and sheds some light on issues that are of interest to instructors in the field. In particular, it demonstrated that females, more than males, seem to have more difficulty learning computer-aided drawing as measured by the final project in this study. Why the females had more difficulty with the project needs further examination. The study also indicated that the majority of students enrolled in GC 120, Foundations of Graphics, have a similar learning style, but that field-dependent students seemed to have had more difficulty than field-independent students in learning the technical graphics course content. Because of the small number of females and field-dependent students in the sample, these findings cannot be considered conclusive, but they do point to a need for research with a larger sample size. As a descriptive study, this research provided some information that had not been previously known, but its major benefit will be that it points to new avenues to study.

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APPENDICES

APPENDIX - A
CONSENT FORM

NORTH CAROLINA STATE UNIVERSITY
INFORMED CONSENT FORM

TITLE OF STUDY: An Investigation into the relationship of learning styles, university major and achievement in learning computer aided drawing in introductory Graphic Communications classes.

PRINCIPLE INVESTIGATOR: Alice Y. Scales

You are invited to participate in a research study. The purpose of this study is to examine the relationship of student learning styles and instruction in computer aided drawing software. Research in this area will allow instructors who teach this type of software to better plan instructional actives that provide for every learning style.

THE RESEARCH WILL BE CONDUCTED IN THREE STAGES:

1. Approximately two weeks after the beginning of the Spring 1999 Semester, students who agree to participate in the study will be given a learning styles test called the Group Embedded Figures Test and a short pretest to determine the level of their prior experiences with computer aided drawing. The learning styles test and pretest combined will only take approximately 20 minutes of the students time.

2. Participants will then continue in their introductory engineering graphics class as normal.

3. At the end of the semester, the project score and the score on the final exam that relate to computer aided instruction will be given to the researcher by the participant's introductory graphics class instructor, and these scores will be analyzed by learning style and student major.

CONFIDENTIALITY:

The information in the study records will be kept strictly confidential. Data will be stored securely and will be made available only to persons conducting the study unless you specifically give permission in writing to do otherwise. No reference will be made in oral or written reports which could link you to the study.

CONTACT:

If you have questions at any time about the study or the procedure, you may contact the researcher, Alice Y. Scales, at 510 N Poe Hall (Box 7801 NCSU), or by phone at 515-1754. If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Dr. Gray A. Mirka, Chair of the NCSU IRB for the Use of Human Subjects in Research Committee, Box 7906, NCSU Campus.

PARTICIPATION:

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study before data collection is completed your data will be returned to you or destroyed.

CONSENT:

I have read and understand the above information. I have received a copy of this form. I agree to participate in this study.

Subject's signature ________________________ Date: __________

Investigator's signature _____________________ Date: __________

APPENDIX - B
PRETEST

Name: ______________________________
Soc. Sec. #: __________________________
Section: ____________

Research Pretest Questionnaire

Please write the letter of the correct answer on the line provided beside each question below. Your score on this questionnaire will not be shown to your instructor or have any effect on your grade in this course.

____ 1. When using coordinate angles in an AutoCAD system, the < indicates an angle value of what coordinate type?

A. The < indicates an angle value when using Absolute coordinates.

B. The < indicates an angle value when using Relative Rectangular coordinates.

C. The < indicates an angle value when using Relative Polar coordinates.

D. The < indicates an angle value when using none of the above coordinates.

____ 2. To change the sizes and distances of dimensions, use variable:

A. DIMTSZ

B. DIMSCALE

C. DIMLFAC

D. DIMRND

____ 3. What is the name, color and linetype of the default LAYER, that allows you to begin drawing within AutoCAD?

A. 0, white, continuous.

B. 0, gray-black, continuous.

C. 1, white, dashed.

D. 1, black, dashed.

____ 4. Within the AutoCAD program, when using Object Snap (OSNAP) as a connecting tool, how does it function when connecting to an object or entity?

A. You have to connect exactly onto an object for it to work.

B. You have to use the @ function for it to work.

C. You have to simply get "near to" with the OSNAP function, for it to work.

D. Osnap will not connect objects together.

____ 5. In AutoCAD, when using the LINE command, if you make a mistake you may use the sub-option UNDO. Thus, if you use the UNDO sub-option when in the LINE command:

A. You do not have to exit the LINE command to use UNDO.

B. You must exit the LINE command to use UNDO.

C. You should exit the LINE command, ERASE the mistake and redraw again.

D. You have to exit the LINE command, quit and re-open the drawing to correct the mistake.

____ 6. In an AutoCAD drawing, a line 5 units long begins at (0,0) and is drawn at a 90-degree angle. What are the coordinates of the endpoint, and in what direction is it moved?

A. 5 units in the X direction (5,0)

B. 5 units in the Y direction (0,5)

C. 5 units in the Z direction (0,0,5)

D. 0 units in the X direction (0,0)

____ 7. In an AutoCAD drawing, which command lets you make multiple copies of selected objects in a rectangular or polar pattern?

A. The ARRAY command.

B. The SYMBOL command.

C. The INSERT command.

D. The POLYLINE command.

____ 8. In the AutoCAD program, the OFFSET command works in the following way:

A. It copies a block symbol -- parallel to another entity at a specified parallel distance.

B. It constructs text fonts -- parallel to another entity at a defined distance.

C. It moves an entity to another entities location at a specified parallel distance.

D. It constructs an entity parallel to another entity at a specified parallel distance.

____ 9. What command in AutoCAD will allow you to transfer existing objects from a present location on screen to a new location on screen?

A. OOPS

B. ERASE

C. SHIFT

D. MOVE

____ 10. In the AutoCAD program, what ZOOM option will display the entire drawing surface up to the drawing limits?

A. ZOOM -- All

B. ZOOM -- Dynamic

C. ZOOM -- Extents

D. ZOOM -- Previous

APPENDIX - C
QUESTIONNAIRE

Name: ________________________________ **Soc. Sec. #** ____________________

Section: ___________________

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1. **NCSU Major:** _________________________________

If Freshman College, what major do you think you will enter? ____________________

---

2. Have you had drafting/mechanical/architectural drawing previous to this course?

_________ Yes _________ No

---

3. How experienced or computer are you in using a computer?

Not at all ____ Some ____ Fairly experienced ____ Very experienced ____

---

4. If you have computer experience, how did you gain this experience? List major learning experience (examples: self-taught, learned from a parent, learned from a friend, too computer classes, learned in classes that used computers, etc.)

---

5. If you indicated that you took computer courses, what courses have you had and were they in middle/junior high school, high school, or college/community college?

Course Title:	**Level of education** (middle school, high school, community college, university)	**Course Length**
A.		
B.		
C.		
D.		
E.		
F.		

6. Gender: _________ Male __________ Female

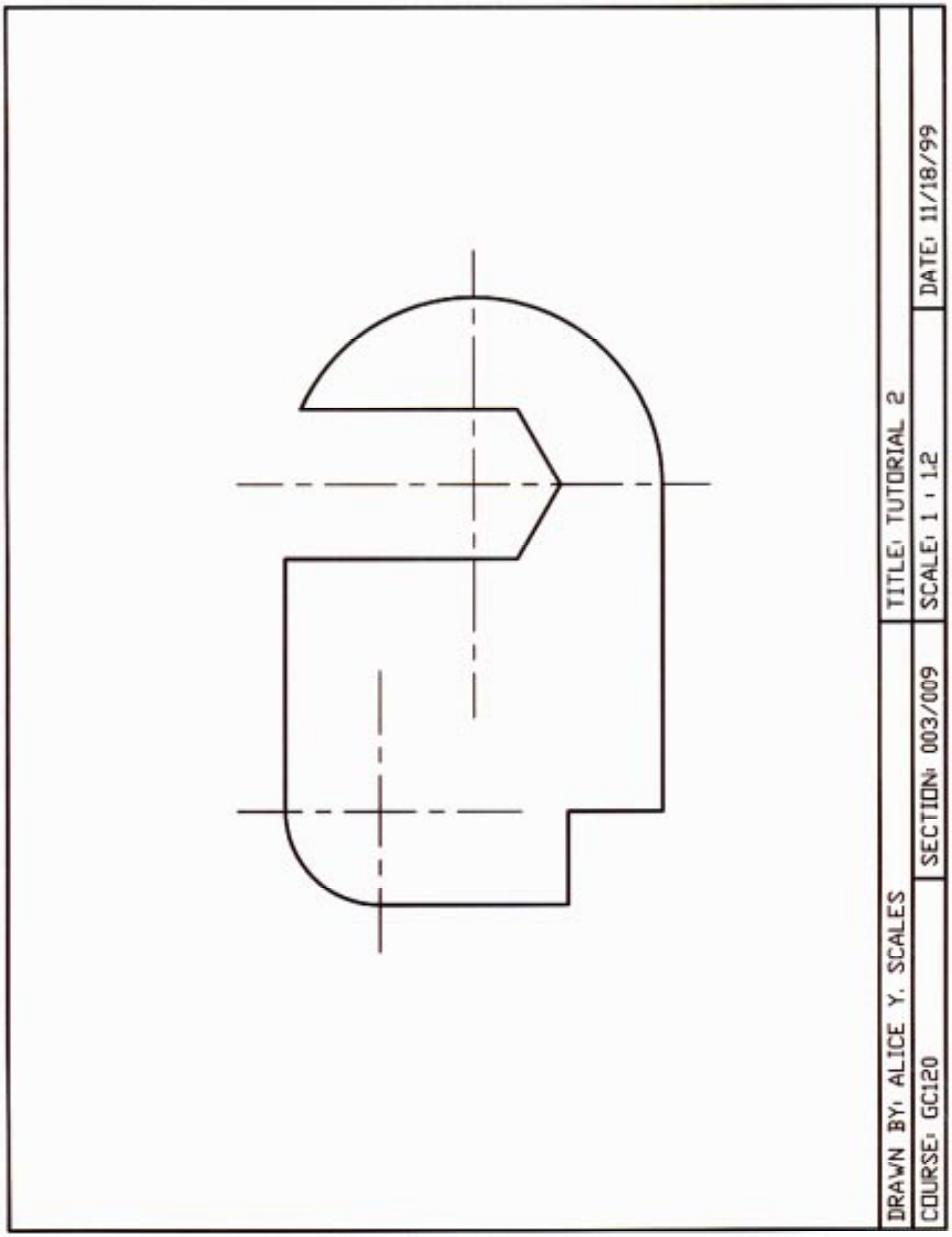
---

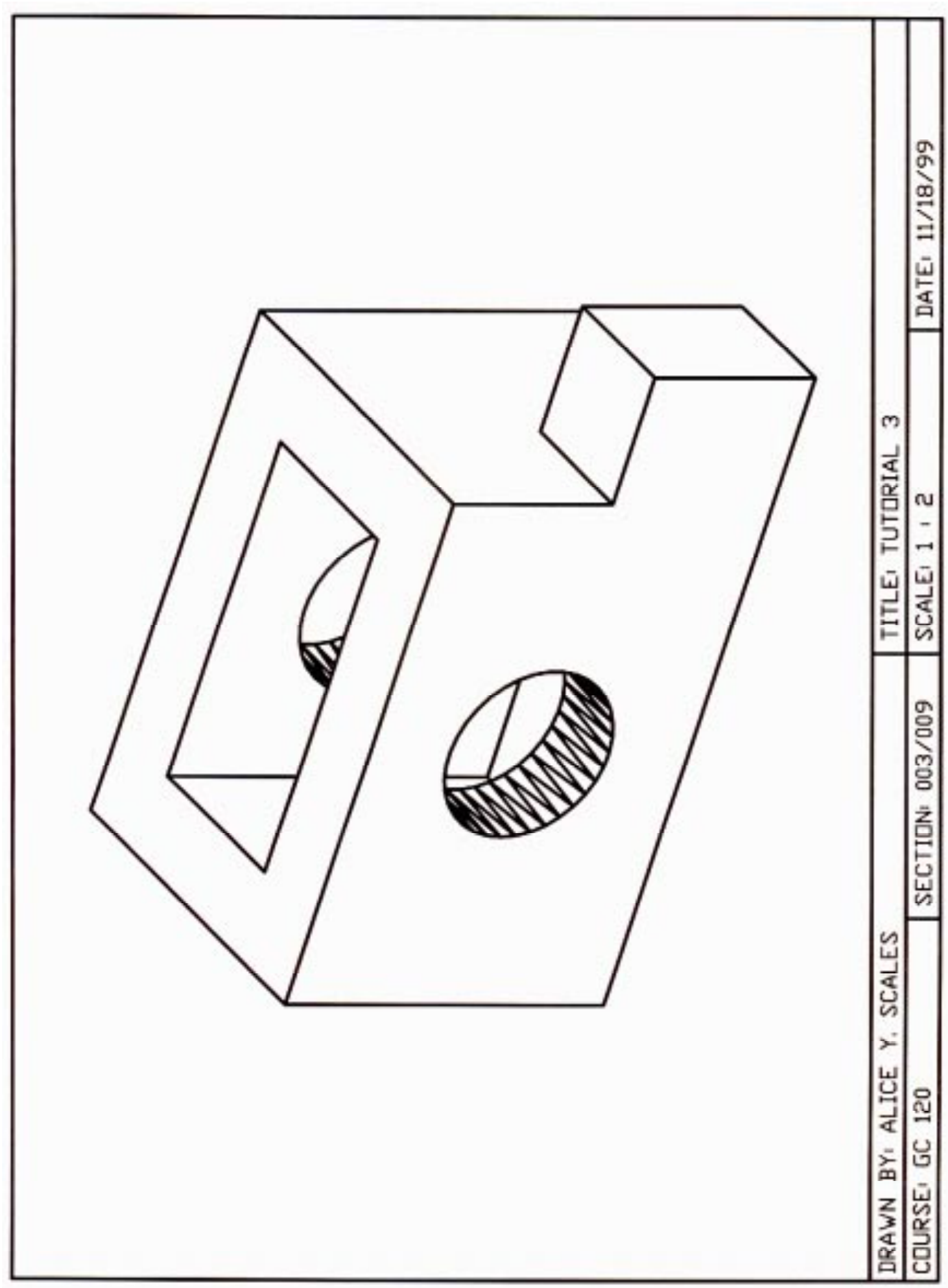
7. Classification: ____ Freshman ____ Sophomore ____ Junior

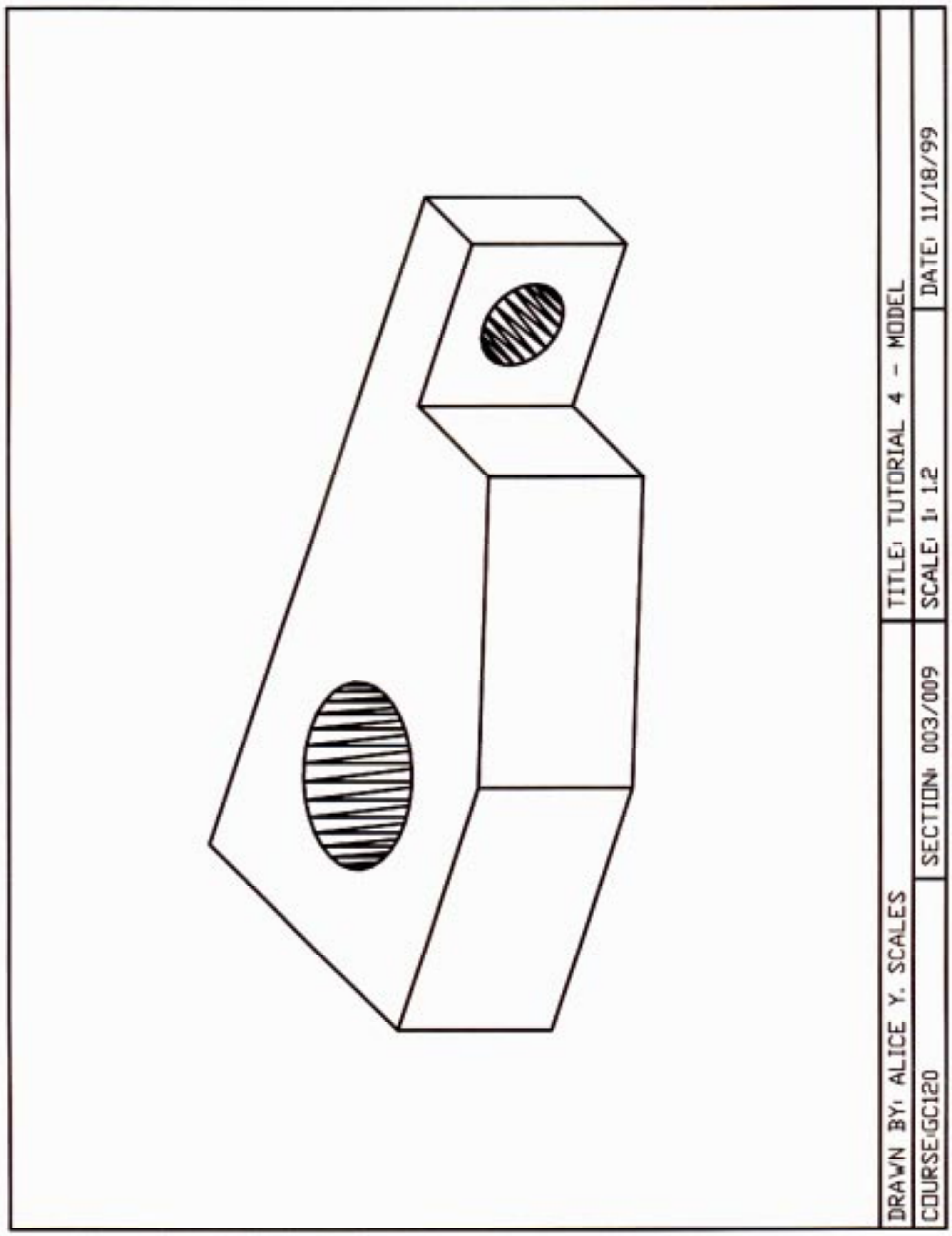
____ Senior ____ Grad Student

APPENDIX - D
COMPUTER-AIDED DRAWING ASSIGNMENTS

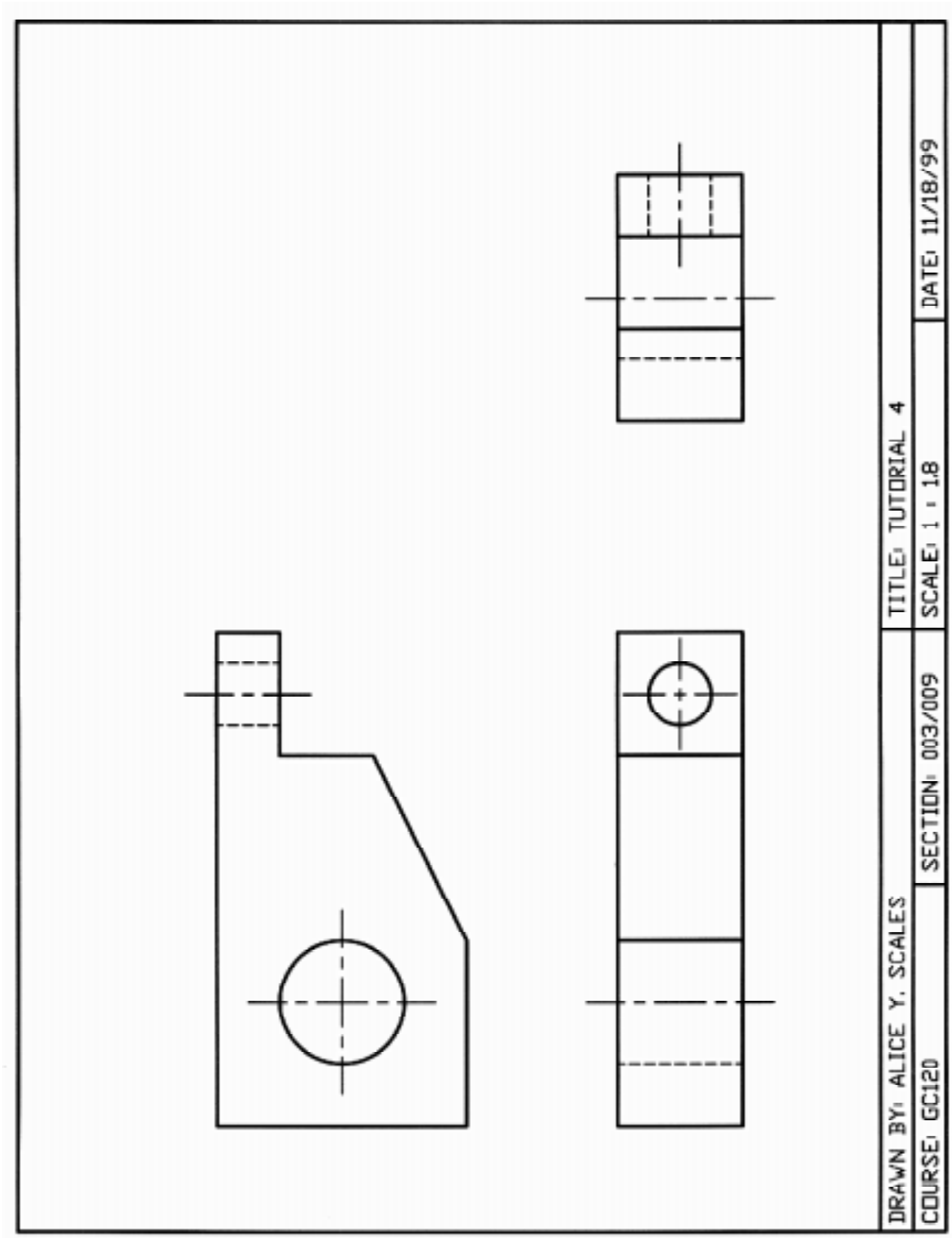
DRAWN BY: ALICE Y. SCALES		TITLE: TUTORIAL 1	
COURSE: GC120	SECTION: 003/009	SCALE: 1 : 1.2	DATE: 11/18/99

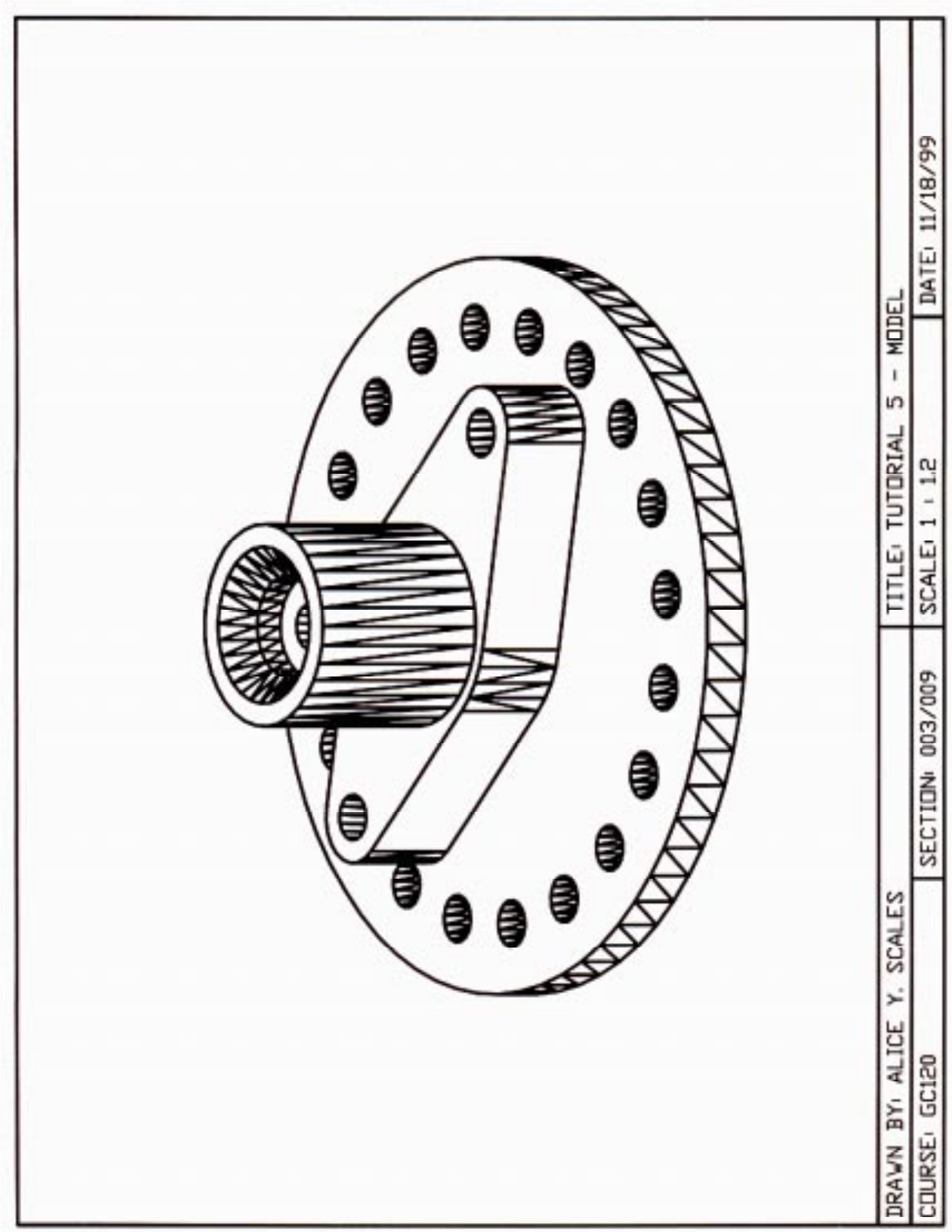

DRAWN BY: ALICE Y. SCALES
TITLE: TUTORIAL 2
COURSE: GC120
SECTION: 003/009
SCALE: 1 : 12
DATE: 11/18/99

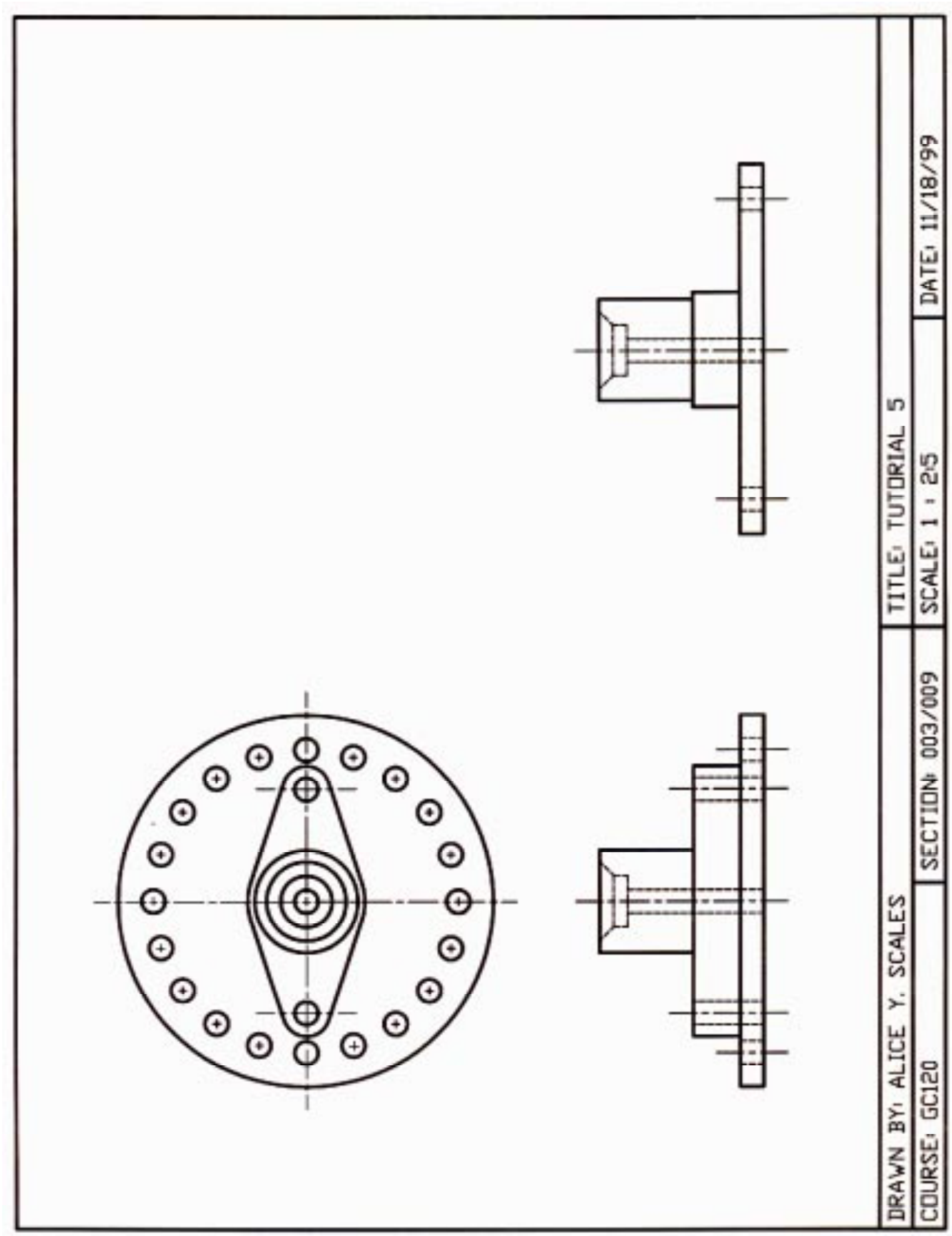

DRAWN BY: ALICE Y. SCALES
TITLE: TUTORIAL 3
COURSE: GC 120
SECTION: 003/009
SCALE: 1 : 2
DATE: 11/18/99

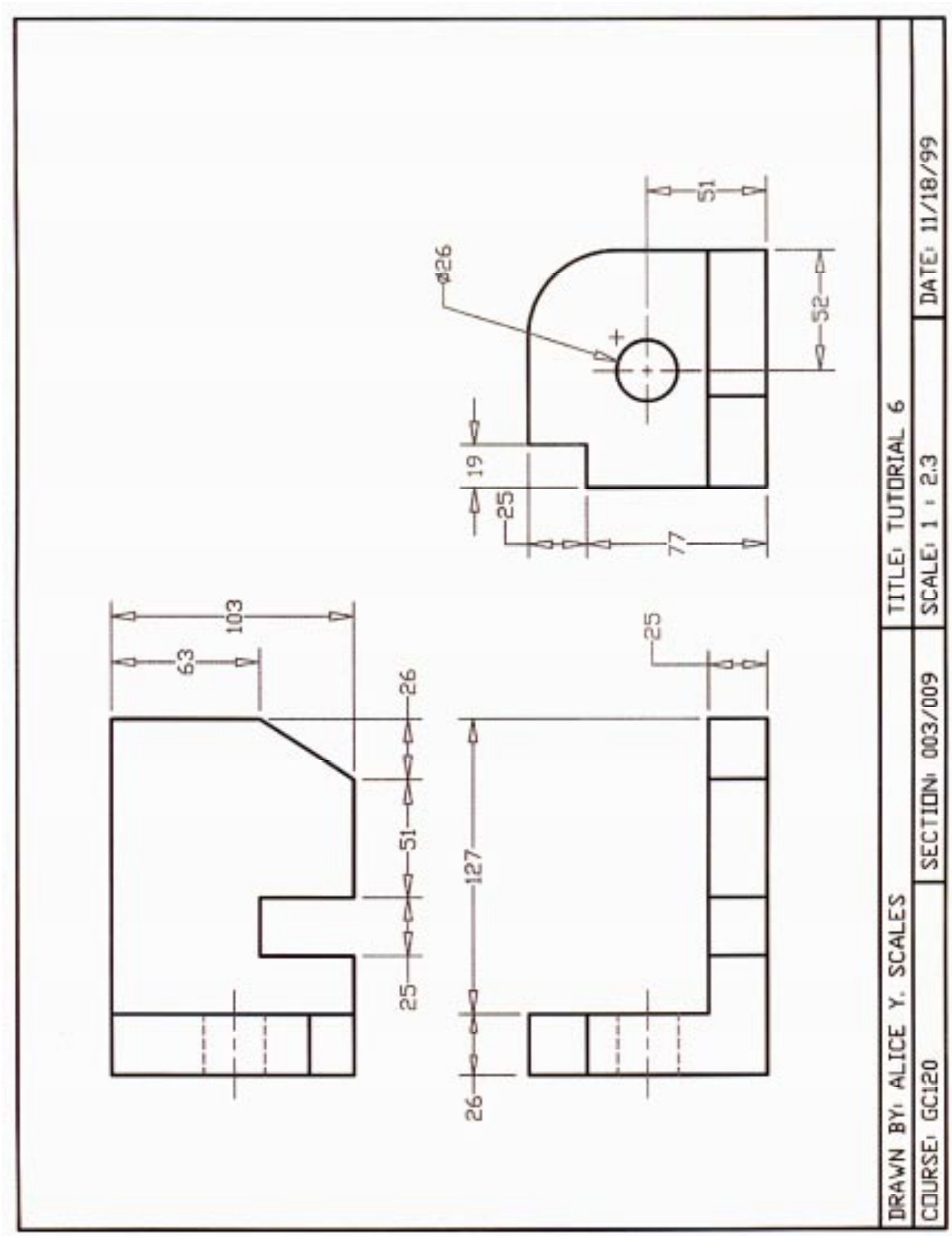


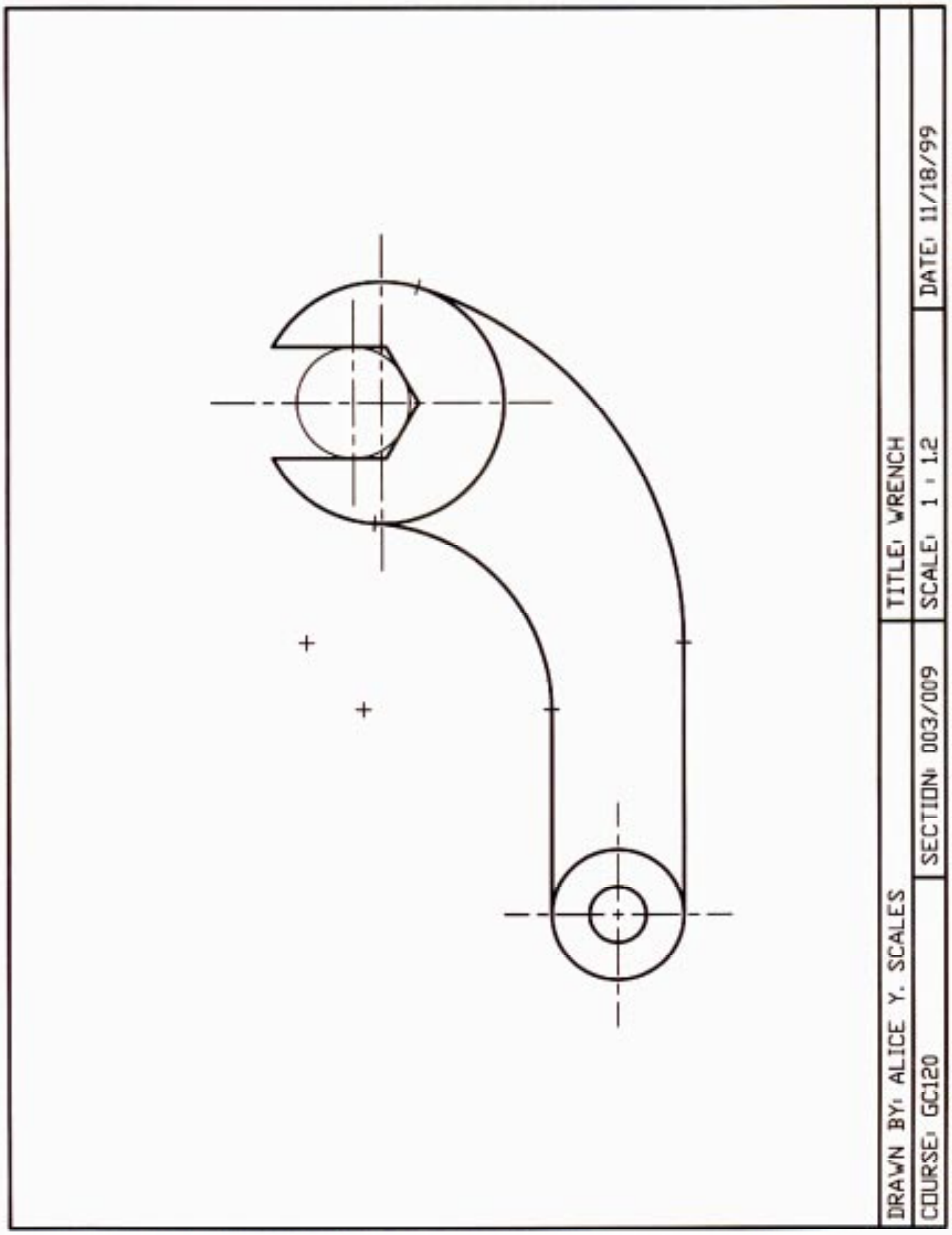
DRAWN BY: ALICE Y. SCALES
TITLE: TUTORIAL 4 - MODEL
COURSE:GC120
SECTION: 003/009
SCALE: 1: 1.2
DATE: 11/18/99


DRAWN BY: ALICE Y. SCALES
TITLE: TUTORIAL 4
COURSE: GC120
SECTION: 003/009
SCALE: 1 : 1.8
DATE: 11/18/99


DRAWN BY: ALICE Y. SCALES
TITLE: TUTORIAL 5 - MODEL
COURSE: GC120
SECTION: 003/009
SCALE: 1 : 1.2
DATE: 11/18/99


DRAWN BY: ALICE Y. SCALES
TITLE: TUTORIAL 5
COURSE: GC120
SECTION: 003/009
SCALE: 1 : 2.5
DATE: 11/18/99


DRAWN BY: ALICE Y. SCALES
TITLE: TUTORIAL 6
COURSE: GC120
SECTION: 003/009
SCALE: 1 : 2.3
DATE: 11/18/99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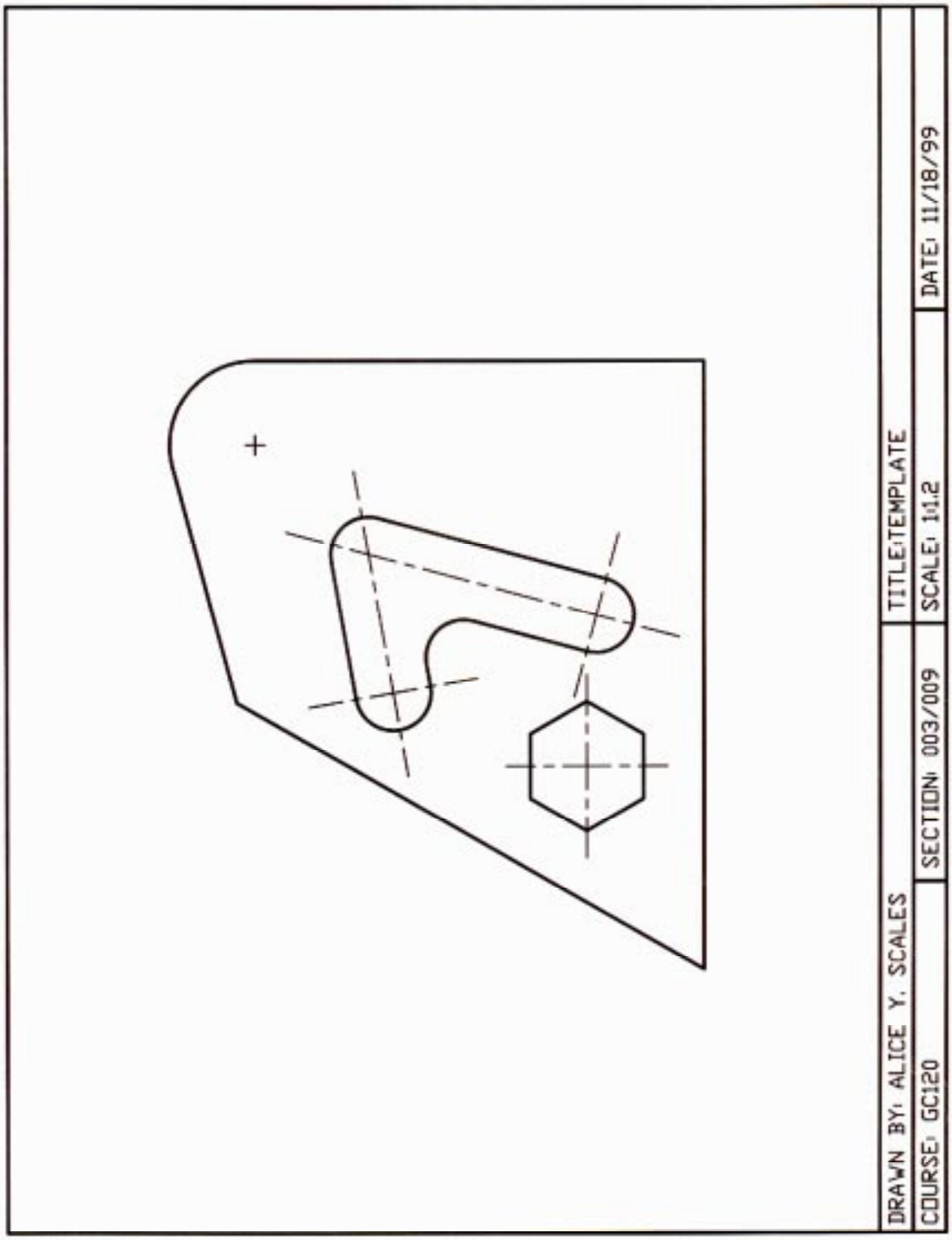
TITLE: WRENCH
COURSE: GC120
SECTION: 003/009
SCALE: 1 : 1.2
DATE: 11/18/99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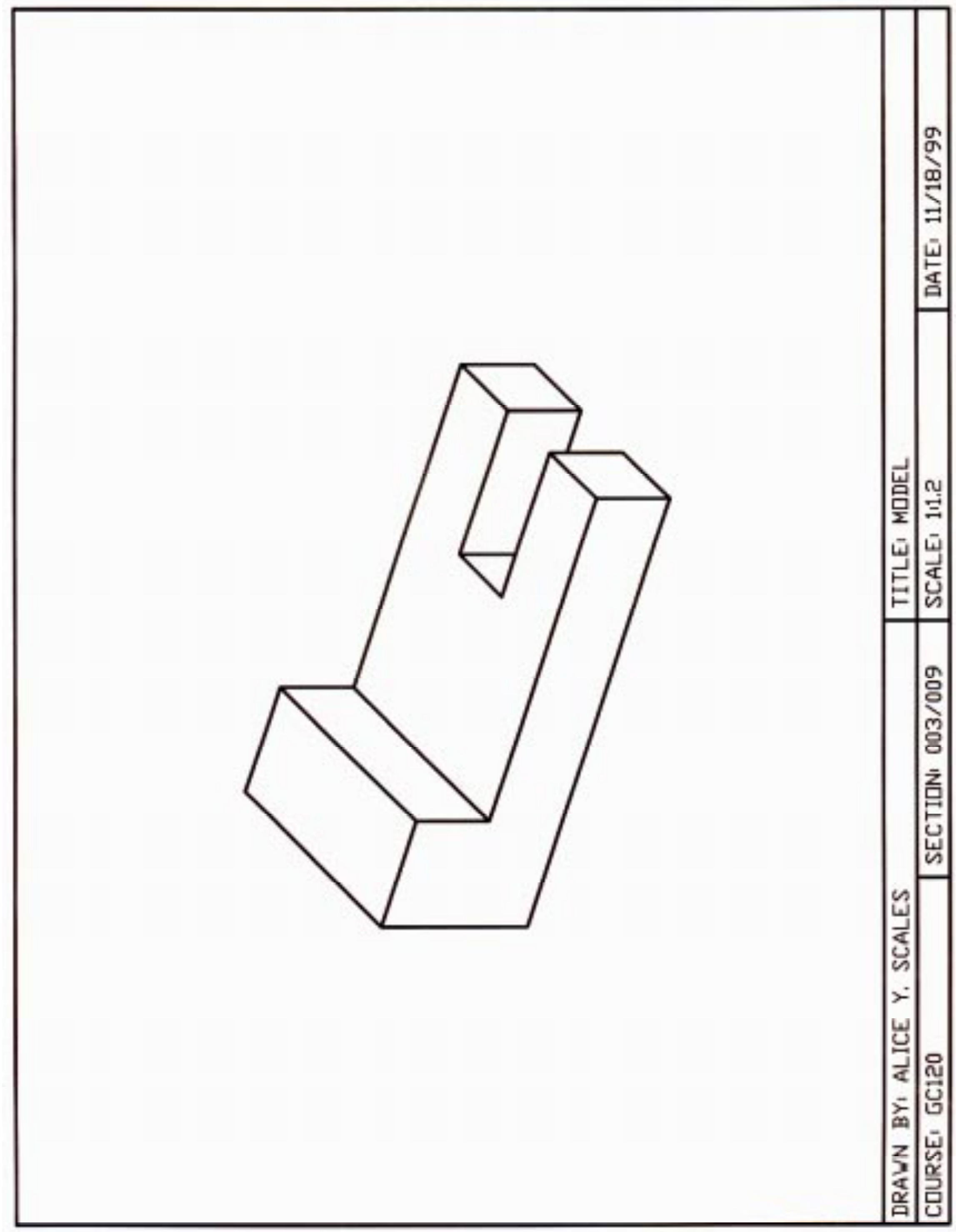
TITLE:TEMPLATE
COURSE: GC120
SECTION: 003/009
SCALE: 1:2
DATE: 11/18/99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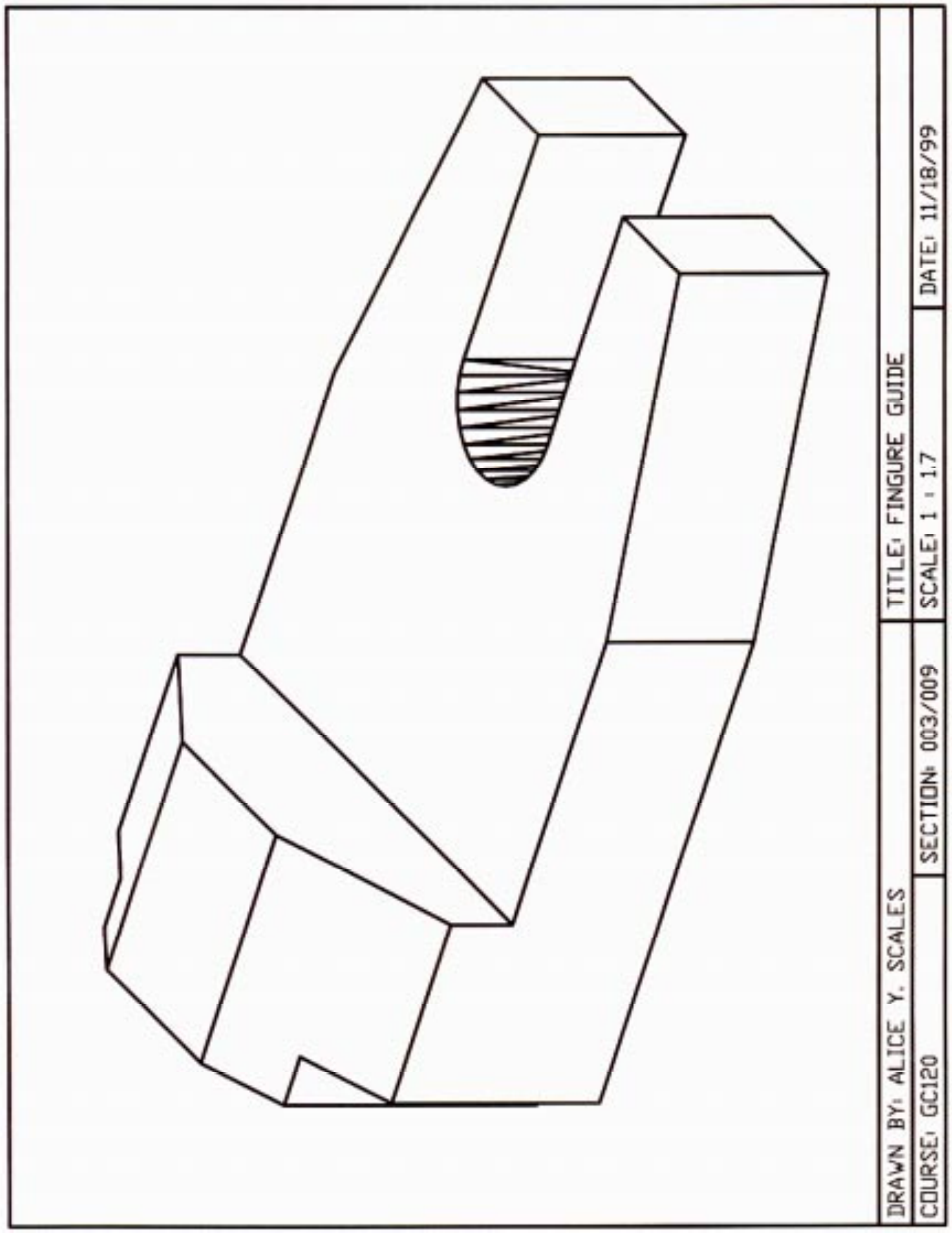
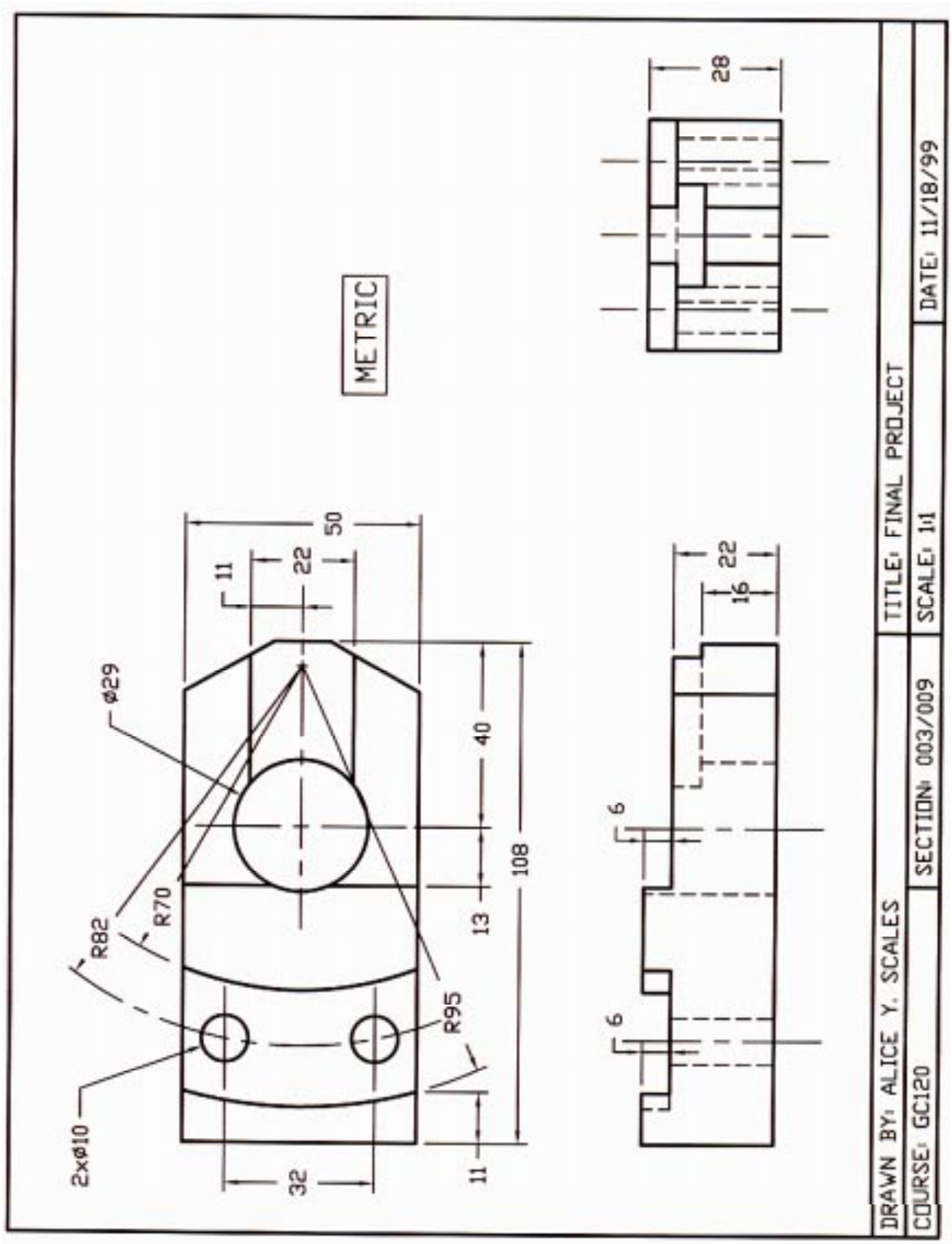
COURSE: GC120
SECTION: 003/009
TITLE: MODEL
SCALE: 1:1.2
DATE: 11/18/99



DRAWN BY: ALICE Y. SCALES
TITLE: FINGURE GUIDE
DATE: 11/18/99
COURSE: GC120
SECTION: 003/009
SCALE: 1 : 1.7

APPENDIX - E
EXAMPLE OF A FINAL PROJECT


METRIC
⌀29
R82
R70
R95
2×⌀10
32
11
13
40
108
50
22
11
28
22
16
6
6
DRAWN BY: ALICE Y. SCALES
TITLE: FINAL PROJECT
COURSE: GC120
SECTION: 003/009
SCALE: 1:1
DATE: 11/18/99