ADAPTING CAD AND VISUALIZATION SKILLS LEARNED THROUGH AUTOCAD® TO AN INDUSTRIAL APPAREL DESIGN SYSTEM

by

Deepti Mathur

A thesis
submitted to the Faculty of Graduate Studies
in partial fulfillment of the
requirements for the degree of
Master of Science

Department of Clothing and Textiles

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ABSTRACT

Computer technology is one of the factors that can be credited with the rapid changes occurring in the apparel industry. These factors are affecting the jobs of apparel designers which in turn impact the type of education required to prepare apparel designers to enter the industry.

The current trend of assessing the success of universities according to the employability of their graduates is driving these institutions to review their curriculum and educate their students according to the needs of the industry. Due to financial constraints, majority of universities offering apparel design programs have been found to be using AutoCAD® for teaching CAD skills (Wimmer & Giddings, 1997).

On the basis of the review of literature, two alternative hypotheses were formulated. Hypothesis 1 stated that students with experience in AutoCAD® learn industrial CAD systems more efficiently and expeditiously than students with only patternmaking skills. Hypothesis 2 stated that students with experience in AutoCAD® have more enhanced visualization skills than students with only patternmaking skills.

A research study was undertaken and data were collected from two convenience samples during the months of January to May 1999 in order to test the hypotheses. The CAD group consisted of 15 subjects with manual patternmaking skills as well as CAD skills acquired using AutoCAD®. The No-CAD group consisted of 15 subjects who were currently in the Clothing and

Textile program and had only manual patternmaking skills. Subjects in both groups were asked to complete a Visualization test (Workman, Caldwell and Kallal, 1997) , five pattern development tasks on the Lectra Systèmes software, and an Achievement test. Descriptive and inferential statistics were calculated on the scores obtained from the Visualization and Achievement tests and the time taken by individual students to complete the Lectra tasks.

Results of the quantitative analysis demonstrated no significant differences in the mean test scores between the CAD and the No-CAD groups at the significance level of 0.05. It was determined that subjects in both groups had similar visualization skills and the participants in the No-CAD group were able to learn Lectra Systèmes software as expeditiously and efficiently as the CAD group.

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CHAPTER 1

Introduction

Technological advances in the apparel industry within the twentieth century have prompted a gradual transition from a reliance on traditional drafting tools to computer aided design (CAD) which provides the following benefits to manufacturers: (a) better communication, visually and electronically, (b) reduced sampling, (c) increased productivity, (d) greater creativity, and (e) better and more accurate design and presentations (Neal, 1996). A recent survey of apparel companies suggests that about 20,000 CAD systems are being used worldwide and most of the companies use at least some form of CAD technology in their design or production processes (Chase, 1996). According to Industry Canada reports, as of 1999 the Canadian apparel industry comprised close to 1600 apparel manufacturing firms (http://strategis.ic.gc.ca/SSG/ap03193e.html#manu). Industry Canada also determines that approximately 23% of the Canadian firms have adopted between five and nine advanced manufacturing technologies (AMT) including CAD systems, factory computers and intercompany networks (http://strategis.ic.gc.ca/SSG/ap03176e.html#tech).

The current trend of assessing the success of universities according to the employability of their graduates is driving these institutions to review their curriculum and educate their students according to the needs of the industries. Since many firms in the industry are implementing computer technologies, there is a growing need for universities that educate students in apparel design/production to include computer aided design/computer aided manufacture (CAD/CAM) programs. An Apparel Human Resources Council summary report (http://www.ccai.com/ahrc/english.htm) suggested that apparel design programs should place greater importance on quality assurance, inventory control and apparel technology so that curricula remains relevant to students and manufacturers. Consequently, colleges and schools across North America are examining ways of integrating CAD into the curriculum to provide students with a working knowledge of cutting edge technology.

A majority of universities across North America are using AutoCAD® for apparel design education (Wimmer and Giddings , 1997) due to the prohibitive prices of industrial apparel design systems. The apparel industry however does not use AutoCAD® for any of its pre-production processes. This gives rise to some questions like: Are the CAD skills learned through AutoCAD® transferable to an industrial apparel design system? Is it useful to learn AutoCAD® before learning apparel-specific industrial software? Does experience on AutoCAD® increase the visualization capabilities of the students? This study was designed to find information relevant to these questions. The recent acquisition of Lectra industrial software by the Department of Clothing and Textiles at the University of Manitoba enabled the researcher to investigate these questions. The results obtained in this study will be useful for faculty members who determine curriculum content.

Industry Trends

The apparel manufacturing industry is changing rapidly. Two of the factors credited with bringing about this change are apparel imports and technology. These factors are affecting the jobs of the apparel designers which in turn impact the type of education required to prepare the apparel designers to enter the industry.

Apparel imports are a major share of the present North American apparel market. Due to a substantial increase in imports in the past few decades, the Canadian trade deficit for textiles and apparel is undergoing an exponential growth (Kearns, 1995). Apparel imports rose from $3 billion in 1992 to $4 billion in 1997 (http://strategis.ic.gc.ca/SSG/ap03193e.html, 1999). This increase in apparel imports is causing loss of jobs and business for the apparel industry (Kearns, 1995).

Sheldon (1988) suggests that apparel manufacturers should invest in technology in order to survive. Technology, as mentioned earlier, is another factor affecting the rapid change in the apparel industry. Because the apparel manufacturers cannot meet the low labor costs of the exporting third world countries, they are striving for "quick response" technology which is an ability to design, produce and deliver goods to the consumer in a short time. Heisey (1984) also perceives "quick response" as a possibility to meet risks in forecasting fashion trends. According to her, once the demand on a fashion trend is known, a company can manufacture quickly using the "quick response" technology. This avoids the risk of manufacturing ahead of demand on the basis of forecasting of fashion trends which may not be necessarily accurate. This "quick response" technology is highly facilitated by computer aided design (CAD)/computer aided manufacture (CAM) technology. To achieve the goal of quick response to reduce lead time between the introduction of a fashion idea and its production and consequent delivery to the consumer, computer aided design is being integrated into every step of the design, pre-production, production and marketing processes. This large scale and stepwise integration makes it important for almost all key personnel involved to have a thorough knowledge of computer aided design systems and the ability to be comfortable in a highly computerized environment.

Rationale

A review of the literature indicates an increase in the trend of CAD usage in the apparel industry. Fraser (1987) surveyed 117 apparel companies and found that 9.4% of them were computerized. Eighty-five percent of these computerized companies felt that CAD systems were a worthwhile investment. Future predictions indicated that 20% of companies should be using CAD within the next five years. Like Sheldon (1988) and Heisey (1984), Fraser states that increasing computerization in apparel design and production processes can be attributed to the "quick response" campaign. Fraser concluded that personnel dealing with CAD systems should have more formal training in the use of computer aided design. Designers, patternmakers and production managers were reported to have agreed that it is hard to find trained people to use computers. A study by Fraser (1987) suggested that while CAD usage was low, anticipation of future designers' use and need for education was high. This study also discussed the level of exposure to types of computerized apparel design systems that the entry level designers will need to have. Sheldon (1988) assessed current and projected use of computerized design equipment and examined how these changes will in turn change the qualification requirements of the entry level designers. Sixty-five percent of the designers projected the use of computerized pattern development equipment and 48% of the designers projected the use of computerized apparel design equipment. All the designers were reported to strongly emphasize the necessity for apparel design education to include hands-on experience on computer aided design equipment.

This projected use of CAD/CAM systems indicates a need for apparel design/production curricula to include CAD/CAM components because of a growing need for designers with CAD/CAM experience. Universities educating students in apparel design and production must prepare students to work in a technological workplace as well as in a creative environment. Educating students with leading technology will provide the industry with employees who are able to meet new challenges effectively. This fact has been recognized by researchers in the field of clothing and textiles culminating in the development of tutorials, simulations and drill and practice programs which introduce the students to the potential of computer aided design (Marshall & Slaybaugh, 1986; Offerjost & Terry, 1987; Belleau, Orzada, & Wozniak, 1992).

As mentioned earlier, the heavy penetration of computer aided design technologies in the apparel industry calls for more intensive integration of CAD in apparel design curricula. Consequently students of the apparel design programs need to be comfortable in a highly computerized environment. However, researchers report visualization problems that occur among apparel design students when learning computer aided design (Kallal, 1983; Racine, 1992). The problems with visualization occur because the conventional apparel design methods rely on many hands-on techniques that cannot be applied to the initial stages of computer aided design. For example, while developing patterns manually, students work with full scale patterns as opposed to miniature patterns on the computer screen. Thus students are unable to visualize the fit and proportion of pattern pieces on the screen. This problem of visualization has also been noted by the students in the Computer Aided Design class in the Department of Clothing and Textiles at the University of Manitoba.

Since a majority of schools use AutoCAD® to teach computer aided design (Wimmer & Giddings, 1997), faculty members and instructors customize this software to make it suitable for apparel design education. However, the apparel industry does not use AutoCAD® for its pre-production processes presenting certain questions for the apparel design educators. Therefore, the following questions arise: Is it useful to teach computerized patternmaking using AutoCAD® or is it sufficient to educate students on manual patternmaking techniques? Who learns industrial software packages more expeditiously and effectively - students with CAD skills acquired on AutoCAD® or students with only manual patternmaking techniques?

Do subjects with CAD skills acquired using AutoCAD® have more enhanced visualization capabilities as compared to subjects with no CAD but manual patternmaking techniques? The present study seeks answers to these questions.

Statement of the Problem

The accelerated computerization of the apparel industry has prompted universities offering apparel design programs to include CAD in their curriculum. However, a review of the available literature suggests two problems with the way computer aided design is being incorporated in these universities. Firstly, AutoCAD®, a generic CAD software, is being customized to teach CAD for apparel design, but AutoCAD® is not used by the apparel industry for its pre-production processes. Secondly, researchers have reported problems of visualization that occur among apparel design students when working on CAD that occur because students are unable to visualize the fit and proportion of pattern pieces on the screen.

The purpose of this exploratory study was then to address the following questions: Who learns to use apparel-specific industry software more expeditiously and efficiently - students with CAD skills learned using AutoCAD® or students with only manual patternmaking and construction skills? Do subjects with CAD skills acquired using AutoCAD® have more enhanced visualization skills as compared to subjects with only manual patternmaking techniques?

Theoretical Framework

The Syntax Independent Access theory proposed by Dyck (1987) was used as the theoretical framework for this study. This theory states that the semantics (basic concepts) of a programming language are independent of its syntax (rules governing the language) and so can be taught separately. If the students are taught the semantics of programming in their Natural Language, these fundamentals can be transferred to any new language. This mechanism has been termed as transfer of knowledge. Transfer, according to Mayer (1987), is "the degree to which a learner can apply existing knowledge to accomplish new tasks." Transfer is positive when the old and new tasks have similar entities with similar description (Wærn, 1993).

Shneiderman and Mayer (1979) distinguished between semantic and syntactic knowledge in computer programming. According to them, semantic knowledge consists of general programming concepts that are independent of specific programming languages. Syntactic knowledge involves the rules governing a programming language.

The theory of Syntax Independent Access is supported by the findings of Shneiderman and Mayer (1979) who noted that it is easier for humans to learn a new syntactic representation for an existing semantic construct than to acquire a completely new semantic structure. This is the reason why beginning programmers find it hard to learn the first programming language but relatively easy to learn a second one of these languages.

Fay (1990) conducted a study to determine if providing explicit instruction in programming design skills prior to instruction in the language skills (syntax) affects the quality of programming knowledge acquired. She found further evidence in support of the Syntax Independent Access Theory suggesting that teaching the basic concepts or semantics of programming in a Natural Language facilitates the process of knowledge acquisition. Although students in the design group (who received pretraining in Natural Language) took longer to design programs, they wrote programs that were more accurate than the no-design group. Fay (1990) suggests that this is because these students understood the concepts of programming better and so took longer to revise and correct their programs.

Like Dyck (1987), some clothing and textiles researchers believe that students who are aware of one type of computer technology can more easily adapt to other types of computer technologies (Miller & DeJonge, 1987; Racine, 1992; Sokolowski, 1996). In other words, Dyck's (1987) Syntax Independent Access theory is applicable to the present study because it is the researcher's belief that if students are aware of the basic concepts of CAD (semantics), it will be easier for them to adapt to other types of CAD systems (syntax).

Limitations

This research was limited to the selection of Lectra systèmes industrial software. The sample size of the study was limited due to limited population of subjects who had completed patternmaking (64.219) and CAD courses (64.432 or 64.333). In addition, the findings of this study were limited by the time lapse between the CAD groups' completion of CAD courses and the data collection procedures for the current study.

Questions to Be Addressed

1. Who learns an apparel-specific CAD program more expeditiously and efficiently- students with CAD skills acquired using AutoCAD® (after learning manual patternmaking) or students with only manual patternmaking techniques?
2. Do subjects with CAD skills acquired using AutoCAD® have more enhanced visualization capabilities than the group with only manual patternmaking techniques?

Hypotheses

The following hypotheses were formulated based on the research results of previous studies:

H_A: Subjects with CAD skills acquired using AutoCAD® will score higher on the achievement test for Lectra industrial software than subjects with no CAD skills.

H_A: Subjects with experience on AutoCAD® will score higher on the visualization test as compared to the subjects with no CAD skills.

Definition of Terms

To better understand the benefits of computerization in the design process, it is important to have a basic understanding of the terminology.

Computer aided design (CAD): Collier and Collier (1990) have defined CAD as the ability of dedicated computer systems to facilitate design creation and alteration. They define CAM as control of production steps and equipment operations by computers.

Although it has been accepted that CAD and CAM are two separate technologies, the more popular term CAD is used throughout this research. For this study, the term CAD has been used to refer to computerized patternmaking.

Transfer of knowledge: Transfer, according to Mayer (1987), is "the degree to which a learner can apply existing knowledge to accomplish new tasks". Transfer is positive when the old and new tasks have similar entities with similar description (Wærn, 1993).

For this study, transfer has been conceptualized as the students' ability to apply CAD skills previously acquired using AutoCAD® to the task assigned on Lectra Systèmes.

Visualization: In the context of apparel design, visualization has been defined by Workman and Zhang (1999) as the subjects' ability to image two-dimensional pattern pieces and mentally translate them into a three-dimensional garment.

Operational Definitions

Explanatory or Independent Variables

1) Type of group: refers to the two groups involved in the study - the CAD and the No-CAD groups. The subjects in the CAD group had experience generating and developing patterns using AutoCAD® along with manual patternmaking and construction skills. The No-CAD group had manual patternmaking and construction skills but no CAD skills.

2) Time taken to complete the Lectra assignment: refers to the total time taken by an individual subject to complete the exercises prepared for the pattern development problems on the computer, using Lectra Systèmes software. This was measured by noting the lapse between starting and finishing time for individual subjects in minutes.

3) Scores on the Visualization Test: reflect the students' pattern development and visualization capabilities. This was measured by the number of correct responses on the Apparel Spatial Visualization Test (ASVT) developed by Workman, Caldwell and Kallal (1997). This test is described in detail in the Chapter 3.

4) Computer Experience: refers to the subjects' knowledge of computers and was identified using the demographic questionnaire. Computer experience consisted of two levels:

i) High

ii) Low

Subjects who had completed at least one university level computer science course were classified with high level of computer experience. Subjects with experience on less than two software packages and no university level computer science course were classified with low computer experience.

5) Most recent GPA: refers to the cumulative Grade Point Average. The most recent GPA reflected each subject's academic performance and competence in the area of clothing and textiles.

In accordance with the University of Manitoba letter grade system, a subject was classified as one with high academic performance if his/her GPA fell between 3 and 4.5. A subject was classified with low academic performance when his/her GPA fell below 3.

Response or Dependent Variables

1) Student Achievement: Student achievement was defined as the knowledge gained by the subject from the pattern development assignments using Lectra

Systèmes. It was represented by the number of correct responses on the achievement test that consists of 15 questions. The achievement test was developed by the researcher and is described in detail in Chapter 3.

2) Scores on the Visualization Test: The scores on the visualization test reflected the students' pattern development and visualization capabilities. This was measured by the number of correct responses on the Visualization test developed by Workman, Caldwell and Kallal (1997) consisting of 20 sets of patterns. This test is described in detail in Chapter 3.

CHAPTER 2

Literature Review

Introduction

This literature review focuses on the integration of computer aided design in university curricula , students' attitudes toward it and the transfer of knowledge from one domain to another. Firstly, research done to date describing approaches used in this integration are discussed. Then the ongoing debate regarding traditional versus computer aided drafting is outlined. Problems of visualization arising due to the introduction of computer aided design are also discussed. Studies regarding programming instruction and transfer of knowledge have been reported. Inconsistencies observed during the review have also been discussed along with questions arising from the review of literature.

There is a limited body of literature available in the field of clothing and textiles which directly deals with CAD. Research regarding its actual integration into the university curricula is also scarce. So, to understand the implementation of computers in university curricula, information has been drawn from disciplines such as education, engineering, architecture, computer science, statistics, sociology, chemistry, and marketing.

Computer Assisted Instruction and Students' Attitudes

Computers have been used in education since the late 1970s. Educators in many fields have developed a variety of instructional uses for computerized programs. An extensive review of the literature suggests that a majority of researchers favor computer assisted instruction (CAI) over traditional instruction. CAI is a term used to refer to instruction which uses some form of computer program in learning activities. Programs are designed to teach, reteach and review or to provide tutoring, drilling, and practice after a concept has been taught (Larsen, 1985). In other words, CAI is used to teach and reteach what is already learned. Premkumar, Ramamurthy and King (1993) investigated the influence of computer assisted instruction (CAI) and personal characteristics on the decision making skills of business students in an introductory financial management course. Results indicated that computer assisted instruction influences and enhances the performance of the students. Aptitude was found to be an important variable that significantly differentiated the high and low decision making groups based on decision quality and satisfaction.

CAI was also found to be effective in an experimental study conducted by Yalcinalp, Geban and Ozkan (1995) who supplemented regular classroom instruction with CAI to teach mole related topics in chemistry. The test scores following the two types of instructions indicated a statistically significant difference favoring the CAI. The CAI approach was also found to enhance students' attitudes toward chemistry as a subject. This comes as no surprise because it is a widely known fact that computer programs allow students to process information actively. Learning, being an active process itself, is enhanced by this active information processing. The authors theorize that the interactive non-threatening nature of computer experience may have had a positive effect on the students' achievement in chemistry and their attitudes toward chemistry as a school subject. Yalcinalp et al. report that CAI produced an improvement in attitudes toward computerized instruction in the experimental group. It is possible that some of the aspects of the program such as complete learner control, immediate feedback, and randomly generated questions and examples might have increased students' motivation. The authors suggest that CAI would have been more effective if it were scheduled as a regular activity. Frey (1995) also noted that factors of scheduled activity and length of exposure are important variables in the effectiveness of CAI.

Mandinach and Cline (1996) conducted a multiyear longitudinal study to assess the impact of technology on teaching and learning. They reported that a computer based systems thinking approach has a positive effect on students across all ability levels (refers to academically strong and weak students). These findings reinforce the fact that focus on practical applications rather than abstractions, engages students in problem solving and develops deeper understanding of content and context.

Rosser, Herman, Risucci, Murayama, Rosser, and Merrell (2000) conducted a study to compare knowledge gains for laparoscopic skill acquisition following a standardized tutorial delivered via CD-ROM versus live instructor. The researchers reported significant differences in performance from pretest to posttest scores and concluded that the CD-ROM tutorial effectively transfers cognitive information necessary for skill development

Varnhagen and Zumbo (1990) evaluated the effectiveness of two different formats of computer assisted instruction (CAI) with traditional in-class instruction. The two CAI programs examined were PLATO74 and PLATO86. PLATO74 was an older program containing numerous pages of text with several computer guided problems and short multiple choice quizzes with feedback spread throughout the program. PLATO86 contained less text, more computer guided problem solving, simulations, graphics and branding routines to trap and correct student errors. These two different programs offering the same course content were compared to determine whether the format of the instruction had any effect on learning performance. These two CAI formats were also contrasted with traditional lecture sessions to see if CAI was more effective than traditional instruction or not. The authors theorized that if research done to date suggesting the effectiveness of the computer as a tool in teaching is true irrespective of the instructional format, then the two programs should be equally effective. Results indicated that instructional format was important in performance. Although the differences were not statistically significant, the PLATO86 group outperformed both the traditional group and the PLATO74 group.

Along with measurement of performance, students' attitudes were also assessed. Varnhagen and Zumbo (1990) theorize that instruction does not directly affect learning. It is mediated by a human factor - students' attitudes. The authors suggest that instruction directly influences students' attitudes. This probably is the reason why almost all researchers studying effectiveness of CAI and its influence on learning also study students' attitudes toward it. Consistent with the hypotheses, the results indicated that CAI had a significant effect on students' attitudes toward the instruction. However, the results indicated that CAI did not have a direct effect on students' performance. These results supported the initial belief of the authors that instruction influences attitudes which in turn influence performance.

Offerjost and Terry (1987) also found a relationship between achievement and attitudes. In their study, the researchers developed a microcomputer lesson to teach color concepts. Offerjost and Terry reported that the lesson was effective in increasing the knowledge of students about the specific color concepts included in the lesson. They found that a positive relationship exists between achievement and students' attitudes towards the use of technology for learning. That is, the more positive the attitude, the higher the achievement is.

Marshall and Slaybaugh (1986) studied students' attitudes toward a computer simulation that assessed construction quality in ready- to- wear apparel. Students had a positive attitude toward the simulation and thought that it was effective.

Frey (1995) recognized a need for the assessment of students' responses toward computer aided design of apparel. A mean difference between the pretest and posttest scores of the CAD group indicated both a reduction in fear about computers eliminating their jobs and an increase in interest toward learning the technical aspects of computers following computer aided design instruction. Data from the non-CAD group suggests that more students would enroll in an elective CAD course if they were less anxious about using computers. From these results we can infer that high anxiety leads to avoidance of computers.

In a meta-analysis of 59 studies, a process of making generalizations from past research, Kulik , Kulik and Cohen (1980) concluded that for the most part, computers made small but significant contributions to the effectiveness of college teaching. They report that it is harder to prove the educational advantages of computer-assisted instruction at higher levels of learning. From their analysis, Kulik, Kulik and Cohen (1980) concluded that at the college level, almost all methods of instruction are effective. Of the 59 studies examined, Kulik, Kulik and Cohen found 11 that reported quantitative results on students' attitudes toward computer assisted instruction. In eight of these studies, statistically significant results were obtained in favor of CAI, only three studies favored conventional instruction. Kulik, Kulik and Cohen (1980) also reported a small effect size in students' attitudes toward subject matter for courses which used CAI. These results are consistent with findings of Yalcinalp, Geban and Ozkan (1995) who reported that CAI improved students' attitudes toward the introductory chemistry course as a school subject. Students in the CAI courses had a more favorable attitude toward the subject matter in two studies. For two of the studies, this difference was statistically significant, with both studies reporting more favorable attitudes on the part of the students in the computer courses.

In another meta-analysis of 101 studies, Kulik and Kulik (1986) assessed the effectiveness of computer based education (CBE) in college students. Three types of CBE were investigated - computer assisted instruction (CAI), computer managed instruction (CMI) and computer enriched instruction (CEI). Results indicated that college-level CBE has overall positive effects on students and it raised final examination scores from the 50th to the 60th percentile. But the analysis results did not indicate any significant differences in effectiveness for different types of CBE implementations. These results are consistent with the findings in the previous meta-analysis of findings of 59 studies conducted by Kulik , Kulik and Cohen (1980). It was found that CAI, CMI and CEI programs all made small positive contributions to student learning. These findings suggest that at the college level students seem to be able to adapt to a variety of uses of computers in teaching.

In an updated analysis of 254 studies, including learners of various levels (kindergarten to college students), Kulik and Kulik (1991) found results that were consistent with previous findings. They did not find type of CBE (CAI, CMI or CEI) to have an impact on examination scores. CBE was reported to have a small but significant effect on performance and students' attitude toward their subjects and computers. It was also reported to substantially reduce the time needed for instruction. The authors concluded that the duration of exposure to CBE and instructional effects were important variables in raising examination scores.

A comparison of the three analyses suggests that effectiveness of CBE is increasing with time, presumably as a function of the growing sophistication of computer hardware and software. Another factor could be that the higher usage of computers due to higher integration in the curricula is making students more comfortable with CAI resulting in better performance.

There is a large body of research in education literature that evaluates the role of computers and their impact on education. Though most of the experimental and meta-analytic studies comparing the traditional mode of instruction with CAI have found results favoring CAI, there are other studies which do not find computer assisted instruction to be effective. Evans, Mickelson and Smith (1984) made an attempt to integrate computers in an undergraduate class of college composition. The researchers did not find any significant differences between CAI and the traditional instruction groups. However, students were reported as appreciating CAI's individual attention and ability to work at their own pace. This lack of significant differences could be due to the nature of CAI provided to the students. A tutorial of basic grammar skills was administered to the students which, even the authors admit, does not help in improving writing skills. This reinforces the findings of Varnhagen and Zumbo (1990) who established that merely using computers as a tool does not promote learning. The subject matter content and instructional format are the key components in improving learning.

Gonzalez and Birch (2000) conducted a study to evaluate the effectiveness of three tutorial modules, equivalent in content but different in mode of presentation, for introducing elementary statistics concepts. The three modules consisted of paper and pencil, basic computerized and computerized multimedia. The researchers reported no significant differences in performance between the three tutorial modules. Holman (2000) also compared the use of CAI in the form of a library tutorial to the more traditional classroom approach to bibliographic instruction and found no significant differences in the two methods of instruction. The students were however reported to have favored the pace of the computerized instruction.

To summarize this section, in most studies it was found that CAI is more effective than traditional instruction. Researchers have found that teaching apparel design using a computerized approach results in better performance and positive attitudes towards subject matter and computers as a tool for learning. CAI has also been found to improve performance across various age and ability levels.

These findings specially hold true for the field of clothing and textiles because it is highly visual in nature. This is the reason why computerized instruction is complementing courses related to visual imagery such as appearance, perception, fashion design illustration, and visual merchandising (Kadolph, Schoenberger, & Chisholm, 1996). Since clothing and textiles students are visual learners, multimedia applications are being incorporated into various areas of design and production (Devane, 1992). Computer animation is being used to teach introductory textiles (Kadolph, Schoenberger, & Chisholm, 1996), multimedia modules have been developed to teach basics of flat pattern design (Koch, 1996), a tutorial developed by Boni (1996a) teaches apparel production and costing to fashion merchandising students. Although successful, these computer assisted instruction strategies are only introducing the students to the potential uses of computer aided design of apparel. To meet the training requirements of an apparel designer specified by the highly computerized apparel industry, it is necessary to supplement manual drafting instruction with CAD. Researchers in various fields have investigated the potential of computer aided design as a mode of instruction. Some argue in favor of supplementing traditional instruction with CAD while others argue against it. Some of these studies are cited in the next section.

Supplementing Manual Drafting with CAD

A majority of researchers favor computer assisted instruction strategies like simulations or tutorials for teaching computer aided design. Tutorials follow the model of programmed instruction by using a question and answer format with questions being interspersed with instruction. In simulations students assume a role and interact with the computer to solve a problem posed in the simulation. Often simulation is the only way a topic can be presented because of the costs or hazards involved in a real-life experience. Usually these simulations or tutorials are administered as a class assignment or part of a project (Belleau, Orzada & Wozniak, 1992; Capjack, 1993; Frey, 1995). This strategy introduces the students to CAD but does not make them proficient in the use of computers for creating apparel. In a typical experimental setting, students would be given a pretest, be exposed to a computer simulation or tutorial and then would be asked to complete a posttest. The students' attitudes toward traditional and computer aided instruction would then be assessed and reported. What is left unexplained is what level of knowledge is sufficient for the introduction of CAD. What also needs to be known is whether CAD should totally replace manual drafting or not.

Researchers arguing in favor of traditional drafting instruction postulate that most of the CAD classes focus on teaching students to select, modify, and apply the computer commands required to complete an assignment. In other words, students possess the ability to solve a drafting problem before they progress to CAD (Fesolowich, 1987). According to them the basic concepts of drafting should be taught in a drafting course which should precede CAD. Fesolowich (1987) believes that if students are taught the two concepts together, it will only serve to confuse them. He suggests a modification in the curriculum by preserving the manual drafting course but placing less emphasis on tasks that can be accomplished more easily on a CAD system and should be taught on it. Williams (1987) suggested that if the students know how to solve a design problem, it does not matter what sort of tool they are employing to solve it. Hardy (1989) questioned the relevance of teaching drafting on a CAD system which may become obsolete even before the students graduate from school. He believes that if students know the basics of drafting, they can adapt to any new tool the industry hands them.

DiMarco (1989) foresees the need to move onto computer aided drafting but feels that traditional and computer aided drafting are complementary to each other and should be taught concurrently. According to him, it is important for a designer to know the basics of drafting but he/she should also be adaptable to new technology. DiMarco also suggests that CAD should be introduced into the basic drafting course by teaching CAD ideas, terminology, basic technology and practical applications. According to him, the transition from traditional drafting to CAD should be gradual, starting from the introduction of basic ideas culminating in advanced computer aided design courses all the time stressing the fact that the computer is only a tool. DiMarco also feels that drafting should not be taught in a CAD course but CAD should be taught in a drafting course. This particular concept of coexistence was also suggested by Schwendau (1986) who believes that CAD technology is booming at a frightening rate. To maintain a semblance of order, students should be taught manual drafting so that they do not become dependent on technology but at the same time are informed of the technological advancements of the drafting industry. Gorman (1990) argued that drafting is not a task or operation but is a way of thinking which is a central part of change. Students who understand this can adapt to new technology all through their careers. Drafting enables students to be productive whether they are using T-squares and triangles, a keyboard or even a voice operated instrument. Brandi (1978) and Lai (1990) reported that instructional mode does not play a significant role on achievement measure. They found that computer aided design is as effective as traditional instruction in teaching principles of patternmaking. Lai's findings also suggested that students' prior experience with patternmaking or construction did not affect their performance. Brandi (1978) found that students with prior patternmaking experience completed the tutorials earlier than the students with little patternmaking experience but it was also reported that the students with little patternmaking experience showed significant gain in learning pattern development and performed better on achievement measures.

Gorman (1990) stated that traditional drafting teaches problem solving (analysis of design) and visualization (2-dimensional representation of the 3-dimensional world) and so never can be entirely replaced by CAD but should be supplemented by it. The present computer aided design technologies provide options for 2-dimensional and 3-dimensional drawings, enhancing students' visualization capabilities (Novitski, 1991). This refutes Gorman's (1990) argument that only traditional drafting has the ability to help students with the visualization problem. However, Novitski reports that most of the architectural schools are teaching their students the basics of programming, database management software engineering and expert systems just the way they were being taught the use of T-squares and triangles. Goutmann (1996) argued for a determination of the exact level of knowledge of the students, when they will be able to solve design problems using computers so that the curriculum can be organized likewise. To answer this question partially, Becker (1991) conducted a study using a Delphi research technique which involves selecting a panel of experts in the given area and making generalizations according to their responses. Becker reported that according to experts in the field of computerized engineering drafting, traditional drafting is an integral part of the curriculum. Becker argues that students in technical fields of study like engineering and architecture should have a basic knowledge of manual drafting before they can move on to computer aided drafting.

Gow (1987) argued that teaching traditional drafting before CAD is redundant and a waste of time. He noted that since the industries are leaning heavily towards the use of computer aided drafting systems, it is time that drafting schools made that change too.

Sheldon and Regan (1990) agreed that apparel design students need basic skills of flat pattern, pattern drafting, pattern grading, marker making and fashion illustration for entry level jobs in the industry but they purport that these skills can be taught on the CAD system itself. This is possible only if all the courses are computerized. They suggest that the need for knowledge of flat pattern techniques, drafting and illustration arises only when computer aided design is taught as one comprehensive course introducing all these concepts at once. To comprehend all of these concepts on the computer in one course, students would need to have the basic knowledge of traditional drafting. According to the researchers, if these concepts are expanded in several different courses using standard CAD software, it would be easier for the students to transfer this knowledge on industrial CAD systems. Moreover, they suggest that CAD promotes creativity by allowing more time for experimental croquis, more variation in less time and presentation of more garment variations in less time to buyers without making up samples. This enables the students to learn the basic principles of apparel design without wasting time in making a new drawing or pattern every time one is needed.

Racine (1992) reported that intermediate and advanced CAD courses in the curriculum are designed for those who have already acquired traditional patternmaking and design skills. She noted that this is due to the fact that apparel design educators have to customize CAD software to make it suitable for apparel design. This brings about a need for a prerequisite background involving traditional drafting and patternmaking skills. If add-on apparel specific software were commercially available to speed up designing, it would be possible to completely computerize apparel designer training.

Kashef (1991) found that CAD systems can replace traditional drafting instruments for teaching pictorial and multiview drawings. According to him, CAD technology has become an essential part of the design system in the industry. Since both CAD and traditional drafting techniques were found to be equally effective in teaching the basics of drafting, it has been suggested that manual drafting instruction should be replaced by CAD because it will prepare students for the real world challenges and cutting edge technologies. Clark-Marlow (1996) also reported that computer aided design teaches the basic principles of drafting as well as the manual techniques and so should be used to teach flat pattern skills efficiently.

Researchers favoring traditional drafting have argued that if students are taught drafting using a specific computer technology, it may become obsolete even before they graduate. However, recent research suggests that students who are aware of one type of computer technology can more easily adapt to other types of computer technologies (Sokolowski, 1996). Boni (1996b) believes that the future belongs to CAD and the students trained on computer aided design will find it easier to get a good job.

Brandes and Garner (1997) defended the position of basic clothing construction classes taught in high schools. They noted that university programs devote too much time in teaching basics of fabric performance, garment construction and patternmaking when it could be utilized to teach more professional entry level skills into the apparel industry like CAD, textile analysis and quality control. High school basic clothing construction classes have been suggested as a possible solution to this problem. A basic clothing construction class introduces the students to the concept of fabric grain and drape as well as an understanding of fabric construction (fabric performance). The students learn basic pattern terminology, relationships between fabric grain, grainline markings on patterns and the shapes necessary to construct a 3-dimensional garment from a 2-dimensional fabric. These skills prepare the students for university courses in textile testing, textile chemistry, quality assurance, flat pattern, garment sizing and alterations thus saving valuable class time required by the industry. The authors suggest that this course not only develops basic skills but also builds the fundamentals essential for a strong technical and theoretical base in the field of clothing and textiles.

Thus, a pattern seems to be forming regarding the introduction of CAD in university curriculum. Although CAD was resisted by educators when it was first introduced into the university curriculum (Williams, 1987; Hardy, 1989; Gorman, 1990), with the increasing penetration of CAD in the industry, researchers recognize a need for incorporating CAD into the curriculum by teaching CAD and traditional drafting side by side (DiMarco, 1989; Resetarits, 1989; Becker, 1991). Recent research has suggested that CAD teaches the basic concepts of drafting as well as the traditional manual methods and so can be used to replace manual drafting (Sheldon & Regan, 1990; Kashef, 1991; Boni, 1996b; Clark-Marlow, 1996; Brandes & Garner, 1997).

The introduction of computer aided drafting has thus given rise to a lively debate. While academicians supporting traditional drafting techniques have managed to voice their concerns over CAD, there is little empirical evidence available to suggest why drafting skills cannot be taught completely on the computer. However, it is important to note the issues raised by the academicians supporting traditional drafting. With the boom in CAD technology, the validity of using CAD software which may become obsolete the next day is highly questionable. However, it has been suggested by researchers supporting CAD education that students who are aware of one type of computer technology find it easier to adapt to any other computer technology. This issue will be addressed in the next section.

Transfer of Knowledge

With the increased use of CAD technology, CAD vendors are selling their products to apparel manufacturers and universities offering CAD education. Tailored according to the budget and specific needs of their target market, these products can be very different from each other. A persistent yet elusive problem for the clothing and textiles educator is teaching CAD skills that are transferable to a variety of CAD systems. Although some of these educators believe that students who are aware of one type of computer technology find it easier to adapt to other computer technologies, there is no concrete evidence available to establish the same (Racine, 1992; Sokolowski, 1996).

Researchers in educational computing have been examining ways to teach programming so that it promotes problem solving skills that are transferable to other domains. Programmers often need to draw systematically on prior programs in the development and construction of new programs (Swan, 1991). Cumulatively, programming language and transfer studies seem to provide conflicting results. For example, multiple studies have reported no significant increases in problem solving skills as a result of programming instruction (Leron, 1985; Salomon & Perkins, 1985; Pea & Kurland, 1987; Johanson, 1988). To explain this, some researchers have suggested that programming instruction alone is not enough to promote problem solving skills. These skills can be enhanced by explicit problem solving instruction and mediated practice in a programming environment (Clements & Gullo, 1984; Clements, 1987; Thompson & Wang, 1988). For example, Mawby (1985) reported that novice users do not have a sufficient working knowledge of the programming language and therefore, never engage in complex programming activities. Without practice on higher level complex programming activities, the higher level thinking skills are not improved.

On the other hand, many educational computing researchers have found links between programming instruction and problem solving skills. Liao and Bright's (1991) meta-analysis of 65 studies suggested that the outcomes of learning a programming language extend beyond the contents of that specific computer language. The authors reported that students are able to acquire cognitive skills such as reasoning skills, logical thinking and planning skills, and general problem solving skills through computer programming activities. Watson, Lange and Brinkley (1992) found that mastery of a programming language syntax (Logo) was not a necessary condition for young children to learn and problem solve within a Logo environment. The children in the Watson et al. study showed positive transfer of knowledge from screen based Logo training to the solution of spatial problems in another learning setting. These results contradict the earlier findings of researchers suggesting that in order for students to learn problem solving skills, they should have considerable practice with and mastery of the programming language. Reed and Palumbo (1992) found further evidence in support of this finding. After a 16 week longitudinal study utilizing the BASIC programming, they reported that there were significant increases in problem solving skills from pretreatment to post treatment. They reported that students who performed better when using the language also scored higher on the problem solving instruments. However, another study by Dalton and Goodrum (1991) suggested that computer programming alone was ineffective in teaching problem solving skills. When paired with systematic problem solving instruction, learners demonstrated significant learning gains.

Au and Leung (1991) found that significant transfer of knowledge occurs from the Logo context to a non-computing context leading to the conclusion that learning Logo with a content oriented approach enhances general problem solving skills. They also suggested that in order for transfer to take place, the tasks assigned should be isomorphic in nature. These results are consistent with Wærn's (1993) theory suggesting that transfer is positive when the old and new tasks have similar entities with similar description.

While attempting to group university students according to their SAT scores, high school marks and prior programming knowledge so as to better tailor an introductory programming course, Lee, Pliskin and Kahn (1994) discovered that students with stronger backgrounds in programming performed better in computer courses. In other words, students with prior programming experience transferred their knowledge to university level computer courses and performed better than students with no programming experience.

In an experimental study, Fay and Mayer (1994) compared a design group (who received pretraining in general design principles presented in English) and a no-design group (who did not receive any pretraining) as they received instruction and practice in writing Logo programs. It was found that the design group wrote programs that were shorter, more efficient and flexible than the no-design group. According to Fay and Mayer (1994), these results indicate broader implications for teaching high level problem solving strategies within the technical fields. These are consistent with the syntax independent theory which favors sequential teaching of high and low level skills (how to design an efficient computer program and how to write grammatically correct commands respectively) in which the students learn the skills in one's most familiar language before applying it in the context of a new language. The researchers found that when students are taught these skills within the syntax of a new language (in this case Logo) a major portion of their cognitive effort is invested in learning the low level skills, that is, the computer language. The learners eventually fail to acquire the high level skill, that is, designing an efficient program. For this reason, the researchers argue, it is important to teach high level skills in a familiar language before asking the students to learn them in the syntax of a new programming language.

Tyler and Vasu (1995) examined the importance of variables like locus of control, self-esteem and achievement motivation in predicting Logo mastery and far-transfer problem-solving ability. They found that math achievement was the most important predictor for far-transfer.

Jacobson and Spiro (1995) conducted a study to investigate a theory-based Hypertext learning environment that provided instruction in a complex and ill-structured domain. The experimental treatment incorporated a Hypertext procedure (based on a recent cognitive theory) that presented the instructional material in multiple contexts to highlight different facets of knowledge. The results of this study indicated that although the control treatment led to higher performance on the measures of memory for factual knowledge, the hypertext treatment promoted superior knowledge transfer.

Grandgenett and Thompson (1991) investigated two effects of using guided programming instruction to train analogical reasoning within a classroom setting. The first effect investigated the far-transfer of guided programming instruction on the development of general analogical reasoning. The second effect investigated the near-transfer of such instruction on a related computer programming skill. Analogical reasoning, as described by the researchers, was ability of a person to utilize previous experiences to understand current situations and the referencing of former problems to gain insight into new ones. Far-transfer was defined as the development of analogical reasoning outside the programming domain and near-transfer was described as the development of analogical reasoning inside the programming domain. The results of this study indicated that analogical training through guided programming instruction may be differentially effective at different grade levels and characteristics. Far-transfer results indicated significant interaction between guided programming instruction and performance of college freshmen. However, this type of instruction hindered the performance of college juniors.

Swan (1991) reported that "texplicit" instruction with Logo programming practice supported the transfer and development of problem-solving strategies. Swan also found that neither discovery learning in a Logo environment nor explicit instruction with concrete manipulative practice promoted transfer.

Although these studies are reporting conflicting results, one has to bear in mind the fact that these researchers are using different methods, different subjects and different experimental techniques to measure transfer. However, we have enough empirical evidence to conclude that a certain amount of transfer of knowledge does occur from programming domains to non-programming domains.

Visualization

According to Workman, Caldwell and Kallal (1999), designers and patternmakers use spatial visualization capabilities to imagine the rotation of a working sketch, the folding and unfolding of pattern pieces and changes associated with addition, subtraction, or movement of components of style. Patternmakers and designers working with computer aided design need even greater visualization skills since they have to mentally manipulate pattern pieces to imagine what a three dimensional garment will look like (Workman & Zhang, 1999). Racine (1992) reported that conventional apparel design methods rely on many hands-on techniques that cannot be applied to the initial stages of computer aided design. Problems of visualization occur due the fact that while learning manual patternmaking skills, students become accustomed to working with full scale patterns but they have to work with miniature patterns on the computer screen. Thus students are unable to visualize the fit and proportion of pattern pieces on the screen. If these concepts are taught with the CAD software at the introductory stage, students may develop a better eye for proportion by the time they reach higher levels of drafting. This problem of visualization was first noted by Kallal (1983) and has also been noted by the students in the Computer Aided Design class in the Department of Clothing and Textiles at the University of Manitoba. According to Racine (1992), this problem occurs because the students find it difficult to transfer the knowledge of hands-on patternmaking techniques to a computer screen.

This problem of visualization can be explained by considering the transfer theory in the field of human-computer interaction (Wærn, 1993). Wærn explained that the transfer of old knowledge (manual patternmaking in our case) to a new situation (computer aided design) requires that the old and new tasks include rules in which the same conditions give rise to similar actions. Also, only if the old and new tasks contain similar entities with similar description, will the transfer be positive. In the situation discussed earlier, transfer of knowledge of patternmaking to computer aided design poses a major stumbling block. The rules governing manual and computer patternmaking are the same but they do not contain similar entities with similar descriptions. Also, they do not have the same conditions giving rise to similar actions.

Approaches in the Integration of Computers in Curricula

An exploration of the relationship between computers and university curricula then suggests that we are looking at an area of change; often the focus is on the computer itself, its attributes and influence, as a catalyst for change. Since the integration of computers in education in the 1970s, changes in curriculum have been the subject of much debate. An analysis of curriculum change is now generally being based in terms of process rather than content or behavioral items (Watson, 1991). Research done to date suggests that there have been two popular approaches to integrate computers in university curriculum. The first approach is development of simulations (Marshall & Slaybaugh, 1986), tutorials (Boni, 1996a), multimedia modules (Koch, 1996), computer lessons (Offerjost & Terry, 1987) and the second approach is supplementation of traditional instruction with CAI in one particular course. Usually, these courses are introductory level courses, for example, Premkumar, Ramamurthy, and King's (1993) introductory financial management course, and Yalcinalp, Geban, and Ozkan's (1995) introductory chemistry course. These approaches have been criticized by researchers like Fox, Thompson, and Chan (1996) who suggested that students should have more hands-on experience with technology within the context of their total academic program. The reason, they argue, is that tutorials, simulations and multimedia modules only provide a brief exposure to technology. This brief exposure does not train the students to settle comfortably in a highly computerized apparel industry. Total supplementation of computers in one single course is a better approach according to the authors but it has its own disadvantages. It gives the students an impression that computers are an add-on rather than an integral part of the curriculum. Also, most of the studies supplementing traditional instruction with CAI are doing it in introductory courses which again does not give enough hands-on experience with technology. For a successful integration of computers in universities, Hartmann (1991) argued for an intensive use of microcomputers across an applied research curriculum. He suggested a useful three part approach to curriculum building : (1) sequenced substantive courses that combine skill development with the theory and methods of the discipline, (2) integrative courses involving self-contained research experiences and, (3) opportunities for more diverse research experiences. In his own university curricula, Hartmann reports, microcomputers are heavily utilized for research. From the first class to the last, students learn how to use the microcomputers to accomplish various tasks. These tasks are integrated into increasingly more complex projects, culminating in a research practicum.

These theories are put to test in Siegel, Good and Moore's 1996 experimental study. Siegel et al. investigated the integration of computers in existing special education curricula. Computer technology was infused into four semesters of study, with varying levels - demonstration, hands on and required use of computers. A mean difference in pre and post attitude scores exhibited improvements in attitudes toward the subject matter and computers. The results also indicated that learning was better with the integration of new technology when more hands-on experience was given. These findings support the approach suggested by Hartmann (1991) and Fox, Thompson, and Chan (1996).

The only evidence of a stepwise introduction of CAD in clothing and textiles literature can be found in Belleau and Bourgeois's (1991) study. To integrate CAD into the curriculum, the focus of design and construction courses was changed from home sewing to industrial techniques employed in mass design and production of apparel. CAD was integrated in every design and construction course. Assignments and projects were remodeled to suit the integrated computer technology. The integration was from simple to complicated. In introductory courses, students worked on drawing and sketching. This course revolved around concepts of color, shapes and elements of design and the students learned all these concepts using a computerized design program. From the introductory course, students progressed to an apparel design studio course. In this course students were taught fashion illustration using microcomputers. The next course involved flat pattern design techniques which were taught using principles of two dimensional pattern development on the microcomputer. Manual techniques were taught to promote understanding of how patterns are developed and modified. The curriculum was organized to make students proficient in the computer aided design systems by the end of their degree. The students were reported to have a positive attitude toward integration of CAD and were motivated to use it in the future. Similarly, Resetarits (1989) recommended a consolidated drafting course with more emphasis on CAD and some on traditional drafting. According to him, the CAD system should then be integrated into future courses within the student's major area of concentration. These recommendations were based on the results obtained from an experimental study comparing traditional and computer aided drafting. He found that the principles and concepts of drafting can be taught on CAD as well as by traditional drafting tools. Resetarits postulated that teaching drafting using a CAD system will eliminate the requirement of a separate CAD course and allow room for another course to be added to the student's major.

The literature cited suggests that a stepwise introduction of computers culminating into supplementation of regular classroom instruction with computer technology is the approach to take while integrating technology in curricula. This approach has been found to be effective in improving performance and attitudes of students. However, more research needs to be done to discover other alternative but accurate approaches. This is one area in instructional strategies that needs to be researched widely but is not the focus of the present study.

Conclusion

In this review of literature, the researcher sought to investigate the integration of computer aided design into the university curriculum and students' attitudes toward it. Industry trends were discussed along with the projection for future use of CAD and changing qualification requirements of entry level designers. Published literature concerning effectiveness of CAI in terms of performance and attitudes was discussed. It was found that overall, CAI is effective as a mode of instruction and has a positive influence on performance and attitudes of students across all age levels.

Research studies investigating the need for replacing traditional drafting with CAD were discussed. A majority of researchers were in agreement for placing more emphasis on CAD but at the same time retaining some parts of the traditional drafting instruction. A stepwise approach for the introduction of technology in curriculum was found to be effective.

Research studies pertaining to prior knowledge and transfer of information were discussed. It was found that the research results support the Syntax Independent Access Theory which states that the syntax and semantics of a programming language are independent of each other and instruction of the semantic concepts in the students' natural language facilitates transfer to a new programming language. Research studies investigating the level of prior knowledge required to move on to computer aided design were also discussed. Although research regarding transfer of knowledge from a programming domain to other domains provided conflicting results, there was enough empirical evidence to establish that a certain amount of transfer of knowledge does occur. Visualization problems observed by researchers occurring due to inability to imagine the fit and proportion of pattern pieces on the computer screen were discussed. This literature review aimed to provide information regarding integration of computer aided design in university curricula but it also raises some questions. A few inconsistencies in the research were also observed which are discussed below.

Although overall favorable results were obtained in the integration of CAD in university curricula, the researcher hesitates to make generalizations based on these findings. First, results of some of the experimental studies integrating computer aided apparel design in university curricula are deemed suspect (Belleau, Orzada & Wozniak, 1992; Frey, 1995). The main reason behind this is that sample sizes of the CAD group in both the studies are very small and hence are not representative of the population of clothing and textiles students. This fact prevents us from making generalizations to the population as a whole. Moreover, in these studies, data for the CAD group are collected from students enrolled in an elective CAD course. One would assume that since these students elected to enroll in a CAD course, they had already developed a certain degree of positive attitude toward CAD and computers as such. This fact questions the validity of comparison between the two groups.

The findings from studies favoring manual drafting techniques only answer our question partially. Because apparel design is also a technical field, it would be important for the students to have at least some knowledge of pattern manipulation before moving on to computer aided pattern design. But what we still do not know is what level of knowledge is enough. That is, should the students have a thorough knowledge of pattern manipulation, draping, drafting, and clothing construction before moving on to computerized apparel design or is it enough to have a basic knowledge of pattern manipulation?

The research studies quoted by this researcher established that, with the increased usage of computers, it is imperative for universities offering apparel design programs to include CAD in the curriculum. However, a question still remains. Since it is not always possible for universities to acquire an expensive CAD system or update their CAD technology frequently due to financial constraints, they may have to teach CAD skills using a variety of software.

Researchers have also reported problems with the way CAD has been incorporated into curriculum (Racine, 1992). Because CAD courses are usually offered as consolidated single courses by the end of the students' program, students are unable to visualize the fit and proportion of pattern pieces on the screen. The present study then aimed to answer the following questions:

Do students with experience on a generic CAD software learn to use apparel-specific industry software more expeditiously and efficiently than the students with only manual patternmaking techniques?

Do students with experience on a generic CAD software have more enhanced visualization skills than students with only manual patternmaking techniques?

CHAPTER 3

Methodology

Research Sample

Two convenience samples consisting of 15 subjects each were recruited from the population of students and graduates of the Clothing and Textiles program at the University of Manitoba. The two samples were termed the CAD group and the No-CAD group. The subjects in the CAD group had completed courses in pattern development (64.219) as well as a CAD course using AutoCAD® (64.333 or 64.432 prior to 1998). The subjects in the No-CAD group had completed a course in pattern development (64.219) but had no CAD instruction for apparel design at the University of Manitoba.

The researcher made presentations in the second, third and fourth year Clothing and Textiles classes at the University of Manitoba to recruit subjects for the No-CAD group. The purpose of the study, the study procedures and the importance of student participation were explained to the students. Subjects in the CAD group were recruited by contacting the students and graduates of the Clothing and Textiles program who took a CAD course using AutoCAD® (64.333 and 64.432). Initial contact with these graduates and students was made by the researcher's thesis advisor who was also the instructor of the CAD courses (64.333 and 64.432) offered at the University of Manitoba. These graduates were contacted by obtaining the telephone numbers provided in the class lists of 64.432 within the last five years (1993-1998). At this point, the researcher would like to note that the majority of students took 64.432 in the last year of their program. Therefore, there were very few students with experience on AutoCAD® who were still in the program. Due to this reason it became imperative to obtain class lists to carry out this study. The graduates and students who indicated interest in participating in this study were then contacted by the researcher who set up a schedule for completing the tests.

Instruments

Treatment

An instructional manual (Appendix H) containing stepwise instructions for five pattern development tasks using Lectra Systèmes software was developed by the researcher. The content of the five pattern development tasks pertained to the following topics:

1) Manipulating single darts
2) Manipulating two darts
3) Converting darts to flare
4) Adding fullness
5) Adding stylelines and seam allowances

The purpose of the treatment was to enable subjects in both the CAD and the No-CAD groups to work through these pattern development tasks using Lectra

Systèmes software. Since subjects in both groups had completed courses in pattern development, it was assumed that the content of the treatment would be familiar to them. The purpose of offering familiar tasks (pattern development problems) in an unfamiliar medium (Lectra Systèmes) was that previous researchers have established that transfer of knowledge occurs when the new task consists of entities that are similar to previously gained knowledge (Wærn, 1993).

Before the commencement of the treatment, each group received a verbal introduction to Lectra Systèmes to accompany the explanation included in the manual.

Visualization Test

The Workman, Caldwell and Kallal (1997) Apparel Spatial Visualization Test (ASVT) was used to test the visualization skills of the subjects. The Cronbach's alpha obtained was reported to be .74 which was used to measure the reliability of the ASVT. This test consisted of 20 sets of pattern pieces that can be constructed in fabric to create a garment. To the right of each set of pattern pieces are sketches of some garments. The subjects were asked to decide which one of these garments could be made from the pattern pieces shown. The subjects were asked to mark their answers on a separate sheet.

The ASVT was administered to subjects in both the CAD and No-CAD groups. The results obtained from this test enabled the researcher to assess the subjects' visualization capabilities.

Demographic Questionnaires

Subjects' experience in pattern development and computers was determined by the demographic questionnaires (Appendix E1 and E2). There were two separate questionnaires, one for the CAD and one for the No-CAD groups. These questionnaires consisted of two parts. The first part requested information on subjects' experience in pattern development by determining the number of apparel design courses completed. The second part focused on the subjects' computer experience. Subjects were classified as having high or low computer experience on the basis of the number of computer programs used and the number of University level computer science courses completed. Subjects' past academic performance was determined by their most recent grade point average.

Achievement Test

The subjects' achievement after completing the pattern development tasks on Lectra Systèmes was measured by means of a paper and pencil test (Appendix I). Subjects in both the CAD and the No-CAD groups completed this multiple choice test consisting of 15 questions. The achievement test was developed by the researcher. Cronbach's alpha (.44) was used to measure the reliability of the Achievement test. The questions asked on the achievement test were based on the material covered in the pattern development tasks using Lectra Systèmes and focused on the usage of Lectra Systèmes for the development of patterns.

After the completion of the test, subjects were asked to indicate if they would be interested in obtaining a summary of research results. It was assumed by the researcher that by this time subjects had developed a better understanding of the study and were able to decide whether or not they would be interested in the research findings of the study in which they participated.

Expert Review

Due to the limited number of subjects available for the study, no pilot study was conducted to test for the appropriateness of the Instruction Manual and the testing instruments. However, two experts who had extensive knowledge of Lectra Systèmes software were asked to review the Instruction Manual and the Achievement Test and provide comments. The experts had two to three years of experience with Lectra Systèmes and had also assisted with the instruction of CAD courses taught at the Department of Clothing and Textiles at the University of Manitoba. The experts suggested rewording some of the steps in the Instructional Manual to make it more clear for the subjects. The experts' suggestions were used to revise the instrument before the final data collection.

Data Collection Procedures

Starting in November 1998, the researcher made presentations (Appendix A) in the third and fourth year Clothing and Textiles classes at the University of Manitoba to recruit subjects for the No-CAD group. The researcher explained the purpose of the study, the study procedures and the importance of subjects' participation. Subjects were guaranteed complete anonymity. Subjects who were willing to participate in the study were asked to write their names and telephone numbers or addresses on the participation form (Appendix B). The contact numbers enabled the researcher to schedule a suitable time for data collection.

To recruit subjects for the CAD group, the researcher's thesis advisor initially contacted the graduates of the Clothing and Textiles program using the phone numbers available on the class lists of 64.432 from the past five years (1993-1998). The contact information of the graduates interested in participating in this study was then provided to the researcher who contacted them and explained the purpose of the study, the study procedure and the importance of subjects' participation over the telephone (Appendix C). Subjects in both the groups were also told that participation in the study was completely voluntary and that they could withdraw from the study at any time. The researcher made phone calls to the subjects to confirm the time to which they had been assigned.

Since Lectra Systèmes software was available on eight workstations in the CAD lab of the Department of Clothing and Textiles, the data collection was done in groups, ranging from 1 to 6 subjects. The subjects from the CAD and the No-CAD group were tested together to control for variation in instruction on Lectra.

The data collection was completed over the period of five months - January to May 1999. When the subjects met for the experiment, they were asked to fill out the Informed Consent Form (Appendix D) as specified by the Ethics Review Committee of the Faculty of Human Ecology. The subjects were then asked to fill out the demographic questionnaires. The subjects in the CAD group received the demographic questionnaire for the CAD group (Appendix E1) and the subjects in the No-CAD group received the demographic questionnaire intended for the No-CAD group (Appendix E2). When this was done the subjects were asked to complete the visualization test (Workman, Caldwell and Kallal, 1997) which took approximately 30 minutes of their time. At this point the subjects were asked to take a 5 minute break if they so desired.

After the break, the researcher provided a verbal introduction to the Lectra Systèmes patternmaking software (Appendix G) which accompanied the written explanation included in the instructional manual (Appendix H). The subjects then worked on the pattern development tasks as outlined in the manual. The subjects were asked to complete all Lectra tasks on their own and address all questions to the researcher. Before starting work on their individual workstations, the subjects were asked to record the starting time. After finishing the task, they were reminded to record the finishing time. After completing the five pattern development tasks, the subjects were asked to complete the achievement test (Appendix I).

Data Analysis

Descriptive Statistics

All the data analyses were performed using the SPSS® version 8.0 statistical software package. To draw a descriptive profile of the subjects involved in the study, frequency counts and percentage distributions were prepared for the demographic data obtained from the questionnaires. This analysis was done to facilitate further investigation of the relationship between various demographic variables and the scores obtained on the achievement test.

To summarize the characteristics of the data obtained from the achievement test, descriptive statistics such as mean, mode, median and standard deviation were done, where appropriate. Stem and leaf plots, normal probability plots and box plots were also done to test the normality of the obtained data.

Hypothesis 1 stated that subjects who have acquired CAD skills using AutoCAD® will obtain higher scores than subjects who have only manual patternmaking skills and no CAD skills. To test this hypothesis, a two sample t-test was done. Hypothesis 2 stated that subjects with CAD skills learned using AutoCAD® will obtain higher scores on the visualization test than the subjects with no CAD skills. To test this hypothesis, a two sample t-test was done.

To investigate the relationship between visualization skills and performance on the Lectra tasks, a Pearson correlation coefficient was calculated on the scores obtained from the visualization test and the scores obtained on the achievement test.

To understand the relationship between the response variables (Visualization test, Time taken to complete the Lectra tasks and the Achievement test) and the explanatory variables (number of apparel design courses completed, computer experience, number of years of employment in the apparel industry, and the most recent GPA), analysis of covariance was performed.

The results obtained from the data analysis are outlined in the next chapter.

CHAPTER 4

Results

Sample

For the purpose of this study, 30 students and graduates of the Clothing and Textiles program at the University of Manitoba were recruited. Fifteen students who had already completed 64.219 (Pattern Development) but had no CAD instruction for apparel design at the University of Manitoba were recruited for the No-CAD group. For the CAD group, 15 subjects who had completed courses in Pattern Development (64.219) and CAD using AutoCAD® (64.333 or 64.432 prior to 1998) were recruited.

Preliminary analysis of the data revealed that one of the participants in the CAD group took a substantially longer time in completing the Lectra task than the rest of the group. An exploration of the subject's background revealed that the subject had dropped out of the CAD course (64.333) during the middle of the term thus disqualifying her from the CAD group (Figure 1). Since the subject had some CAD experience, it was not possible to group her in the No-CAD group. Therefore, the data belonging to this particular subject was not included in the statistical analysis. Due to this, at the time of statistical analysis, the CAD group consisted of 14 subjects and the No-CAD group consisted of 15 subjects.

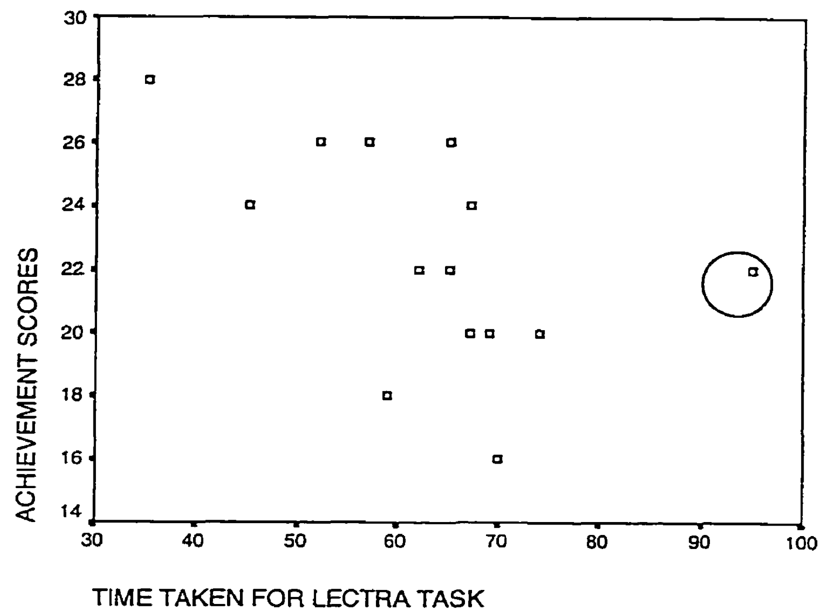

Figure 1. Scatter plot illustrating the outlier in the CAD group. The total time taken for Lectra tasks was measured in minutes.

Demographic Profile of the Sample

Age

The majority of participants (92.9%) in the CAD group were between the ages of 20 to 29 years (Table 1). Even though the majority of subjects in the No-CAD group were in their undergraduate program, there was more variability in their age range as opposed to the CAD group which contained current students and graduates of the Clothing and Textiles undergraduate program. This finding is interesting since it indicates a possibility that young subjects are less anxious about computer technology and are more likely to register for CAD courses than the subjects in the older age group.

Table 1

Age Range of the Subjects in the CAD and the No-CAD Groups

Age Range in Years	CAD	No-CAD
N	14	15
Less than 20	0	3
20-29	13	6
30-39	1	2
40-49	0	4

Program of Study

All the participants (100%) in the CAD and the No-CAD groups reported that their major was Clothing and Textiles. The CAD group consisted of 13 females and 1 male. All the subjects in the No-CAD group were females.

Thirteen participants in the CAD group reported their year in the program. The majority of participants in the CAD group were either in the last year of the program or had completed their degree (Table 2).

In contrast to the CAD group, the participants in the No-CAD group were in various years of the Clothing and Textiles program. Both groups included students from the graduate program in Clothing and Textiles. This was expected since the CAD group was recruited from the population of Clothing and Textiles students and graduates who had taken a CAD course (64.432 or 64.333).

Table 2

Number of Credits Taken by Subjects in the CAD and the No-CAD Groups

Credits completed	CAD	No-CAD
120 (Graduates)	8	4
90-117	4	2
60-87	1	4
30-57	0	5
Total	13	15

As opposed to this, subjects in the No-CAD group were recruited from the population of Clothing and Textiles students who had completed a pattern development course (64.219). Since the pattern development course is a prerequisite for a number of advanced apparel design courses, the majority of students interested in the design stream of the Clothing and Textiles program took it early into their programs. Since more students had completed pattern development, it was possible to recruit subjects from a larger population. However, it was not possible to recruit students from a larger population for the CAD group because students usually complete the CAD course in their graduating year.

More subjects in the No-CAD group (13 out of 15 participants) reported their GPA as opposed to the CAD group (Table 3). Since not all the participants in the CAD and the No-CAD groups reported their GPA, it was not possible to make deductions as to which group displayed higher academic performance. However, the available data suggested that the academic performance of the No-

CAD group (76.9% of the 13 subjects had GPA between 3 and 4.5) was better than the CAD group (70% had GPA between 3 and 4.5).

Table 3

Cumulative GPA Reported by Subjects in the CAD and the No-CAD Groups

Cumulative GPA	CAD	No-CAD
Below 3	3	3
3 - 4.5	7	10
Total	10	13

In order to assess the patternmaking experience of the participants, they were asked to select the number of apparel design courses they had already completed. Six apparel design courses were listed in the demographic questionnaire. The following table (Table 4) illustrates the number of apparel design courses completed by the participants in both groups.

As expected, the majority of subjects in the CAD group had completed more apparel design courses than the subjects in the No-CAD group. This was because the majority of subjects in the No-CAD group (60%) were in the first or second year of their undergraduate programs as opposed to 85.7% of the subjects in the CAD group who were either in the last year of the program or had completed their degree requirements. As a result, more subjects in the CAD group had had an opportunity to take several apparel design courses offered by the Department of Clothing and Textiles at the University of Manitoba.

Table 4

Number of Apparel Design Courses Completed by the Participants.

Apparel design courses completed	CAD	No-CAD
1	0	2
2	0	7
3	3	2
4	9	2
5	1	2
6	1	0
Total	14	15

Since previous studies outlined in the review of the literature indicated that performance on measures of achievement for computer technology are related to past computer experience, subjects' computer experience was assessed from their responses in the demographic questionnaire (Table 5). Computer experience was defined as being high if participants had completed at least 74.126 (Introduction to Computer Usage I). Low computer experience was defined as knowledge of two or fewer software packages and no computer science courses.

Computer Experience

More subjects in the CAD group (71.4%) had high computer experience as opposed to the subjects in the No-CAD group (60%) (Table 5). These results were expected since CAD courses are offered as electives in the Department of Clothing and Textiles at the University of Manitoba. Therefore, subjects who chose CAD courses were likely to have more interest in computers than other students in the program and were also likely to take more computer courses.

Table 5

Computer Experience as Reported by the Participants

Computer Experience	CAD	No-CAD
Low	4	6
High	10	9
Total	14	15

Employment History

Participants were also asked to report their employment experience in the apparel industry. The following table (Table 6) illustrates subjects' past employment experience in the apparel industry in years.

More participants in the CAD group (35.7%) had been employed in the apparel industry than the participants in the No-CAD group (13.3%), which is reasonable since the majority of subjects in the CAD group (85.7%) were either in the last year of their program or had completed their degree and therefore had an opportunity to work in the apparel industry.

Table 6

Number of Years of Previous Employment in the Apparel Industry

Time employed (years)	CAD	No-CAD
None	9	13
<5	4	1
5-9	0	0
10-19	1	0
>20	0	1
Total	14	15

However, it was also interesting to note that none of the participants in the CAD group who were previously employed had ever worked with industrial CAD systems. This was one of the criteria while recruiting subjects for the CAD group in order to avoid bias in the tests. This was because the researcher had theorized that subjects with previous knowledge of industrial systems will be better able to transfer their knowledge to the patternmaking tasks to be performed on Lectra industrial software as opposed to the subjects with knowledge of AutoCAD® and manual pattermaking.

Four of the five participants in the CAD group who were previously employed in the apparel industry also reported that they were currently employed in the apparel industry. In the No-CAD group, two participants were previously employed and one participant was currently employed in the apparel industry. The job titles held by these participants are listed in Table 7.

Table 7

Job Titles Held by the Participants in the CAD and the No-CAD Groups

Job Title	CAD	No-CAD
Retailer	3	0
Manager	0	0
Merchandiser	2	0
Designer	1	0
Patternmaker/grader/markermaker	0	3
All of the above	n/a	1

The CAD group consisted of six subjects who had been or were currently employed in the apparel industry. Three subjects in the No-CAD group were either currently employed or had been previously employed in the apparel industry. Of these three, one participant reported that she had been employed as a retailer, merchandiser, manager, and patternmaker/grader/marker. This participant was also the one who had been employed in the apparel industry for over 20 years. One participant reported that she had been employed as a designer and patternmaker/grader/marker. One participant reported that she had been employed as patternmaker/grader/marker. It was interesting to note that none of the participants in the CAD group who had experience in the apparel industry had any experience in patternmaking, grading or marker making.

In order to ensure that none of the participants had experience with industrial CAD systems, they were asked to report if they had used any CAD systems. Three participants in the CAD group reported that they had used other CAD systems. It was found that AutoCAD® was the CAD system used by all of these participants. Since the subjects were asked to work on patternmaking tasks using Lectra industrial software, in order to avoid biases it was desirable that none of the participants (CAD or No-CAD group) be experienced in using any industrial CAD software.

The majority (64.3%) of the participants in the CAD group had used AutoCAD® less than one year ago. Three reported that they had used AutoCAD® one to two years ago. Two reported that they had used AutoCAD® three to five years ago.

Describing the Data Obtained From the Tests

Exploratory data analysis was performed to test for the normality of data obtained from the Achievement (Chronbach's alpha=.44) and Visualization tests (Chronbach's alpha=.74) for the combined CAD and the No-CAD groups. Information obtained from stem and leaf plots, normal probability plots and box plots suggested that the data were normally distributed indicating that a random sample having a normal distribution was drawn for this study. To summarize the characteristics of the data obtained from the Achievement test and the

Visualization test, descriptive statistics such as mean, mode, median and standard deviation were obtained. The results of the descriptive statistics are outlined in the following table (Table 8).

Table 8

Details of Scores Obtained on Visualization and Achievement Tests

Test		CAD	No-CAD
Number of Subjects (N)		14	15
Visualization	Possible	20	20
	Mean	15.64	15.53
	Standard Deviation	1.91	3.85
	Maximum	18	20
	Minimum	13	4
Achievement	Possible	30	30
	Mean	22.43	20.67
	Standard Deviation	3.44	5.00
	Maximum	28	30
	Minimum	16	10

The participants in the CAD group obtained an average score of 15.64 on the Visualization test with a standard deviation of 1.91. The average score of the No-CAD group was 15.53 with a standard deviation of 3.85. These results are interesting since they indicate that even though the average scores of the subjects in both the groups were similar, the participants in the CAD group performed more consistently (standard deviation 1.91) than the No-CAD group (standard deviation 3.85) whose scores were more variable ranging from a minimum of 4 to a maximum of 20. The subject who scored the highest (20 out of 20) was in the No-CAD group and had never been employed in the apparel industry. However, she had taken 3 apparel design courses. It cannot be argued that simply taking more apparel design courses is related to higher visualization skills since all of the participants in the CAD group had completed 3 or more than 3 apparel design courses but did not get maximum scores on the test for visualization. For the purpose of future research, the researcher suggests that questions related to home sewing experience be asked in the demographic questionnaire to investigate if it is related to subjects' visualization skills.

The participants in the CAD group took an average of 60.64 minutes to complete the task on Lectra Systèmes with a standard deviation of 10.57. The No-CAD group took a mean of 59.87 minutes to complete the Lectra tasks with a standard deviation of 13.5 minutes. Where the CAD group took a minimum of 35 minutes and maximum of 74 minutes to complete the tasks, the No-CAD group displayed greater variability in the time required to complete the tasks (minimum of 45 and maximum of 95 minutes). These results were similar to the ones obtained by Fay (1990) who reported that subjects in the Design group (with pretraining in Natural Language) took longer to design their programs as opposed to the no-design group. In the present study, the subjects in the CAD group understood the concepts of computer aided design better and so asked fewer questions and worked on their own as compared to subjects in the No-CAD group who asked more questions and needed more help in visualizing the patterns on the screen. As a result, the CAD group took longer to complete the patternmaking tasks using Lectra Systèmes as compared to the No-CAD group.

The mean score obtained by the CAD group on the Achievement test was 22.43 with a standard deviation of 3.44. The participants in the No-CAD group who obtained an average of 20.67 in the achievement test with a standard deviation of 5.0 closely followed this score. As is obvious from the box plots in Figure 2, the scores of the participants in the CAD group were closer to the mean as opposed to the No-CAD group where more participants scored lower than the group mean. A few group members who scored exceptionally well pulled the score of the No-CAD group towards the mean

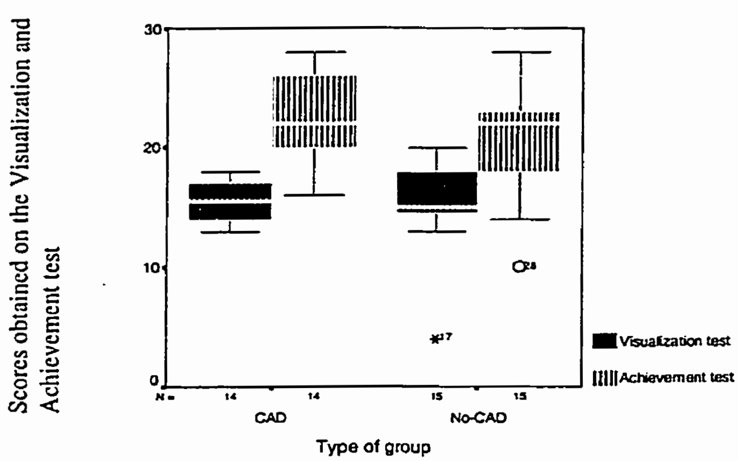

Figure 2. Box plots displaying scores obtained by subjects in the CAD and the No-CAD group

Inferential Statistics and Hypothesis Testing

Hypothesis 1 stated that subjects who have acquired CAD skills using AutoCAD® would obtain higher scores on the achievement test than subjects who have only manual patternmaking skills and no CAD skills (H_a: $\mu_{CAD} > \mu_{No\text{-}CAD}$). A two sample t-test was performed to test the null hypothesis of no difference (H_0: $\mu_{CAD} = \mu_{No\text{-}CAD}$). The means of the test scores were compared at the significance level of 0.05 for testing this hypothesis. The t value obtained was 1.09 (p = 0.279) with 27 degrees of freedom (Table 9). The p value obtained (0.279) was greater than the significance level 0.05. Therefore, the null hypothesis of no difference could not be rejected and the proposed alternative hypothesis suggesting that subjects with CAD skills as well as manual patternmaking skills will obtain higher scores than subjects with only manual patternmaking skills was not supported.

Table 9

Results of the Independent Two Sample t-tests

Tests		N	Mean	SD	t	p
Achievement	(CAD)	14	22.43	3.44	1.09	0.279
	(No-CAD)	15	20.67	5.00		
Visualization	(CAD)	14	15.64	1.91	0.096	0.244
	(No-CAD)	15	15.53	3.85		

Hypothesis 2 stated that subjects with CAD skills learned using AutoCAD® would obtain higher scores on the Visualization test than the subjects with no CAD skills (H_a: $\mu_{CAD} > \mu_{No\text{-}CAD}$). The null hypothesis of no difference (H_0: $\mu_{CAD} = \mu_{No\text{-}CAD}$) was tested. To test the null hypothesis, a two sample t-test was performed. A t value of 0.096 (p=0.244) with 27 degrees of freedom was obtained (Table 9). This probability was greater than the specified significance level of 0.05. As a result the proposed alternative hypothesis stating that the subjects with CAD and manual patternmaking skills will obtain higher scores than the subjects with only manual patternmaking skills was not supported.

To investigate the relationship between visualization skills and performance on the Lectra tasks, the Pearson product-moment correlation coefficient was calculated using the scores obtained from the Visualization test and the scores obtained on the Achievement test. A positive but low correlation of 0.170 was found (Table 10). A low negative correlation (r = -0.165) was also observed between the time taken to complete the Lectra tasks and the scores on the Achievement test indicating that participants who completed the Lectra tasks early were also the ones who performed better on the Achievement test (Table 10). The relationship is however not strong and so we cannot infer that the majority of participants who achieved higher scores on the Achievement test took less time to complete the Lectra tasks.

Table 10

Pearson Product-Moment Correlation Coefficients for the Scores Obtained on the Visualization and Achievement Tests and the Time Taken to Complete the Lectra Tasks

	Visualization	Lectra tasks*	Achievement
Visualization	1.000		
Lectra tasks*	0.048	1.000	
Achievement	0.170	-0.165	1.000

*refers to the total time taken to complete the Lectra tasks

An analysis of covariance was performed for each of the three response variables (Visualization, Time taken to complete Lectra tasks and Achievement) to control for the covariates which were number of apparel design courses completed, subjects' computer experience, number of years of employment in the apparel industry, and most current GPA. Although the relationship between number of apparel design courses completed and the scores on the visualization test ($p = 0.085$) was not found to be statistically significant at alpha level 0.05, there is a trend (Figure 3) toward the relationship between level of training and visualization skills (Table 11). No relationships were found to be significant among the three response variables and the demographic variables tested.

Table 11

Probability Values (p) Obtained From ANCOVA for the CAD and the No-CAD Groups

Variables	Achievement	Lectra tasks	Visualization
Apparel design courses taken	0.301	0.416	0.085
Computer experience	0.917	0.361	0.775
Time of previous employment	0.286	0.574	0.429
Most current GPA*	0.418	0.828	0.253

*Ten participants in the CAD group and 13 participants in the No-CAD group reported

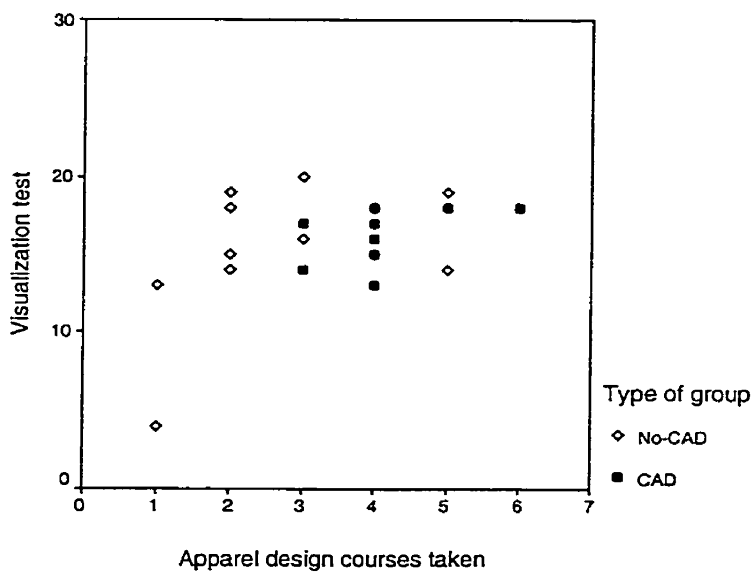

Figure 3 Scatter plot illustrating the relationship between number of apparel design courses taken and the scores on the visualization test.

CHAPTER 5

Discussion, Conclusion, Recommendations

The main purpose of this exploratory study was to investigate whether or not subjects with CAD skills acquired using AutoCAD® learn industry specific software more expeditiously and efficiently than subjects with only manual patternmaking skills. Also, the researcher wanted to investigate whether or not subjects with CAD skills acquired using AutoCAD® have more enhanced visualization skills as compared to subjects with only manual patternmaking skills. Results indicated that there were no significant differences between the two groups (CAD and No-CAD groups) on the scores for the Achievement and Visualization tests. These findings which were outlined in chapter 4, will be summarized and discussed in this chapter.

Sample

Thirty graduates and students of the Clothing and Textiles program participated in this study. The CAD group initially had 15 subjects who had taken courses in pattern development (64.219) and computer aided design (64.333 or 64.432 prior to 1998). However, preliminary analysis of data indicated that one student took a longer time to complete the Lectra tasks than the rest of the CAD group. An exploration of the subject's background revealed that she had not completed the CAD course using AutoCAD®. Since the subjects in the CAD group consisted of only those subjects who had completed a CAD course using AutoCAD®, the data obtained from this particular subject were not used. Therefore the CAD group finally consisted of 14 subjects. The No-CAD group consisted of 15 subjects who had completed a course in pattern development (64.219) but had no CAD (computer aided design) instruction at the University of Manitoba.

Summary of Results

On the basis of the literature review performed in Chapter 2, two hypotheses were formulated. Hypothesis 1 stated that subjects with CAD skills acquired using AutoCAD® learn industry specific software more expeditiously and efficiently. Hypothesis 2 stated that subjects with CAD skills acquired using AutoCAD® have enhanced Visualization skills as compared to subjects with only manual patternmaking skills. Two sample independent t-tests were performed on the scores obtained by the CAD and the No-CAD groups on the Achievement and the Visualization tests. Results revealed that there were no significant difference between the mean scores obtained by the two groups on each of the tests.

A low negative correlation ($r = -0.165$) was found between scores obtained on the Visualization test and the Achievement test. This indicated that in this study no significant relationship was identified between visualization skills and the ability to learn industrial CAD software. A non-significant relationship ($p = 0.085$) was found between number of apparel design courses completed and visualization scores indicating a trend towards a relationship between level of training and visualization skills for the subjects in this study. However, achievement scores were not found to be related to previous patternmaking experience (number of apparel design courses completed), computer experience, work experience (years employed in the apparel industry), and subjects' most current GPA.

In the following sections these results will be discussed in relation to previously reviewed literature under the following headings: Transfer of knowledge, Visualization, and Supplementing manual drafting with CAD.

Transfer of Knowledge

Dyck's (1987) Syntax Independent Access theory suggested that the semantics (basic concepts) of a programming language are independent of its syntax (rules governing the language) and so can be taught separately. She reported that if students are taught the semantics of programming in their natural language, they can transfer this knowledge to any new programming language. On the basis of this theory, the researcher had hypothesized that students who have acquired CAD skills using AutoCAD® (semantics) will learn apparel specific industry software (syntax) more expeditiously and efficiently than students with only manual patternmaking and no CAD skills. However, the results of the present study indicated that subjects with knowledge of manual patternmaking were able to learn industry specific software (see Table 8 for scores on the Achievement test) as well as subjects with knowledge of manual patternmaking and CAD.

A review of the literature indicated that the results of the present study were consistent with other researchers (Brandi, 1978; Lai, 1990; Belleau , Orzada, & Wozniak 1992; Clark-Marlow, 1996) who reported that computer aided design is as effective as traditional instruction in teaching principles of patternmaking.

Therefore, educators favoring traditional instruction can argue that subjects with manual patternmaking skills know the basic principles involved in creating patterns and so can use any tool - computers or a ruler and pencil. However, more and more design, patternmaking, grading and markermaking positions in the apparel industry require the knowledge of CAD (Sheldon & Regan, 1990; Racine, 1992; Boni, 1996b; Koch, 1996; Sanders, 1996; and Brandes & Garner, 1997). These reports suggested that students need to have a working knowledge of CAD to get jobs in the apparel industry. The research results of the present study did not report any significant gain when learning industry specific systems that can be explained by previous experience with AutoCAD®. However, experience with AutoCAD® did provide students with valuable CAD experience which might be essential when applying for a job in the apparel industry.

The results of the present study illustrated that these students do not need to acquire CAD skills using AutoCAD® before proceeding to industrial CAD software. They can learn CAD skills on an apparel specific industry system like Lectra directly after they have acquired the knowledge of basic manual patternmaking. It would then be worthwhile to investigate if students who acquire CAD skills using an industry specific software, learn other industrial CAD system more expeditiously and efficiently.

Visualization

According to Workman, Caldwell and Kallal (1999), visualization as it pertains to patternmaking is the ability required to imagine the rotation of a working sketch, folding and unfolding of pattern pieces, and changes associated with addition, subtraction, or movement of components of a style (e.g., yokes, seamlines, gathers). While developing two dimensional paper patterns, patternmakers can still fold darts and join seams to create a three dimensional form. However, manipulating patterns on a computer is a strictly two-dimensional process since the patternmaker cannot fold darts or join seams. Also, patternmakers often work with full size patterns when manipulating patterns manually but have to work with miniature patterns on the computer creating problems in visualizing the fit and proportion of pattern pieces.

For the present study, the Apparel Spatial Visualization Test (ASVT) developed by Workman, Caldwell and Kallal (1997) was used. The scores on the visualization test did not yield significant mean differences between the CAD and the No-CAD groups. These results were not consistent with the findings of Workman and Zhang (1999) who also used the ASVT to test the visualization abilities of students across different levels of training. They found that students with manual patternmaking and CAD skills obtained higher scores than students with manual patternmaking but no CAD skills and students with no patternmaking or CAD skills.

Workman and Zhang (1999) reported that these results indicated a relationship between the level of training and visualization abilities. This was consistent with the results of the present study which revealed that the number of apparel design courses completed was non-significantly related to performance on the Visualization test (significance 0.085). However, these results also indicate that domain specific training in computer aided design is not required for improving visualization capabilities. Moreover, no correlation was found between scores on the Visualization test and the Achievement test. This indicates that even if visualization skills are related to level of training, they are not related to how students learn industrial CAD software. In other words, training on CAD and manual patternmaking helped enhance students' visualization skills (Workman & Zhang, 1999) but good visualization skills do not ensure success in learning industrial CAD software. It is also possible that training on computer aided design systems requires specific visualization skills that cannot be tested using the ASVT. This is further substantiated by the fact that all the subjects in the No-CAD group reported problems in visualizing the pattern pieces on the screen while working on the Lectra tasks. They reported problems in recognizing the way darts, necklines, and armholes appeared on the computer screens. These problems were not encountered by the CAD group since they were accustomed to manipulating patterns on the computer screen. However, the CAD group reported that initially they had some problems in manipulating the patterns since the center front of the patterns is aligned horizontally in Lectra as opposed to vertical alignment in

AutoCAD®. Due to this, they had to readjust their thinking when working with the X and Y co-ordinates on the screen to draw lines, insert points and reshape darts.

Supplementing Manual Drafting with CAD

Since the first introduction of CAD in the industry, researchers have postulated that students need to know traditional manual patternmaking skills before learning CAD (Fesolowich, 1987; DiMarco, 1989; Resetarits, 1989; Becker, 1991). Other researchers agree that students need to know the basics of patternmaking (Sheldon & Regan, 1990; Kashef, 1991; Clark-Marlow, 1996; Boni, 1996b; Brandes & Garner, 1997) but also report that CAD teaches the basic concepts of drafting as well as the traditional manual methods and so can be used to replace manual patternmaking.

The results of the present study indicated that students with knowledge of manual patternmaking learned industry specific systems as efficiently and expeditiously as subjects with knowledge of manual patternmaking and CAD. So there is no advantage in using AutoCAD® software for teaching patternmaking if industry-specific software is available other than the fact that a majority of design, patternmaking, grading and marking positions within the apparel industry require the knowledge of computer aided design (Sheldon & Regan, 1990; Racine, 1992; Boni, 1996b; Koch, 1996; Sanders, 1996; and Brandes & Garner, 1997). Also, as Kallal (1983) suggested, CAD instruction in the classroom enabled the students to parallel the learning process and educational environment with experiential learning and industry practice. The results of the present study indicated that subjects with only manual patternmaking skills learned industrial CAD systems as well as subjects with CAD and manual patternmaking skills. However, the acquisition of CAD skills along with manual patternmaking skills increases the employability of the graduates which is the reason why most universities are integrating CAD in their curricula. Therefore, it is the researcher's recommendation that CAD skills continue to be taught in universities offering Clothing and Textiles programs after the students have learned manual patternmaking skills.

Summary and Conclusion

With the increasing use of computer aided design systems in the apparel industry, CAD skills are becoming an integral part of the job descriptions of entry level designers, patternmakers, graders and markermakers. To provide an edge to the graduates of their programs, Clothing and Textiles educators are incorporating CAD education in apparel design curricula. Due to the high costs of the apparel specific industrial CAD systems, a majority of clothing and textiles educators customize AutoCAD® to teach CAD skills for patternmaking. The generic nature of AutoCAD® had given rise to questions like: Is it useful to learn AutoCAD® before learning the industrial CAD systems? Does experience on AutoCAD® increase the Visualization capabilities of the students? To answer these questions, the present comparative exploratory study was designed. On the basis of the literature reviewed, two alternative hypotheses were formulated. Hypothesis 1 stated that students who had acquired CAD skills using AutoCAD® will learn to use an apparel specific industrial system more expeditiously and efficiently. Hypothesis 2 stated that subjects with CAD skills acquired using AutoCAD® will have more enhanced visualization skills.

Thirty students and graduates of the Clothing and Textiles program at the University of Manitoba were recruited for this study. Students who had already completed a pattern development course (64.219) and CAD (64.333 or 64.432 prior to 1998) were recruited for the CAD group and subjects who had completed a pattern development course (64.219) were recruited for the No-CAD group. Stepwise instructions for five pattern development exercises using Lectra industrial software were developed by the researcher. The participants in the CAD and the No-CAD group completed these tasks on the computer and completed a paper and pencil Achievement test. They also completed a paper and pencil visualization test called the Apparel Spatial Visualization Test developed by Workman, Caldwell and Kallal. A comparison of the performance of both the groups on the Achievement test and the Visualization test was determined by two sample independent t-tests. On the basis of the results obtained, the null hypotheses indicating that there was no difference in the means of the CAD and the No-CAD group for Visualization and Achievement scores could not be rejected. The two hypotheses were tested at a significance level of 0.05. A Pearson product-moment correlation coefficient indicated that there was no significant relationship between scores on the Visualization and the Achievement tests. Results of ANCOVA however revealed a non-significant relationship between level of training (number of apparel design courses completed) and visualization skills. Therefore, the aggregate results of this study indicate that participants with knowledge of manual patternmaking performed as well as the participants with knowledge of CAD and patternmaking.

Recommendations for Further Research

The results of this study indicated that the participants in the CAD and No-CAD groups learned apparel specific industrial systems similarly. The CAD group did not perform significantly better on the measures of achievement due to prior training with AutoCAD®. These results have serious implications for educators who determine curriculum content for apparel design programs. Further research needs to be done in the following areas:

1. The present study should be repeated with a larger sample size to investigate if students with experience on one apparel specific industrial CAD system learn other industrial CAD systems more expeditiously and efficiently. Experience with AutoCAD® did not contribute to students' achievement scores on the Lectra tasks indicating that students do not need to learn CAD skills using AutoCAD® before learning industry specific systems. This implies that they can learn industry systems directly after learning manual patternmaking techniques. But will this be the case for every new industrial CAD system? It would be interesting to investigate whether students will transfer knowledge of one apparel specific industry system to the other or will they need extended periods of training to start learning newer systems

as their companies acquire newer apparel design systems or they change jobs within the apparel industry.

2. While developing the Achievement test for the present study, the researcher had included questions that would draw upon the subjects' knowledge of Lectra and pattern development. Other questions were related to the rote memory of the subjects since that is usually an effective method of judging how well the subjects learned a new software. However, results of reliability analysis (Cronbach's alpha = 0.44) illustrate that this instrument needs to be revised extensively to get more internal consistency. The researcher also recommends the development of a computerized test consisting of pattern development tasks to be completed on an apparel specific industry system. This would provide a more reliable measure of testing achievement on an industry system.

3. Additional research is required to investigate whether or not the Apparel Spatial Visualization Test assesses visualization skills that are specific to computer aided design. The visualization problems reported by the computer aided design classes at the University of Manitoba and Racine (1992) indicate that students are unable to visualize the fit and proportion of the pattern pieces on the computer screen. More research needs to be done to determine if the ASVT is testing the visualization skills that are required for manipulating patterns on the computer screen.

4. Since a majority of universities offering apparel design programs cannot afford the high prices of industrial apparel design systems it is the researcher's recommendation that where industrial CAD systems are not available, CAD skills continue to be taught using AutoCAD®. This will provide the students of apparel design programs with the CAD skills required to obtain entry level positions in the apparel industry.

5. Further investigation is required to determine if basic and advanced patternmaking can be taught completely on CAD systems. Due to the heavy penetration of CAD in the apparel industry, students aspiring to get jobs in the apparel industry will need to be comfortable working in a highly computerized work environment. For this purpose, educators who determine curriculum content will need empirical evidence that suggests that pattern development instruction can be completely computerized. Further research needs to be done to provide evidence for the same.

6. For the purpose of future research, the researcher recommends that questions related to home sewing experience be asked in the demographic questionnaires to investigate if it is related to subjects' Visualization skills and Achievement on Lectra tasks.

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APPENDIX A

In Class Presentation - No-CAD group

Hello everyone,

My name is Deepti Mathur and I am a graduate student in the Department of Clothing and Textiles. Currently I am working on my master's thesis the purpose of which is to investigate the transfer of knowledge from AutoCAD® to apparel specific industrial software. With the increasing use of computer aided design (CAD) in the apparel industry, many universities are incorporating CAD in their apparel design curricula to provide their students with cutting edge technologies. A recent survey by Wimmer and Giddings (1997) indicates that about 39% of the schools in the United States are using AutoCAD® to teach CAD. However, the apparel industry does not use AutoCAD® for its pre-production processes. This gives rise to an important question: Are CAD skills learned using AutoCAD® transferable to apparel specific industrial software? This study is designed to assess whether or not the CAD skills taught using AutoCAD® are transferable to apparel specific industry software. I am hoping that the results obtained from this study will provide evidence relevant to that question.

To help us obtain information which will be useful for addressing this question, your participation in this study would be greatly appreciated. Participation in this study will provide you with an opportunity to develop patterns on the computer using the recently acquired Lectra industrial CAD system.

We would really like you to participate. If you are willing, please write your name and phone number on the Participation Form and return it to me.

This study will take approximately an hour and half of your time. This timeline may differ from person to person. You will be assured of complete confidentiality in your response since your names will only be known to me and will not appear anywhere on the published results of the study. After the study is complete, the record of names will be destroyed. At this point, I would also like to mention that you can withdraw from this study any time or refuse to answer any question without any detriment to your ongoing association with the University of Manitoba. Your identity will not be known to Dr. Fetterman who may be the instructor for your future courses.

You will have an opportunity to learn about the outcomes of this study by requesting a summary. You can indicate the same on the achievement test when you come to participate in the study.

If you would like to contact me in case of questions about my study or if you wish to withdraw at any time, I may be reached at 474-9292.

Thank you for your time. I am looking forward to working with you.

APPENDIX B

Participation Form

No, I do not wish to participate in this study________

Yes, I would like to participate in this study_________

If yes, please provide your:

Name____

Phone
number____

Address____

____

____

Thank You !!!

APPENDIX C

Telephonic Presentation - CAD group

Hello,

My name is Deepti Mathur and I am a graduate student in the Department of Clothing and Textiles. Currently I am working on my master's thesis the purpose of which is to investigate the transfer of knowledge from AutoCAD® to apparel specific industrial software. With the increasing use of computer aided design (CAD) in the apparel industry, many universities are incorporating CAD in their apparel design curricula to provide their students with cutting edge technologies. A recent survey by Wimmer and Giddings (1997) indicates that about 39% of the schools in the United States are using AutoCAD® to teach CAD. However, the apparel industry does not use AutoCAD® for its pre-production processes. This gives rise to an important question: Are CAD skills taught using AutoCAD® transferable to apparel specific industrial software? This study is designed to assess whether or not the CAD skills learned using AutoCAD® are transferable to apparel specific industry software. I am hoping that the results obtained from this study will provide evidence relevant to that question.

Since you are one of the people who took a CAD course using AutoCAD®, your participation in this study would be greatly appreciated. Participation in this study will provide you with an opportunity to develop patterns on the recently acquired apparel specific industry software - Lectra.

We would really like you to participate, so if you are willing please let me know about your time commitments so we can schedule a convenient time for you to explore Lectra.

This study will take approximately an hour and half of your time. This time may differ from person to person. You will be assured of complete confidentiality in your response since your name will only be known to me and will not appear anywhere on the published results of the study. After the study is complete, the record of names will be destroyed. At this point, I would also like to mention that you can withdraw from this study any time or refuse to answer any question you are not comfortable with.

You will have an opportunity to learn about the outcomes of this study by requesting a summary. You can indicate the same on the achievement test when you come to participate in the study.

If you would like to contact me in case of questions about my study or if you wish to withdraw at any point of time, I may be reached at 474-9292.

Thank you for your time. I am looking forward to working with you.

APPENDIX D

Informed Consent form

APPENDIX E1

Demographic Profile

Code: ____

Age:____

Major:____

Sex: M__ F___

No. of credits completed (If you have a degree, this will be 120 credits)

____

Cumulative G.P.A________________

Please check the U of M apparel design courses you have taken:

____Pattern Development (64.219) ____Construction (64.215)
____Pattern Drafting (64.435) ____Tailoring (64.336)
____Draping (64.323)
____Computer-Aided Design (64.432)
____ Apparel Design Certificate Program

Please check the University of Manitoba computer science courses taken:

____ None
____Introductory computer usage I (74.126)
____Introductory computer usage II (74.127)
Other (specify)_________________________

Check the CAD programs you have used.

AutoCAD____ ApparelCAD____
Fittingly Sew____ Dress Shop____
PC Pattern____ Symmetry_____
None____ Other (specify)_________________

Are you currently employed in the apparel industry? ___Yes ___No

If yes, how long have you been employed at the apparel industry ?

____

Have you previously worked in the apparel industry? ___Yes ___No

If yes, how long have you worked in the apparel industry?

____

What was/is the title of your job (patternmaker, marker maker etc.)

____

Have you used any other type of CAD system for pattern development, grading and/or marker making? ___Yes ___No

If yes, what CAD system have you used?

____

When did you last use AutoCAD® ?

____

APPENDIX E2

Demographic Profile

Code:____

Age:____

Major:____

Sex: M__ F___

No. of credits completed:____________________

Most recent G.P.A_______________

Please check the UM design courses you have taken:
____Pattern Development (64.219)
____Pattern Drafting (64.435)
____Draping (64.323)
____Computer-Aided Design(64.432)
____ Apparel Design Certificate Program
____Construction (64.215)
____Tailoring (64.336)

Have you used a computer before? ____Yes ____No

If Yes, what did you use the computer for?
____Games
____Word Processing
____Data Entry
____Graphics
Other (specify)______________

Check the CAD programs you have used.
AutoCAD____
Fittingly Sew____
PC Pattern____
None____
ApparelCAD____
Dress Shop____
Symmetry_____
Other (specify)_________________

Please check the UM computer science courses you have taken:
____ None
____Introductory computer usage I (74.126)
____Introductory computer usage II (74.127)
Other (specify)_________________________

Are you currently employed in the apparel industry? ___Yes ___No

If yes, how long have you been employed at the apparel industry?

____

Have you previously worked in the apparel industry? ___Yes ___No

If yes, how long have you worked in the apparel industry?

____

What was/is your job title (patternmaker, marker maker etc.)?

____

APPENDIX G

Explanation Text

Hello,

Thank you all for being here today. I hope you will enjoy using the Lectra patternmaking system.

If you look beside your computer terminals, you will find some forms, questionnaires and an instruction manual. First, please read and sign the informed consent form. Please note that you can withdraw from this study at any time. Then I ask that you supply us with some background information by completing the demographic questionnaire. Once you have completed these two forms, I will collect them from you.

As you already know, you are divided in two groups - the No-CAD and the CAD group. All of you are requested to work through some pattern development problems for which I have prepared step-by-step instructions in the accompanying instruction manual. Please read the instructions carefully while working on these problems. Before you start, I will provide you with a basic introduction to Lectra. You are most welcome to ask me questions during my explanation.

Turn to page 1 of your instruction manual. A glossary of terms that are unique to Lectra has been provided for your benefit. On your computer screen, you will find that along with a set of patterns, there are pull down menus on the top of the screen which is very similar in format to any Windows-based program.

These pull down menus can be activated by clicking button 1 of your mouse on them. Button 1 of your mouse is the left mouse button.

In the exercises you will often be instructed to click button 1 at various points on the patterns. One of these points will be what appears to be a square at the beginning and ends of entities like lines and arcs. These are called end points and may appear in blue or white.

Another type of point will be a crossmark. These are called characteristic points and may appear in white, blue or red. The red characteristic points are called curve points and are used to control curves of lines, arcs and circles.

While reading the instructions, you will often come across functions like **F1** and **F2**. These functions contain most of the commands that you will use in solving the pattern development problems. These function keys are accessible from the bottom right corner of the screen. Clicking on one of these keys with button 1 of your mouse brings up a corresponding menu.

The format or sequence may appear this way - **F3 - Modification - Reshape**. This instruction means, click on **F3** at the bottom right corner of the screen and click on **Reshape** under the **modification** menu. Along with the function keys, you will also be instructed to use some keys on your keyboard. These will appear within double quotes and will be in bold type. They may also appear as symbols. For example this arrow pointing downward (↓) stands for the **Down Arrow key** on your keyboard.

As a result of actions performed by you, certain dialogue boxes may appear asking you for **dx** and **dy** options. These represent the x and y axes on the computer screen. **dx** represents horizontal movement on the screen and **dy** represents vertical movement on the screen. In these **dx** and **dy** boxes you will have to enter certain measurements which will be provided to you. An example would be 0 and 1" and have to be typed as such in the dialogue boxes.

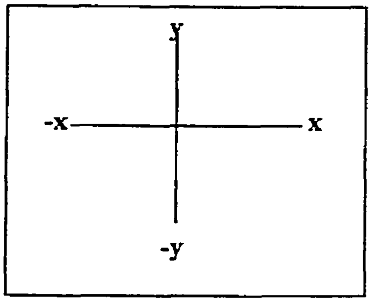
Before you start exploring Lectra, please note the starting time on page 3 of the instruction manual. When you are done, immediately note your finishing time on the same.

Text for the Flipchart

button 1	**Left mouse button**
button 3	**Right mouse button.**
□	**End Point.**
×	**Characteristic Point.**
F1, F3, F8	**Function keys.**
F3 - Modification - Reshape	Path for accessing the function you need.

Four Keyboard keys

↓	[↓]
Home	[Home]
Page Down	[PgDn]
J	[J]

dx and dy	**x and y axes.** **dx-** horizontal movement **dy**- vertical movement 
0 , 1" etc.	Numbers to be typed in the dialogue boxes that come up following an action performed by you.
Current Sheet	**Current Sheet** Available on the upper right corner of the screen
Curve Points	**Curve Points** Available on the status bar at the bottom of the screen

APPENDIX H
Instruction manual
Glossary of terms

button 1 — **Left mouse button**
button 3 — **Right mouse button.**

□ — **End Point.** Appears at the beginning or end of entities like lines and arcs. It may be white or blue in color.

× — **Characteristic Point.** May appear in white, blue or red. Red points are called curve points and they control the curves of arcs, lines and circles.

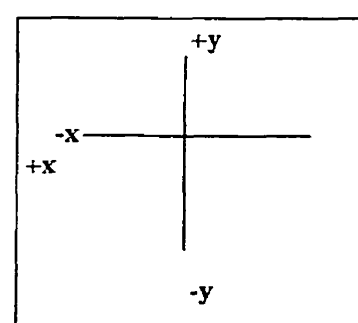
F1, F3, F8 — **Function keys.** Accessible on the bottom right corner of the screen. Clicking once on one of these keys with button 1 of your mouse will bring up the corresponding menu item.

F3 - Modification - Reshape — Path for accessing the function you need. This particular instruction means - Press the **F3** function and select **Reshape** found under **Modification** menu.

Four Keyboard keys

↓	[↓]
Home	[**Home**]
Page Down	[**PgDn**]
J	[**J**]

dx and dy — **x and y axes.**
dx- horizontal movement
dy- vertical movement



0 , 1" etc.	Numbers to be typed in the dialogue boxes that come up following an action performed by you. If double quotation marks appear after the number, type these marks after the numbers.
Current Sheet	**Current Sheet** Available on the upper right corner of the screen
Curve Points	**Curve Points** Available on the status bar at the bottom of the screen

Code____

Starting time ____________ **Finishing time**____________

Design #1

Manipulating single darts

Using the one dart sloper as the base, move the dart to the center front/waist intersection.

Procedure

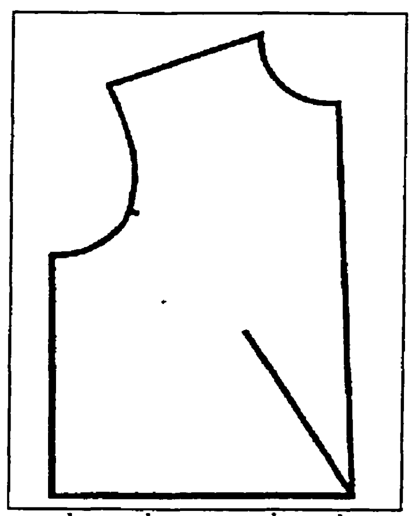
1) Click button 1 on the bodice front one dart sloper
2) Click on **Current Sheet.**
3) Press **Home.** This will enable you to view the pattern closely.

Extending the waist dart to the bust point

4) **F3 - Modification - Reshape**
   Click on the tip of the dart. A dialogue box will appear with options dx, dy, dl and Rotation.
   Press ↓ before entering **-0"24** beside dx. Press ↓ and enter **0** beside dy box.
   Press ↓ and the dialogue box will disappear. The dart is extended to the bust point.

Pivoting the waist dart to the center front/waistline intersection

5) **F5 - Folds - Pivoting Dart**
   Click button 1 at each of the following points:
   a) Tip of the dart (bust point)
   b) End point of the dart leg closer to the center front
   c) End point of the dart leg closer to the side seam
   d) End point of the new dart location (center front/waist intersection)



6) After the last click, a dialogue box appears asking you for the ratio of the dart. This is the percentage of the dart that will be moved to the new location. Since this will remain a one dart pattern, press the ↓ on the keyboard and enter **100** in the ratio option to move the entire dart.

Press **Enter** to submit this information.

7) **Page down** to view the modified pattern. Lectra creates a new sheet for the pattern you are working on whenever a major action is performed. For example, transferring darts or closing dart ends.

To smooth the waistline at the old dart location

8) **F3 - Modification - Attach**
Click twice on the blue end points marking the original dart location.

9) **F3 - Modification -Merge**
Click on the blue end point you have just attached in step 8 until it becomes a blue characteristic point.

F3 - Modification - Deletion
Click on the blue characteristic point. It disappears.

10) If the center front is not parallel with the **x- axis,**
F2 - Orientation - Rot 2 pt
Click once on each of the two blue end points at the center front/neckline intersection and the center front/waistline intersection.

To see the entire piece, press Home.

Shortening the bust dart

11) **F3 - Modification -Reshape**
Click on the dart tip (bust point). In the dialogue box that appears, press the ↓ before entering **0"24** beside dx. Press ↓ and enter **0** beside dy.

Press the ↓ and the dialogue box disappears.

Shaping the dart ends

12) Select **F5 - Folds - Dart Cap**
Click once at each of the following points:

a) The dart tip (apex of the dart)

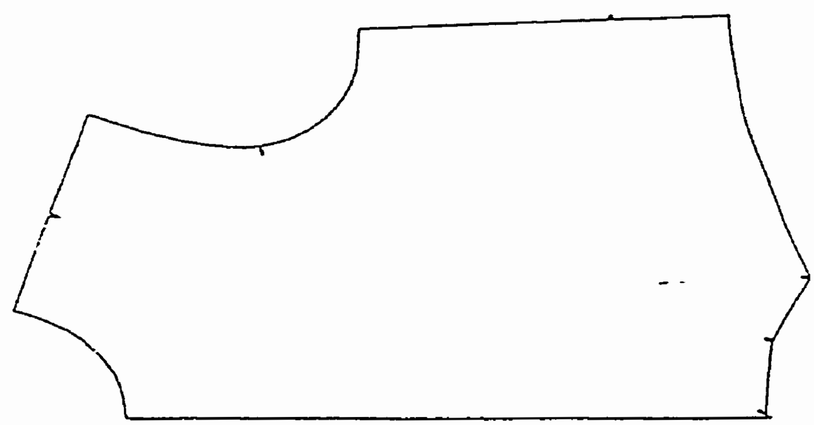
b) End point of the dart leg by the side seam

c) End point of the dart leg by the center front.

13) **Page Down** to view the modified pattern with the dart end closed.

Turn the page to look at the finished pattern.

The finished pattern looks like this:



Congratulations!!! You have successfully completed the first pattern development task .

Design #2

Manipulating two darts

Dividing the single dart into two and moving them to different locations

Procedure

1) Press **J** to view all the pieces on the screen
2) Click on **Current Sheet** on the upper right corner of the screen.
3) Select the bodice front one dart sloper by clicking button 1.

Extending the waist dart to the bust poin t

4) **F3 - Modification - Reshape**

Click on the tip of the dart. A dialogue box appears with options dx, dy, dl and Rotation.

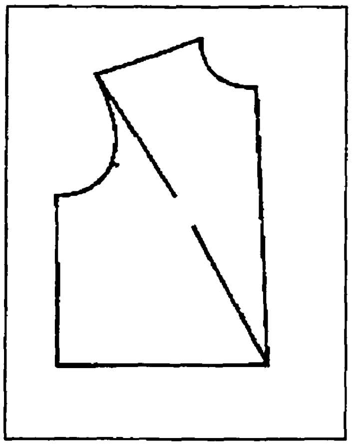
Press ↓ before entering **-0"24** beside dx. Press ↓ and enter **0** beside dy

Press ↓ and the dialogue box disappears. The dart is now extended to the bust point.

Pivoting half of the waist dart to center front/waistline intersection

5) **F5 - Folds - Pivoting Dart**

Click button 1 once at each of the following points:



a) Tip of the dart (bust point)
b) End point of the dart leg close to the center front
c) End point of the dart leg close to the side seam
d) End point of the new dart location (center front at waist)

a) After the last click, a dialogue box appears asking you for the ratio of the dart. This is the percentage of the dart that will be moved to the new location. Since this will be a two dart pattern, press ↓ and enter **50** in the ratio option to move half of the dart.

Press **Enter** to submit this information.

6) **Page Down** to see the modified pattern.

7) If the center front is not parallel to the x-axis,

F2 - Orientation - Rot 2 pt
Click once on the center front/neckline and center front/waistline intersections.

8) Press **Home** to view the pattern closely.

Pivoting other half of waist dart to shoulder/armscye intersection

9) **F5 - Folds- Pivoting Dart**
Click button 1 at each of the following points of the original bust dart:

a) Tip of the dart (bust point)

b) End point of the original dart leg closer to the center front

c) End point of the original dart leg closer to the side seam

d) New dart location at the shoulder/armscye intersection

9) After the last click, a dialogue box appears asking you about the ratio of the dart. This is the percentage of the dart that will be moved to the new location. Since this is the last dart of a two dart pattern, press ↓ and enter **100** in the ratio option.
Press **Enter** to submit this information.

23) **Page Down** to view the modified pattern.

To smooth the waistline at the old dart location

12) **F3 - Modification -Attach**
Click twice on the blue points marking the original dart location.

13) **F3 - Modification - Merge**
Click once on the blue end point you attached in step 12. It becomes a characteristic point.

F3 - Modification - Deletion and click on it the characteristic point. It disappears.

Shortening the darts

14) **F3 - Modification - Section**
Click on the characteristic points at the dart apex and at the waistline.

15) **F3 - Modification - Reshape**
Click on the dart tip (bust point). Move the mouse to determine which dart you have picked. If the waist dart moves with the

movement of the arrow enter the following information in the dialogue box that comes up.

Press ↓ before entering **0"24** beside dx. Press ↓ and enter **-0"10** beside dy.

Press ↓ and the dialogue box disappears.

If the shoulder dart moves with the movement of the arrow, enter the information in step 16 in the dialogue box that appears.

16) To shorten the shoulder dart enter the following information in the dialogue box that comes up.

Click on the tip of the shoulder dart.

A dialogue box appears.

Press ↓ before entering **-0"24** beside dx. Press ↓ and enter **0"22** beside dy.

Press ↓ and the dialogue box disappears.

Note: Both the center front/waistline and the shoulder darts have to be shortened.

Shaping the dart ends

17) **F5 - Folds - Dart Cap**

Click once at each of the following points for the center front/waist dart:

a) Tip of the dart (apex of the dart)

b) End point of the dart leg by the side seam

c) End point of the right dart leg at the center front

18) **Page Down** to see the modified pattern

19) Click button 1 once at each of the following points for the dart at the shoulder/armscye intersection:

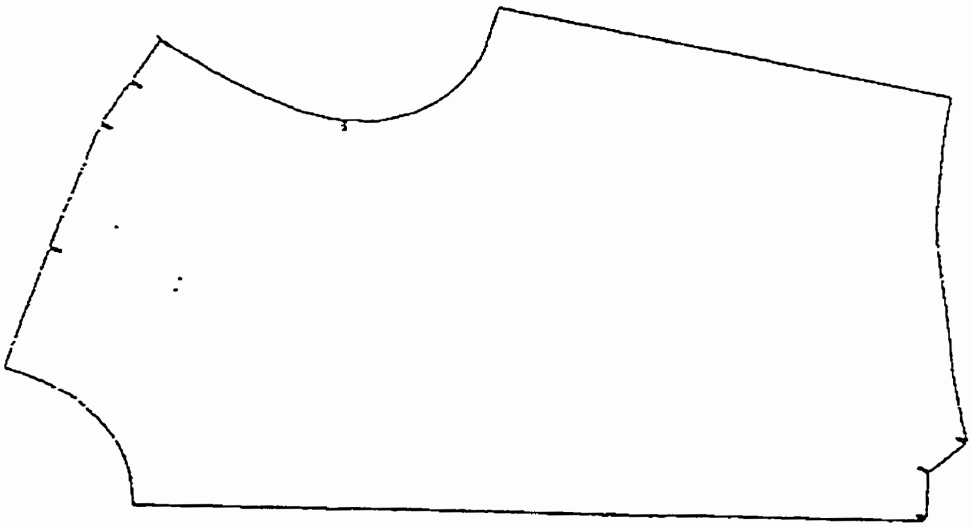
d) Tip of the dart (apex of the dart)

e) End point of the dart leg at the shoulder closer to the neckline

f) End point of the dart leg at the shoulder/armscye intersection

20) **Page Down** to view the modified pattern which appears with the dart ends closed.

Turn the page to see the finished pattern.



Congratulations!!! You have successfully completed the second pattern development task .

Design #3

Converting Darts to Flare

Starting from the two dart skirt front, pivot the darts to the hemline and convert them to flare

Procedure

1) Press **J** to view all the pieces on the screen.
2) Click on **Current Sheet**.
3) Select the skirt front by clicking button 1 once.

Measuring the distance from the dart tips to the center front

4) **F8 - Measurement - Length**

Click on the tip of the dart closer to the side seam. Holding the Ctrl key click on the center front line. Release Ctrl Key.

F8 - Measurement - Spreadsheet (size 10) to view the distance between the tip of the dart close to the side seam and the center front.

Record this distance as Distance 1=________

5) Click on the blue title bar of the spreadsheet and holding button 1, move it up on the screen. Click button 1 once on the close bar to get rid of the spreadsheet.

6) Repeat steps 4 to 5 to view the distance between the dart tip closer to the center front.

Record this distance as Distance 2=_________

Click on the blue title bar of the spreadsheet and holding button 1, move it up on the screen. Click button 1 once on the close bar to get rid of the spreadsheet.

Marking the new dart locations

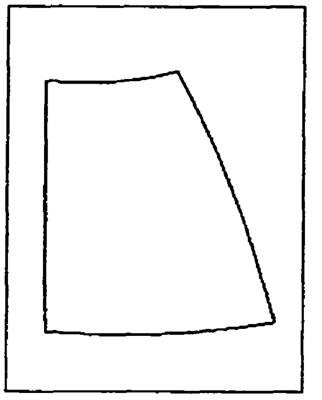
7) **F1 - Points - Add point**

Click on the end point at the center front/ hemline intersection and drag up on the hemline until the measurements beside the arrow read the length for Distance 2.

Repeat this step for the length taken for Distance 1.

Pivoting darts to new locations on the hemline

8) **F5 - Folds - Pivoting Dart.**
Click button 1 once at each of the following points for the dart closer to the center front:
a) Tip of the dart.
b) End point of the dart leg close to the side seam
c) End point of the dart leg close to the center front
d) New dart location (the characteristic point closer to the center front/hemline).



9) After the last click, a dialogue box appears asking you for the ratio of the dart. This is the percentage of the dart that will be moved to the new location.
Press ↓, enter **100** in the ratio option and press **Enter.**
10) **Page Down** to view the modified pattern.
11) Repeat steps 8 to 10 for the remaining dart.

12) **F2 - Orientation - Rot 2 pt**
Click once on the center front/waist intersection and the center front/hemline intersection.
Press **Home** to view the full pattern.

Shaping the dart ends

13) **F5 - Folds - Dart Cap.**
Click once at each of the following points for the dart <u>close to the side seam</u>:
a) Tip of the dart
b) End of the dart closer to the side seam
c) End of the dart closer to the center front.
14) **Page down** to view the modified pattern.

15) Click once at each of the following points for the dart <u>close to the center front</u>:
a) Tip of the dart
b) End of the dart closer to the center front
c) End of the dart closer to the side seam.
16) **Page Down** to view the modified pattern.

17) If the center front is not parallel to the x-axis,

F2 - Orientation - Rot 2 pt

Click on the blue end points at the center front/waistline intersection and center front/hemline intersection.

Press **Home** to see the entire piece.

18) To smooth the waistline at the original dart location,

F3 - Modification - Attach

Click only twice on each of the two blue end points that mark the locations of the old darts.

19) **F3 - Modification - Merge**

Click on each of the blue end points on the waistline that mark the location of the old darts until they become characteristic points.

20) **F3 - Modification - Deletion**

Click on the characteristic points that appear following the action in step 19. Also, click once on the notches and characteristic points that appear on the hemline.

Smooth the hemline

Click once on the notches and characteristic points that appear on the hemline

To add new curve points

21) Click on **Curve Points** on the bottom left corner of the screen.

22) **F1 - Points - Add Point**

Click on the center front/hemline intersection with button 1. Holding the Shift key, drag up to the location on the hemline where you need a curve point.

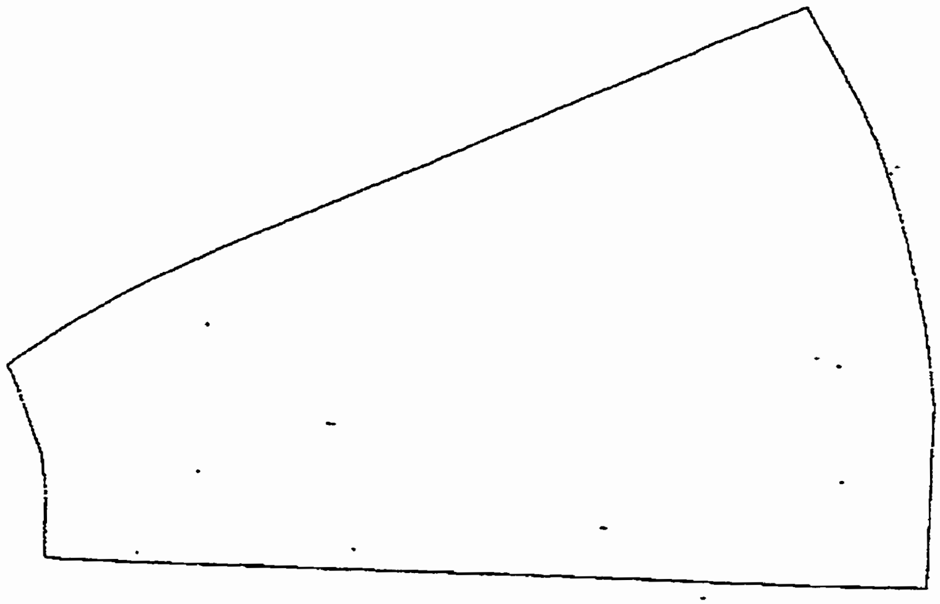
Repeat this step untill you have added at least 7 curve points.

23) **F3 - Modification - Reshape**

Shape the hemline by clicking and dragging repeatedly on these curve points.

24) Turn off curve points by clicking on **Curve Points** on the status bar at the bottom left corner of the screen to conceal them.

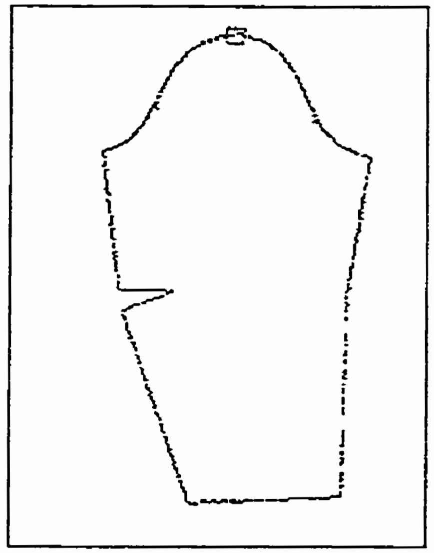
Turn tha page to look at the finished pattern.



Congratulations!!! You have successfully completed the third pattern development task .
Only two more to go!!!

Design # 4
Adding fullness to the sleeve cap

Procedure



1) Press **J** to view all the patterns on the screen.
2) Click on **Current Sheet**.
3) Select the sleeve by clicking on it once.

Breaking the capline in half

4) **F3 - Modification - Section**
   Click on the blue end point on the top of the sleeve cap.
5) **F3 - Modification - Detach**
   Click twice on the blue end point at the top of the sleeve cap.

Adding fullness to the sleeve cap

6) **F1 - Points - Add Point**
   Click once on the end point 1 (Fig. 1) and drag up on the wristline until the measurement beside the cursor reads 4"6.
   A characteristic point appears.
7) **F3 - Modification – Section**
   Click button 1 once on the characteristic point you just created
   It becomes an end point.
8) **F3 - Modification - Detach**
   Click button 1 twice on the end poin created in the previous step.


Fig. 1

9) **F3 - Modification - Stretch**
   Click once on each of the blue end points 1 and 4 (Fig. 1) of the sleeve ca
   A dialogue box appears.
   Press ↓ <u>before</u> entering **0** beside Shift X, press ↓ and enter **1"16** beside Shift Y.
   Press ↓ and the dialogue box disappears.

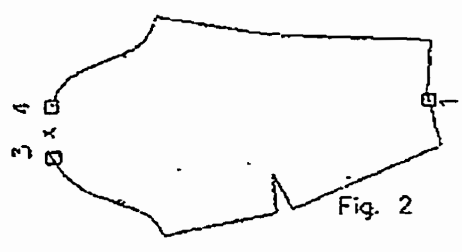


Fig. 2

10) Click once on each of the blue end points 1 and 3 (Fig. 2) of the sleeve cap.
   A dialogue box appears once again.

Press ↓ before entering **0** beside Shift X, press ↓ again and enter - **1"16** beside Shift Y. Press ↓ and the dialogue box disappears.

Adding height to the sleeve cap

11) **F1 - Points - Division**
Click once on each of the two blue end points 3 and 4 (Fig.2) on the sleeve cap. A dialogue box will appear at the top left hand corner of the screen asking for division number. Type **2** in this box and press **Enter**. A blue characteristic point appears between the two blue end points.

12) **F3 - Modification - Reshape.**
Click once on the characteristic point at the sleeve cap (located between the
two blue end points).
A dialogue box comes up.
Press ↓ and enter **-0"24** beside dx and **0** beside dy.
Press ↓ and the dialogue box will disappear.

13) **F3 - Modification - Pin**
Click button 1 once on all the end points and the notches on the sleeve cap except points 3 and 4.

14) **F3 - Modification - Move**
Click once on one of the blue end points on the top of the sleeve cap and holding the **Shift** key, click on the characteristic point.

15) Repeat the above step with the other end point.

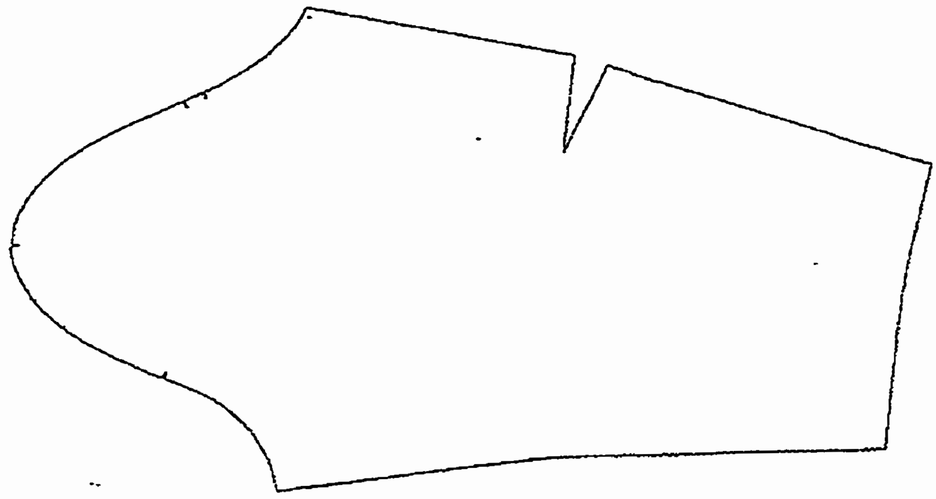
16) **F3 - Modification - Attach**
Click on the blue end point at the top of the sleeve cap and end point 1 on the wristline until all the end points are attached. The cap line is finished.

17) **F3 - Modification - Remove Pin**

18) **F3 - Modification - Merge**
Click button 1 once on end point 1 (Fig. 2).

19) **F3 - Modification - Deletion**
Click once on the characteristic point you just created in the previous step.

Turn the page to look at the finished pattern.



Congratulations!!! You have successfully completed the fourth pattern development task .

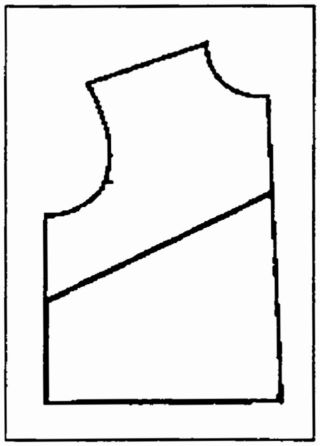
Design #5

Drawing a styleline and adding seam allowances to it

Procedure

1) Press **J** to view all the patterns on the screen.
2) Click on **Current Sheet.**
3) Select the one dart bodice front sloper by clicking on it once.

Shaping the dart ends



4) **F5 - Folds - Dart cap**
   Click once at each of the following points for the bust dart:
   a) Tip of the dart (apex of the dart)
   b) End point of the dart leg by the side seam
   c) End point of the dart leg by the center front
5) **Page Down** to view the modified pattern.

Creating the styleline

6) **F1 - Points - Relative point**
   Click on the side seam and armhole intersection and drag it towards the hemline until it reads **4" 22** and click once on the side seam line.
   Then click once on the neckline and center front intersection and drag it down towards the hemline until the arrow reads **4"22** and click once on the center front line.
   You will notice that two characteristic points appear at these locations.
   F1 - Lines - Straight and draw a line between these two characteristic points.

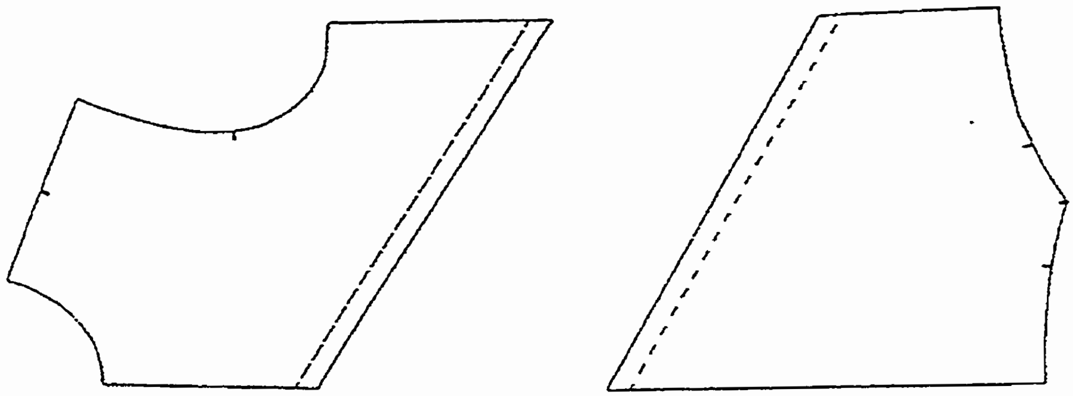
Cutting the bodice at the styleline

7) **F5 - Derived pieces - Cut2Pts**
   Click on the two blue end points marking the ends of the style line.
8) **Page Down** to view the modified pattern.

Adding seam allowance to the styleline

9) **F4 - Industrialization - Line seam**
   Click once on the style line and drag until the dialogue box on the upper left hand corner reads 0"16.
   Page Down and repeat this step for the other part of the bodice front.

The finished patterns should look like these:



Congratulations!!! You have now successfully completed all the five pattern development tasks using Lectra Systèmes software.

Please note your finishing time on page 3 of the manual and return it to me!!

Appendix I
Achievement Test

Code:____

Please circle the correct answer.

1) Which command is used to extend the dart tip to the bust point?

   a) Reshape

   b) Move

   c) Stretch

   d) none of the above

2) What is the use of the command **Dart Cap** ?

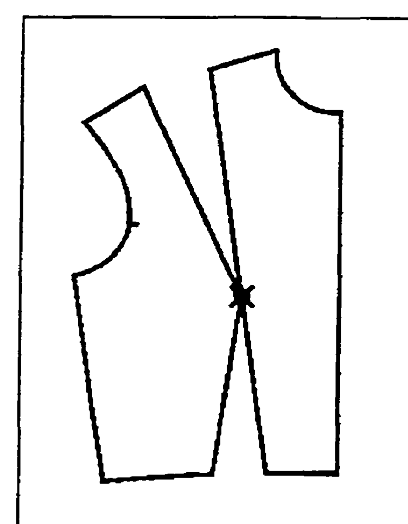
   a) Locating the bust point

   b) Reshaping the bust point

   c) Moving the dart

   d) Shaping the dart ends

3) Using the one dart sloper, what ratio (%) would you enter in the dialogue box while executing the **Pivoting Dart** command to create this design?



   a) **100**

   b) **50**

   c) **75**

   d) none of the above

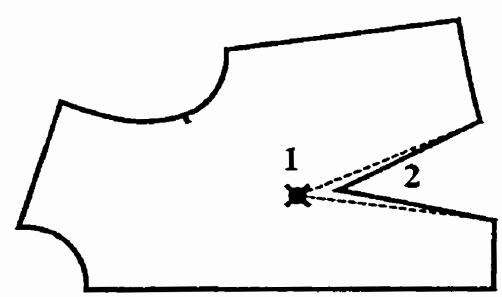
4) Which function key would you use to create style lines ?

a) **F1** b) **F2** c) **F3** d) **F5**

5) Which function key contains the commands that help you shape the ends of a dart?

a) **F1** b) **F2** c) **F3** d) **F5**

6) To shorten the bust dart in this problem, you have to move the dart tip by 1" from point 1 to point 2. What would you enter in the dx option of the dialogue box that appears when you click on the dart tip?



a) **1"**

b) **-1"**

c) **1" and 32th**

d) **0**

e) none of the above

7) In which menu do you find the function for measuring the distance between two points?

a) **F1**

b) **F3**

c) **F8**

e) none of the above

8) What does the spreadsheet command do?

a) measures the distance between two points

b) displays the distance between two points

c) none of the above

9) Circle the correct sequence of commands used to delete one of the end points that mark the old dart location

a) **F3 → Modifications → Merge; F3 → Modifications → Delete**

b) **F1 → Points → Add Point; F3 → Modifications → Delete**

c) **F3 → Modifications → Reshape; F3 → Modifications → Delete**

d) **F3 → Modifications → Section; F3 → Modifications → Delete**

e) none of the above

10) To correct the orientation of a pattern, the center front of which is not parallel to the x-axis, what selection of commands would you use?

a) **F1 → Straight → Line**

b) **F2 → Orientation → Rot 2 pts**

c) **F2 → Orientation → -90^0**

11) What happens when you press **J** on the keyboard?

a) the pattern piece on the screen is enlarged

b) the pattern of your choice is selected

c) all the patterns are arranged on the desk top

d) none of the above

12) What do the **dx** and **dy** options signify?

a) **dx** is the horizontal movement on the screen and **dy** is the vertical movement on the screen.

b) **dx** is the vertical movement on the screen and **dy** is the horizontal movement on the screen.

c) none of the above

13) To make the armhole curve smoother, which of the following commands will you use?

a) Stretch

b) Move

c) Reshape

d) none of the above

14) When pivoting darts, what is the first end point that you click on ?

a) bust point

b) left dart leg

c) dart tip (apex of the dart)

d) right dart leg

15) What key is depressed to view one current sheet on full screen?

a) **J**

b) **Page Down**

c) **Home**

d) none of the above

Thank you for completing the test. Please indicate below if you would like to receive a summary of results

____ Yes, I would like to receive a summary of results

____ No, I would not like to receive a summary of results

Certificate of Achievement

This is to certify that Mr/Ms ______________________________ participated in the study - "Adapting CAD and Visualization skills learned through AutoCAD® to an alternative apparel design system" conducted in the Department of Clothing and Textiles at the University of Manitoba. This study utilized Lectra Systèmes software for pattern development.

Researcher *Thesis Advisor*