

**CAD GRAPHICS UTILIZATION
IN THE DESIGN AND MARKETING PHASES OF
TEXTILE/APPAREL PRODUCT DEVELOPMENT**

by
Suzanne Marie Venkataraman

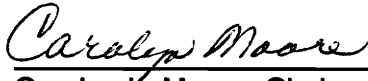
Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

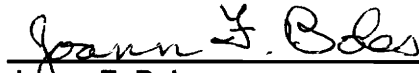
in

Clothing and Textiles

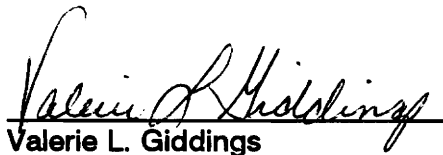
APPROVED:



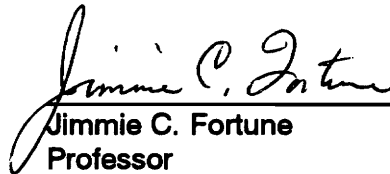
**Carolyn L. Moore, Chairperson
Assistant Professor
Clothing & Textiles**



**Joann F. Boles
Associate Professor
Clothing & Textiles**



**Valerie L. Giddings
Assistant Professor
Clothing & Textiles**



**Jimmie C. Fortune
Professor
Administrative & Educational Services**

**September, 1992
Blacksburg, Virginia**

L/D
5655
V855
1992
V465
C.2

C.2

ACKNOWLEDGEMENTS

The author wishes to express her sincere appreciation to her advisor, Dr. Carolyn L. Moore, for her friendship, understanding, patience, and encouragement during this long research process. To other members of her committee, Dr. Joann F. Boles, Dr. Valerie L. Giddings, and Dr. Jimmie C. Fortune, the author expresses her gratitude for their interest and guidance.

Appreciation is extended to Janet Bryant, Dove Robertson, Kathy Amos, Janet Wimmer and Peggy Quesenberry for their help and encouragement. Special thanks to Karen Watson, Farrell Doss and Yvette Harps-Logan whose friendship and encouragement she will always remember.

The author would like to thank her parents, Mr. & Mrs. Lionel Tessier & Mr. & Mrs. Robert Lavoie, for their support and love during many years of school. To her husband and best friend, Srinivasan Venkataraman, a special thanks for all his love, patience, understanding, and help for without it this research would not have been possible. And lastly, the author wishes to dedicate this research to her newborn daughter, Chantel Marie. May this research be an inspiration to her that "anything is possible with determination".

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	v
LIST OF FIGURES	vi
CHAPTER I. Introduction	1
CHAPTER II. Statement of the Problem	5
Objectives	5
Assumptions	6
Limitations	6
Definition of Terms	7
CHAPTER III. Review of Literature	9
CAD History in the Textile/Apparel Industry	9
Quick Response and Computer-aided Design	13
CAD Graphics used in Textile/Apparel Design and Marketing	15
Computers in Textile and Apparel Education	22
Industry Related Research	27
CHAPTER IV. Framework	29
Contextual Framework	29
Conceptual Framework	33
CHAPTER V. Methods	36
Description of the sample	36
Development of the Instrument	36

Description of the Final Questionnaire 37
 Data Collection 38
 Analysis of Data 39
 CHAPTER VI. Results and Discussion 40
 Description of Demographics 40
 Utilization of CAD Graphics 54
 Objective 1: 54
 Effects of CAD Graphics 58
 Objective 2 58
 Future Needs and Uses of CAD Graphics 60
 Objective 3 60
 CHAPTER VII. Summary, Implications and Recommendations 62
 Summary 62
 Implications 64
 Suggestions for Further Study 65
 REFERENCES 66
 APPENDICES 72
 VITA

LIST OF TABLES

TABLE 1.	Company Size and Primary Product Frequency Distributions	41
TABLE 2.	Educational Level and Number Of Years Designer Worked in Current Position	43
TABLE 3.	Industry Experience	44
TABLE 4.	Job Title	46
TABLE 5.	Prior CAD Experience Other Than The Present Company	48
TABLE 6.	Other CAD Experience	50
TABLE 7.	CAD Graphics Systems in the Company	51
TABLE 8.	Personnel Trained on the System	52
TABLE 9.	Personnel Actively Working on the System	52
TABLE 10.	Number of Hours Per Day Spent on the CAD System	53
TABLE 11.	Training Period to Become Proficient on a CAD Graphics System . . .	54
TABLE 12.	CAD Graphics Applications	55
TABLE 13.	Usage of CAD Graphics Systems	57
TABLE 14.	Benefits of CAD Graphics System	60

CHAPTER I

Introduction

The emergence of computers has altered the traditional processes of manufacturing goods as well as managing organizations. We are now amidst the information processing revolution in which speed and efficiency play key roles in all areas of manufacturing. In spite of the widespread acceptance of automation by many industries, the apparel industry has been hesitant to automate due to the continual changes in fashion which are dependent on the "taste" of the consumers.

But in today's highly competitive global business environment, which is evidenced by the import statistics, it is imperative for the apparel industry to adapt to the technological advancement. In 1960, less than 4% of apparel purchased in the U.S. was imported (Jarnow, Guerreiro & Judelle, 1987), and in 1990 it was estimated that up to 58% was imported (Truth in Fashion, 1991). The low cost of labor outside the U.S. and a fairly lenient import policy have encouraged many labor oriented industries like the apparel industry to become importers rather than manufacturers.

Unfortunately such a trend progressively results in the loss of employment and the eventual downfall of the industry. Hence, the apparel industry must realize that in order to be competitive and survive in the marketplace, the marriage of fashion and technology is essential. Adapting to new technology and operating with innovative strategies seem to be the most constructive method to counteract the low cost of imported apparel. Computers are available for use in all aspects of apparel product development, from the conceptual processes (design and marketing) through the pre-assembly processes (pattern making, grading and marking).

American apparel manufacturers cannot compete with the low cost of imported apparel, therefore they must adapt to a new organizational-product strategy called quick response (QR). By using QR manufacturers have an ability to design, produce, and deliver goods with a shorter lead time (Sheldon, 1988a). QR is advantageous because it allows the goods to be physically closer to the American market, whereby improved quality control and shortened lead times are possible. A quicker response can offer fashion retailers the advantage of buying closer to when consumers purchase the goods, therefore, helping to reduce forecasting errors by retailers (Sheldon, 1988a). Quick response and an increased utilization of technological innovation, such as computer aided design (CAD) are solutions to keep the American apparel industry alive.

The impact of CAD technology can be seen in the changing ways the apparel manufacturers perform their everyday duties. It is becoming imperative for future designers to have a working knowledge of CAD systems to become a part of the technological revolution. Since the industry is beginning to progressively accept and adapt to the new technology, it is essential for educational institutions to offer the computer courses to the students to enable them to successfully enter the job market. Many apparel manufacturers search for designers already familiar with CAD systems to head the introduction of CAD in their company (Fader, 1990). Becoming proficient on a CAD system takes a considerable amount of time and most businesses are understandably reluctant to spend the time and money to fully train a person. It is therefore advantageous economically if a company hires someone already trained.

Computer-aided design systems are continually improved or modified to suit the increasing demands of the apparel industry. It would be unrealistic to expect educational institutions to be constantly changing their curriculum to keep abreast of the changes in the industry. Nevertheless, it is essential to determine the basic expertise required for a graduate to successfully enter the job market. A study in 1989 showed only 17% of the colleges and universities in clothing and textiles were currently offering some training in CAD (Knoll, 1990c). Reasons for this include inadequate budgets of higher education to afford CAD equipment and lack of CAD training of faculty.

Research has been done by Fraser (1985) and Dagro (1989) to determine the attitudes of designers, patternmakers, and production managers toward computer-aided design in all phases of apparel product development. A study by Swanson (1987) identified the areas in which CAD could be used in the everyday activities of a designer. No research has been found in current literature on determining actual expertise or experiences required of CAD operators/managers in their work environment. CAD systems are presently available for all phases of apparel product development ranging from designing/marketing, pattern making, grading, to marker making. CAD graphics technology is one of the latest tools to become available to the textile/apparel industry. In 1985, less than five percent of the industry was computerized. However, according to the American Association of Apparel Manufacturers, one quarter of the estimated 40,000 plus fashion designers working in the United States in 1990 used computers. Though there has been a significant growth in computerization, the United States still lags behind Europe and Japan (Van

De Bogart, 1990). This research was undertaken to determine the utilization of CAD graphics in the design/marketing phase of textile/apparel product development. The information will help educators to incorporate graphics in their design and merchandising courses in order to help prepare students to enter the job market in the area of CAD graphics.

CHAPTER II

Statement of the Problem

The U.S. textile/apparel industry operates in a global market. The domestic industry cannot compete with lower wages paid in other countries, but it has operationalized the concepts of quick response through a variety of computer applications. Computer aided design graphics is a technology recently applied to the design and marketing areas of fabric and apparel production.

The purposes of this study were to identify CAD graphics utilization in the design and marketing phases of textile/apparel product development, to determine the effect of CAD graphics on the product development in the textile/apparel industry, and to identify future needs and uses of CAD graphics in the textile/apparel industry.

Objectives

1. Identify the utilization of CAD graphic systems in the design/marketing phases of textile/apparel product development.
2. Determine the effect of the uses of CAD graphics systems on textile/apparel product development.
3. Identify future needs and uses of CAD graphics in the textile/apparel industry.
4. Develop an instrument from which valid information can be drawn.

Assumptions

For the purpose of this study:

1. It was assumed that users of different apparel CAD graphics systems use their systems for similar applications.
2. It was assumed that the CAD operators/CAD managers would take the time to respond to each item of the questionnaire and answer each item truthfully.
3. It was assumed that the persons completing the questionnaire were competent in the area of CAD graphics due to their job description.

Limitations

1. Measure of user competence was indirect.
2. The study was limited to those mentioned in articles from the review of literature and those companies willing to participate.
3. Companies who use over-the-counter graphics software were not included in this study.
4. The size of the sample is small.
5. The study may be limited by the degree to which individuals could identify their own needs.

Definition of Terms

Apparel product development- The manufacturing of ready-to-wear clothing for the mass market that includes designing, marketing, patternmaking, grading, cutting, sewing, and the assembling of garments.

CAD- acronym for computer-aided design. The use of computer systems to assist in the creation, modification, analysis, or optimization of apparel.

CAD Graphics- The display of colors or objects in the form of garments, textiles, pictures, and lettering, etc.

Data Tablet- electronic grid which transmits location information to the computer with the help of a pen or mouse.

Digital Scanner- a device used to input images into a CAD graphics system.

Draping- the creation of a garment by positioning a piece of fabric over the contours of a model.

Grading- the increasing and decreasing of a production pattern to form a size range.

Interface- area where programs or systems meet and act on or communicate with each other.

Marker making- the making of a cutting guide (outline) of all production pattern pieces for one style in one or more sizes.

Output- information fed out of the computer usually in the form of a print out from a printer.

Pattern Block- a basic or master pattern from which other patterns are made.

Pattern design- the method of making a 2-dimensional representation for clothing using pattern blocks and/or master patterns to meet apparel production specifications.

Quick Response- the ability to design, produce, and deliver goods with a shorter lead time (Sheldon, 1988a).

Texture Mapping-the creation of fabric fullness and cling to simulate a realistic sense of fabric fold and contours with true properties of fabric on a CAD graphics system.

Tolerance- limits placed on optimum specifications in production.

Yarndyes- an industry term for any woven textile design.

CHAPTER III

Review of Literature

A background knowledge of the introduction and use of computer-aided design (CAD) in the textile/apparel industry and the importance of CAD in the classroom was necessary to establish a basis for this study. Therefore, selected literature is presented on 1) CAD history in the textile/apparel industry, 2) Quick Response and CAD, 3) CAD graphics used in textile/apparel design and marketing, 4) computers in textile and apparel education, and 5) related research.

CAD History in the Textile/Apparel Industry

Like all other aspects of manufacturing, fashion design is now changing from a manual process to high-tech with the introduction of CAD. This advancement in technology is essential for the apparel industry today to face the competition of imports and to survive. CAD technology is a key factor in improving the apparel industry's competitive edge in a world market. The use of CAD has increased steadily since its introduction in the 1960's.

During the sixties computerized grading was introduced to the industry. This type of system allows the user to digitize the sample pattern and the grade rules into the computer. After the user inputs the grade rules, the computer generates plots of all the required sizes and stores them for future use. The primary benefits of grading by computer are time reduction and accuracy. It takes approximately ten times as long to grade by hand than to grade by using a computer (Hirschorn, 1983). The

computer is 100% precise when correct grade rules are entered correctly. When patterns are graded by hand certain variables such as visual impairments, variation of alignment of tools, and other human errors in the mechanics of grading can result in inaccuracies. When a computer is used for grading the process is standardized. The computer does not change measurements and therefore, uniformity of grade is consistent from style to style (Hirschorn, 1983).

Marker making by computer was introduced in the early 1970's. Benefits of computerized marker making are that the operator can visualize many yards of fabric on the screen at one time. And one can easily manipulate various configurations of pieces on the screen in order to achieve the minimum usage of fabric according to various constraints for a particular marker. Markers can be stored for future reference or for later use. If slight modifications are needed from one season to another then the style can be modified and can be replaced in an existing marker. Some adjustments may be required by the marker maker but markers can be planned ahead, made quickly, and adjusted in a short period of time. These capabilities do not exist when making markers manually (Kosh, 1990). Other benefits are the reduction in lead time, increased flexibility, and savings in fabric usage. An average fabric savings of 3-5% is accepted in the apparel industry as a primary justification for purchasing CAD for marker making.

Automatic marking was also introduced during the 1970's. Automatic computerized marking is when a marker, which today can consist of 10 - 1,000 pieces, is made without human intervention or assistance while attempting to minimize the total length of material. The operator can enter one or more of several marking

constraints such as tilt, flip, stripe/plaid, shading, cutting, etc. into the computer prior to the automatic process (Gordon, 1989). Automatic marking usually cannot achieve the same level of material utilization as a human operator because the computer cannot duplicate the human brain in many special tasks which are needed in marker making. But it is being used successfully in some situations such as in costing markers where quick estimates are needed, where automatic marking matches the efficiency of the human operator in simple markers, or where severe constraints limit the options in the marker. Some areas of the industry, such as menswear, use automatic marking successfully since they have limited size markers and severe constraints (as to how the pattern must be placed on the fabric) which limit both the number of possibilities and efficiency that either human or machine may achieve. A strategy used by many companies is to use both machine and operator for automatic marking. The person should be used to perform the complex recognition, planning, and reasoning tasks; the capability of the machine should be used to perform fast and precise calculations (Gordon, 1989).

In the early 1980's, pattern design was introduced. Patterns can be altered and drafted in many different ways when the pattern design system (PDS) is used. The development of PDS by computer has automated product development and allowed the pattern maker to store existing patterns in libraries and retrieve them when needed. Because a pattern can be stored in a library, one needs to put it into the computer only once. Then patterns can be retrieved and modified to make new patterns without changing the existing ones. PDS software is both time saving and accurate.

Reported studies indicate positive acceptance of pattern design using CAD.

However, companies with fewer fashion changes, such as menswear, seem to find CAD for pattern design more useful than companies with many fashion changes. Staples (1990) reported a low use of CAD for pattern design and a wide variation of uses among the companies she surveyed. Many companies used CAD to make pattern changes, grade patterns, to make production patterns, and to make first patterns. Companies with low fashion change seem to use PDS more since they are able to streamline a variety of operations at once. The transition for low fashion manufacturers from manual pattern design to CAD is simpler and more quickly implemented than for high fashion manufacturers. Most of the pattern making done in low fashion companies were alterations to existing patterns, and an indepth knowledge of pattern making was usually not needed. It is questionable whether this is true pattern making or just pattern alterations. Also in Staple's study most pattern makers had responsibilities other than pattern making to fill their work day.

High fashion companies were less likely to use CAD pattern making because of the nature of the pattern designer's job and the type of product styling. High fashion manufacturers use a variety of specific pattern design skills which are complex, and the turn around time required for new patterns is much shorter than in low fashion companies. Staples (1990) found that computer use for pattern design is not widespread and the adoption of computers for pattern design is still low and slower than previous projections from other studies (Sheldon, 1988a). The most frequently cited reason for not computerizing pattern making was the necessity to purchase additional terminals specifically for pattern making. The terminals which were in

house were used mostly for grading and marking. Computer use for grading and marking is still much higher than for anything else.

CAD graphic systems for fashion design and marketing were introduced in 1983 (Wilhelm, 1983). This type of system allows the user to input fabrics, sketches, and photographs into the CAD graphics system via a scanner or video camera. Once the item is in the system one can then recolor, enhance, or alter the item in many ways according to the design software used (Kosh, 1989a). Companies are using CAD graphics as an idea or creative tool, as a conceptual or decision making tool, and as a presentation and/or marketing tool (Microdynamics, 1990). Benefits of using CAD graphic systems are that the design cycle is shortened, some/all garment samples are eliminated, some/all artists for textile/fabric rendering are eliminated, and more time for additional ideas to be presented is allowed. In the early years of CAD systems, it was thought that only the companies which generate sales in excess of \$50 million would purchase these types of systems. CAD systems are now affordable to smaller companies as well since the price of systems has been lowered with the introduction of the PC based CAD graphics system (Van De Bogart, 1988a).

Quick Response and Computer-aided Design

The U.S. apparel industry has been fluctuating economically since the drastic increase in textile and apparel imports. Development of quick response (QR) strategies is one of the many ways the industry is trying to cope with the situation. QR is defined as the ability to design, produce, and deliver goods to the consumer with a shorter lead time (Sheldon, 1988a). Since the current strategy is retail

dominant, QR has been suggested as a method to improve U.S. apparel manufacturers' competitive position in the world market (Kincade & Cassill, 1990).

Retailers are buying closer to the market and there is a gradual change in many markets to buy in a single shot with little or no reorder intent. Retailers also expect immediate reorders for goods which are "hot" items. Retailers who provide a constant flow of new and fresh items in their stores every two to three weeks are getting customers more frequently (Weintraub, 1987). Because of this retail need, manufacturers who are fashion oriented must implement QR in the initial decision-making process - the design and merchandising phase of their business. Many manufacturers are implementing QR through modernization and technological development (Weintraud, 1987). Shorter lead times will allow the retailer to place orders closer to the time consumers purchase, and therefore will reduce fashion forecasting errors (Sheldon & Regan, 1990).

Computerization of various processes and improved communication are strategies used in shortening response time. Sheldon (1988a) reported forty-seven percent of apparel designers felt that more knowledge of CAD would help designers shorten response time between manufacturers and retailers. Although computerization has been available for many years, adoption has been slow by some companies due to the high initial investment. Quick response may be the factor needed to push apparel manufacturers to computerize.

The computer aided design graphics system is a tool which can be used to relieve the designer of some of the time-consuming and repetitive tasks leaving more time for executing design ideas. Some apparel companies consider CAD graphics

systems as a vital part of the total finished goods production cycle. It is a link from product design to the production process. Utilizing CAD graphics can eliminate the need to look at some samples and saves days in the final garment approval process. Hand painted woven textiles (yarndyes) normally take up to two weeks to complete, but now with CAD graphics, users can take two days to make 20 color variations on that yarndye (Van De Bogart, 1988b). There is a shorter lead time for production when the more correct information is given to the mills for the samples the first time. Advantages of designers using CAD graphics systems are the ability to scan in images or develop images in the system and then recall them, duplicate them, and modify those images quickly. Computers will not replace the creative minds of designers but is a tool that can be used to make the production of design ideas easier, and perhaps enhance creativity itself (Sheldon & Regan, 1990; Van De Bogart, 1988c).

CAD Graphics used in Textile/Apparel Design and Marketing

In 1984, Microdynamics introduced the first computer-aided design color graphics system for the apparel designer. This system started the wave for the future in CAD color graphics systems for the apparel/textile industry (Microdynamics, 1990). Now leading companies such as Computer Design Inc. (CDI), Infodesign, Microdynamics, and ModaCad offer advanced systems for the designer, artist, and merchandiser who are involved in the design cycle of the sewn goods industry. With high resolution displays, powerful graphics, and carefully selected input and output devices, these

systems provide the users with a creative tool, a decision making tool, and a presentation tool to be used in their everyday work environment (Kosh, 1989a).

The first generation color graphic systems on the market provided the user with the capability to sketch and paint using a data tablet with a pen or mouse. The pen or mouse aided the selection of tools in the software such as pens, brushes, and texture brushes of various sizes. Input devices were not available and output devices consisted of a Polaroid instant camera with a hood to fit over the front of the screen. First generation printers required over an hour to produce printouts and had only 60 colors. Customers who bought systems in that time period were committed to its potential in reducing sample costs. Then a camera was added as an output option which allowed pictures to be taken from a device which had a 35mm camera attached. Slide film as well as regular print film could be used in the camera. One had to process the film at a photo studio. In 1985, black & white video camera was available as an input device as well as an early ink jet printer for output. This printer had a capacity of 125 colors and the output time was reduced to minutes. Although this printer provided acceptable output on several media, the required maintenance and lack of dependability of the printer in the apparel design field are problems (Microdynamics, 1990).

In 1986, second generation systems were introduced which supported input of images via a color video camera with a screen resolution of 512 pixels by 408 lines. With 32,000 colors available on the screen at one time, textiles, photographs, and accessories could be input into the system in true color. Software updates at this time included image processing tools capable of manipulating full color images such

as rotating, scaling color changes, multiple imaging, and animation. Colors could be mixed on the screen using an on-screen palette or altered using numeric values in hue, saturation, and value or by manipulating red, green, and blue values. The introduction of the color digital scanner in 1987 to the design systems provided a high resolution input of fabrics, paintings, photographs, and magazine pages. The color digital scanner can scan in items as large as 11 x 17 inches. Depending on the software used, the scanner can zoom in on any image and correct color if necessary. The scanned-in image is then saved on the hard drive of the computer (Waddell, 1988).

Color video cameras are also available for input into CAD graphics systems. These color video cameras are 300, 500, and 700 line cameras and are used when inputting a 3-D object into the CAD graphics systems and/or large fabric repeats. The resolution of the video camera is usually not as sharp as when scanning in an image with a color digital scanner. This also depends on the user's expertise of handling the camera. Also introduced were new color thermal printers for output devices (Microdynamics, 1990).

Draping on CAD graphic systems was introduced in the late 1980's. Draping technology is the creation of fabric fullness and cling to simulate a realistic sense of true fabric properties in the formation of folds and contours. Simulating a fabric and garment reduces high costs in initial creation of fabrics and samples. Draping allows apparel companies to better compete in today's QR marketplace. Draping reduces both time-to-market as well as material and labor costs. New developments in draping technology allow designers to simulate finished goods and fabrics on life-like

models. This new development is called texture mapping in 2-dimension (2-D). Textile designers and manufacturers can accurately visualize fabric and finished garments before a sample is designed and produced. The textile is developed and then draped in 2-D which simulates 3-dimensional (3-D) and the image looks so real it can be used for storyboards, advertisements, and catalogs. Manufacturers can drastically reduce sample making costs by seeing the design before it is actually made (Freedman, 1990; Van De Bogart, 1990). Designers can determine where the highlights and shadows will show on the model. Fabric can be moved, rotated or scaled so that the size, direction, or position of fabric can be easily altered to the designer's specifications. A designer can visually move the pattern on the overlaying fabric and determine the location or size of the repeat as it would appear on the finished garment. By achieving this realistic rendering on the screen, the completed 2-D image appears to have a 3-D depth. These product development features speed the conceptual process by allowing the designer faster visual realization of an idea (Cedrone, 1991).

Though there are some 3-D design software packages available on the market, they are not as user friendly as the 2-D design software. A wire-frame image (mannequin) which has 3-D perspective and the ability to rotate to any angle can be draped and sculpted with fabric simulating the mechanical properties of the actual cloth. From there, the draped image transforms into a flat pattern which can be used as a first pattern (Friedman, 1991). This first pattern is very crude and one must alter it greatly in order to cut a sample from it. Due to the amount of alterations required, there is great controversy in the CAD marketplace whether these type systems are

actually as useful as they appear. In most cases more research and development is needed in the area of 3-D graphics and fabric properties in order for them to be efficient in the apparel industry. With the rapid revolution of computer technology, this process will likely will be perfected in the near future (Henderson, 1986; Martel, 1990).

Firms that use CAD graphics systems include men's and women's sportswear, sweaters, uniforms, bed linens, shoes, accessories, textiles, and furniture. The systems are being used to determine colorways, make style changes, design and recolor fabrics, prepare in-house and buyer presentations, prepare marketing presentations, and much more. CAD graphics systems cannot be based solely on return on investment (ROI), as marking and grading, and pattern making CAD systems which have been on the market for 20 years, and show an understood payback. A CAD graphics system may not produce a payback as quickly as expected. Therefore, such systems should not be bought on this economic premise. The payback of a CAD graphics system is difficult to quantify. It is a revenue enhancer rather than a cost saver (Rutberg, 1990). The CAD graphics system saves labor and speeds up the design and production process. Color stories and garment designs can be selected prior to producing costly prototypes and textile paintings. These systems will not totally replace every final sample or sometimes final painting to be used in manufacturing.

There are CAD graphics systems which can be used to develop yarndyes, prints, and knits from the initial creation to the production in the mill. In print design original croquis can be developed right in the CAD graphic system and then color separations

can be made. Direct interface to print machinery is also available with some systems. Yarn dyes can be developed by inputting the warp and fill yarns into the CAD graphic system and then weaving the actual fabric on the screen. Peg (warp) and draft (filling) plans along with manufacturing and layout plans can be generated for the actual weave on some systems along with interfacing to the actual looms. Knits can be developed in exact gauge sizing and the ability to graph a knit and then automatically change the size of the overall stitch or design can be done on some CAD graphic systems. Some systems can be interfaced to actual knitting machinery (Cedrone, 1991). The ability to recolor textiles has been proven to be an important area for CAD graphics systems and can save companies a lot of money. When selecting colorways for fabrics as well as for garments, a designer may view five or more colorways of a design to choose the final combination. Paintings by freelance artists cost anywhere from \$ 60 - \$350 each and can take from a day to a week to produce. Paintings on CAD graphic systems can reduce this phase from minutes to a few hours in time to produce several colorways and some systems can reduce the final cost of the painting for the textile mill (Beard, 1990). Such systems were developed to provide a quick response solution to the usually long and slow creative process of designing fabrics and garment lines. CAD graphics systems are generally conceptual tools, decision making tools, and presentation tools. The main uses by some companies are inputting or developing textiles for color changes, viewing selected fabrics on silhouettes via texture mapping, merchandising color stories and lines on screen, and developing catalogs of seasonal lines.

Though there are a lot of good features of CAD graphics systems, many companies are deciding to wait for further development in the area of color matching and printing technology. There is inconsistency in color matching between the monitor color and the printer color. The monitor uses transmitted light for displaying color. The printer has pigment color which is reflected light. Monitors also create different shades of color from the center of the monitor outward (Kosh, 1989c).

This color difference may or may not be distinguishable to the naked eye depending on the CAD graphics system. Color matching between two different media to actual fabrics has always been a problem. While the CAD graphics system does not solve this problem completely, it does allow color changes to be made quickly, and therefore most companies feel it outweighs some of the color matching problems (Kosh, 1989c).

All color used in designing cannot be created on the monitor. Fabrics which are woven become three-dimensional so the light reflection changes the look of the color. The printer may not be able to produce the exact color match, but it may be a close enough match to be acceptable rather than having the designer painting it manually. Most companies find the closest color acceptable and will often add a paint chip or fabric swatch onto the presentation board which represents the true color. Usually the better the quality of the CAD system and printer, the better will be the color matching ability. Usually these systems are the highest priced CAD graphics systems and printers. New higher quality printers are being research and developed all the time (Kosh, 1989c; The Future is now, 1991).

Different types of printers are now on the market that can interface to CAD graphic systems. The most common printers used at the present time are thermal printers, ink jet printers, sublimation printers, and color laser printers. Typically the more expensive a printer is, the better quality of the output and the more colors it is able to reproduce (Kosh, 1989b).

Computers in Textile and Apparel Education

Colleges and universities offering clothing and textiles programs are preparing graduates to work in the apparel/textile industry. According to Sheldon and Regan (1990) there are two philosophies which concern the relationship of higher education and the industry. One states that college and university faculty should keep up with what is happening in the industry they are preparing graduates to enter. The other states that colleges and universities should lead the industry in innovation, research, and development. Inadequate budgets is one problem related to the low number of colleges and universities teaching courses in CAD (Sheldon & Regan, 1990).

Computerized equipment and software for the apparel industry cost anywhere from \$30,000 to \$300,000 and an additional yearly maintenance fees equaling 4-10% of the initial cost. With limited budgets, the cost of these systems becomes prohibitive. With the many changes in technology which are affecting the apparel industry, clothing & textiles educators must include updated technology in teaching apparel design.

Computers have changed the way in which apparel companies are managing their businesses. Because of this change students should be well trained in computers and perhaps lead the industry in utilizing computers for design. Sheldon

(1988a) indicated that apparel manufacturers are increasing their use of computers in the design area. In 1987 only 37 % of apparel companies were using computers in apparel product development (Knoll, 1990c). Sheldon's study indicated that there would be 65 % projected use for computers in design by 1992. The areas which will increase in CAD use will be in illustration and pattern making functions. Because of this increase, 65 % of apparel designers surveyed by Sheldon (1988a) predicted that by 1992 entry level designers must have computer experience. Fraser (1985) found that designers were reluctant to adopt computers because they felt designing was a creative process and computers would make it a mechanical process. Production managers favored the implementation of CAD. Though designers feel reluctant to implement CAD, the realization is that management will make the decision about implementing CAD and then search for a CAD operator/manager to help implement it in their company. Clothing and textiles programs in colleges and universities can provide the industry with such people if they try to lead the industry in its efforts to computerize in apparel product development.

Many educational institutions have tended to postpone the teaching of computer-aided design in clothing and textiles. Knoll's 1990 study showed that only 17 % of American colleges and universities that offer courses in textiles and clothing are teaching computer aided design (Knoll, 1990c). A study reported by Knoll conducted by the Federal Office of Technology Assessment stated that classrooms are much less computerized than offices or factories. Part of the reason was limited funding; however, teachers also had resisted the inconvenience of adding new-equipment training to their already overburdened schedules (Knoll, 1990c). Teachers need

training to adjust their roles and instructional strategies to educate students with the new technology. To meet the demands of the apparel industry in CAD, it is critical that university programs adjust curricula to include CAD. Course development has been limited due to scarce resources and lack of faculty expertise (Koch, 1990). A solution (which has been adopted at one university) is to employ a CAD instructor or specialist to facilitate the integration of CAD into the design, production, and merchandising courses. This person would be in charge of the upkeep and maintenance of the equipment and become proficient with all the programs used with the system, software updates, and hardware. He/she would also monitor labs while students work on the system and team teach with other faculty to facilitate the completion of assignments on the system (Belleau & Bourgeois, 1991).

The cost of the equipment should not stop educators from increasing the student's computer competence to the level required to work on industry equipment. There are relatively inexpensive alternatives for preparing computer-literate designers. Many clothing and textiles educators have been applying AutoCAD, a software package originally designed for architects and engineers. This software has now been adapted to do everything from sketching designs to plotting markers. The relatively low cost makes the system a viable alternative to apparel-oriented systems for educational institutions as well as small businesses (Miller & Racine, 1988). The software is run on microcomputers equipped with the AutoCAD software. This software offers a full range of operations. Using a digitizer, one can enter slopers into the system and a scanner allows the input of patterns and sketches. Any pattern alterations can be done via the computer and then the markers can be developed.

AutoCAD is also an excellent tool for designing motifs and fabrics as well as for fashion illustration. To streamline the illustration process, icons have been developed which make the system user friendly. Icons representing croquis figures and motifs such as flowers, animals, and nautical wear are available at a keystroke. Icons are also available for slopers, buttons, buttonholes, and symbols as well as a grading menu (Miller, 1989; Miller & DeJonge, 1987; Miller & Racine, 1988).

Reference manuals and tutorials for AutoCAD have been developed by many universities because of the lack of documentation geared toward apparel design applications (Huck & Hedrick, 1990). Tutorials have been developed for industry-oriented systems which incorporate design related exercises and projects to ensure students practice so they become self-sufficient users of the technology (Kallal, 1989). Teaching tools for AutoCAD are essential to maintain the interest and excitement of apparel students who did not have prior CAD experience, thus simplifying the basic AutoCAD commands needed to continue learning more advanced processes in apparel product development. These tutorials/manuals are not only teaching aids for the classroom, but may be used for individuals to learn AutoCAD on their own (Steinhaus, 1988).

Autocad, MacDraw, MacPaint, SuperPaint, Aldus Freehand as well as other paint systems have also been incorporated in the classroom using microcomputers in order to give students some CAD experience. Paint software is used in the area of fashion garment libraries, garment line presentation, pattern drawing, figure drawing, and garment design. Other systems are used for sketching, developing presentation boards, and for surface design of textiles (Koch, 1990). Students can develop textile

motifs and place them in a variety of repeats and colorways for textile design.

Advertisements and illustrations in a variety of layouts can also be developed.

Fashion designs can be created and viewed in a variety of line development, color, and illustration styles (Koch, 1990; Rosenthal, 1989).

The main goal of using CAD graphics is to teach industry applications in abstract and relative design concepts of scale and proportion. This knowledge can then be transferred in order for students to have an understanding of how to design apparel using CAD on apparel oriented systems in industry (Knoll, 1990a). By having some CAD experience students can learn industry-oriented systems more easily and offer companies that do not have CAD systems advice in decisions related to computerization. They also can be integral in its implementation in the company (Koch, 1990).

A study by Knoll (1990b) showed that clothing and textiles faculty were aware of the necessity to include computer technology in their professional capacities as teachers and researchers and that they were enthusiastic in furthering their education in computer technology. They were also aware of the urgency to incorporate computer technology into clothing and textiles curricula. The current computer use by faculty surveyed in clothing and textiles was 76 % in word processing software. This has not changed since the study by Law (1983) in which she found word processing to be the most common application of computers in Home Economics. Knoll found that 58 % of educators surveyed were interested in learning computer-aided design due to the awareness of the importance of CAD skills to apparel design and production, though only 17% of the sample was using CAD software in 1987.

Most educators stated that there was a five year plan to incorporate computer technology in their departments and the most growth of computer introduction would be in the fashion merchandising and apparel design areas.

The study results suggest that substantial growth in computer use in clothing and textiles college programs can be expected during the decade of the 1990's. Faculty perceived there would be more funding available for computer facilities, therefore increasing the use of computers in existing curricula. Computer literacy requirements would then be increased for all students including some CAD training for design students. At the present time students received 70 % of their computer training in the computer science/math departments with 39 % receiving training in clothing and textiles. The most common software used in computer-aided design is AutoCAD. Other CAD software commonly used by faculty are Microdynamics, MacPaint, and Lectra software (Knoll, 1990c).

Industry Related Research

The only research that could be located pertaining to the use of CAD systems by designers was done by Swanson at Colorado State University in 1987 and reported in her master's thesis. Her research examined professional designer's time spent at design functions, the specific activities performed within the selected functions, and the specific CAD graphic systems available which could benefit designers in performing the design functions and activities. The investigation was conducted using two surveys, one for apparel designers, and one for CAD graphic suppliers. Five hundred apparel designers and nine CAD graphic suppliers were surveyed.

Frequency distributions were calculated on the amount of time designers spent on design functions and activities and on the activities CAD graphic systems could handle directly and indirectly. The percentages of time spent on design functions were calculated. Product planning (24 %), product development (17 %), researching (15 %), and art/design (11 %) were the functions on which designers spent the most time.

From a listing of 57 activities, those indicated by designers to be the most important were style variations, new styling, silhouette, fit, garment construction, previous product performance, color, fabric, product sketching, consumer trends, competition-retail store visits, trims/findings, and fashion trends. All activities indicated as important fell into four functions in which designers spent their time.

It was found that at least one, and in some cases five, CAD suppliers were available for all activities indicated as important by the designers. All seven CAD companies that responded could handle the activity of product sketching (Swanson, 1987). This study showed how a new tool of technology, CAD, can aid in performing the current functions and activities of a designer.

CHAPTER IV

Framework

A background knowledge of the contextual and the conceptual framework was necessary to establish a basis for this study. Therefore, selected literature is presented on 1) the contextual framework, and 2) the conceptual framework.

Contextual Framework

American industries are facing a serious threat from competitors around the world. The U.S. production of most domestic goods has steadily declined since the 1970's. (Macdonald & Piggott, 1990). The U.S. apparel industry has shrunk over the past decade and many manufacturers have opted to move their operation overseas to survive and stay competitive. While it may be a strategy to survive, the downside is the displacement of the work force, unemployment, and an ultimate dependency on imports. The industry has to change the traditional ways of doing business to survive in this tough economy (Dworkin, 1991). The belief that there is a quick-fix easy solution to most problems is only a myth. The problems that the apparel industry faces today is a culmination of a variety of factors accrued over a long period of time. Therefore, there is no easy method to rectify the problem.

Systematic ways of determining the inadequacies of an existing system and finding solutions to the problem are generally categorized under needs assessment. Several models of needs assessment have been proposed. This study relates the needs assessment process to Kaufman's needs assessment model. This model gives

priority in the identification and recognition of the problem before attempting to find solutions (Kaufman & English, 1979).

Most strategies are based primarily on needs and satisfaction of the consumer. After all, the consumer is an integral part of the business cycle. The term "quality" is often referred to when discussing strategies. It is ironic that the Japanese companies have become successful by implementing the American concept of putting quality first, whereas the domestic market has failed to capitalize on it. In the recent past, hundreds of American companies are striving to improve the quality in all phases of their organization. Acceptance of quality as a vital issue is exemplified by the fact that even competing companies are co-operating to improve quality (Macdonald & Piggott, 1990).

The Taguchi methodology, which is often misquoted as a philosophy, is a good engineering method. The emphasis of this methodology is to push quality back to the design stage so as to reduce the dependency on final inspection to maintain quality. Adapting this method would ensure stability of output with intrinsic quality and reliability irrespective of transient changes in the manufacturing process (Bendell, 1988).

Automation is probably the most economical way to improve efficiency and quality. Some management personnel, due to lack of a technical background, may be skeptical about automation. With the advances in the computer technology that automation will be the norm in the future. Discussion of the methods of automation is beyond the scope of this study. Nevertheless, some methods are briefly discussed to give an idea of the concepts being contemplated.

Computer integrated manufacturing (CIM) is a concept of completely integrated enterprise. The CIM model conceptualizes three functional segments surrounding the corporate core - the conceptual or idea segment (marketing and R & D/Engineering); the logical or plans and control segment (production plans and controls); and the physical or action segment (production operations). The CIM vision includes creating an automated system for predicting future customer needs, designing products to fulfill those needs, controlling the quality, and setting standards and monitoring the performance of the company. Pessimism toward CIM) is caused more by resistance to change than by the unavailability of technology to realize the vision (Thacker, 1989).

Some of the concepts behind an effective CIM model in the apparel industry are CAD/CAM, Just in Time (JIT), and Quick Response(QR). The textile industry is very labor intensive and hence product development takes considerable amount of time (Keating, 1992). The advent of CAD/CAM systems have dramatically reduced the lead time. Effective global communication has made it possible to quickly interact with manufacturers and customers (Global communications, 1992). Such effective communication networks have paved the way for concepts such as "Quick response" and "Just in Time" to succeed.

The core of QR is fulfilling product orders quickly. Strategies such as bar coding, which have been around for years, form a part of the cohesive set of strategies referred to as QR. The success of QR depends on the implementation of all its strategies and not just a part of it. Just in Time concepts include making the products

available when required, which helps in maintaining minimal inventory resulting in reduced costs.

The present study focuses on CAD graphics applications in the apparel industry. CAD systems, which were primarily used in the field of engineering, are now making their entry into the apparel industry. The application of CAD graphic systems falls into the categories of styling, coloring, texturing of garments and creating sales and advertising aids. CAD systems cannot be viewed as a panacea for all the perils facing the apparel industry. It is a tool to help the designer in rapidly visualizing creative ideas. The fear of loss of creativity, the fear of reducing the designer to a machine operator, and a general uncomfortable feeling around computers are some of the problems faced by designer in making the transition to using CAD systems. Experienced designers may find the transition more difficult than one whose curriculum in design school included an exposure to computers and CAD. This is the core idea behind this study.

Though a number of studies have reported the various applications of CAD in the apparel industry, there is not enough information indicating the expertise required to be familiar with the system. The present study is an effort to determine the current utilization of CAD graphics systems in the industry. In addition, the author hopes results of the study will affect changes in curriculum to prepare students for the industry.

The author is convinced that CAD systems are not just a passing phase in the industry. Many studies have already reported reduction in design time and product development time and higher return of investment. With such phenomenal

advantages there is no doubt that the usage of CAD systems in the industry will be the norm in future.

Conceptual Framework

Needs assessment can be defined as a systematic process of determining the inadequacies of the existing system as compared to an ideal system. Usually such determinations are made to find ways to overcome the inadequacies.

Though the concept of needs assessment has been used in business and industry, it is usually associated with education. Needs can be social, psychological, or physical. Bradshaw (1972) defined four different kinds of needs: normative need, felt need, expressed need, and comparative need. Anticipated future needs and critical incident needs have also been suggested.

The four basic models of needs assessment are (Trimby, 1979):

1. Harless' front end analysis
2. Lee's needs assessment
3. Coffing's client needs assessment, and
4. Kaufman's needs assessment.

Kaufman's model emphasizes the recognition and definition of the problems or needs of the present situation before trying to find solutions. In simple terms it is a systematic "problem solving process". The first three models address the decision making process of needs assessment.

Kaufman's systematic problem solving process comprises the following:

- 1. identify the problem based upon the needs**
- 2. determine solution requirements and identify solution alternatives**
- 3. Select solution strategies from among alternatives**
- 4. Implement selected methods and means**
- 5. Determine performance effectiveness**
- 6. Revise as required (Kaufman & English, 1979)**

No assumptions are made while identifying the existing problem. Current information relevant to the desired objectives are gathered. Usually this process is done by asking straight forward simple questions. The instrument can be observations, questionnaires, or interviews.

From the current information the shortcomings are identified. The next step involves the analysis to determine all possible solutions to overcome the shortcomings. The feasibility of the potential solutions is determined by weighing the advantages and disadvantages of each solution. Mosrie (1980) used two groups of people; one to list the solutions and the other to rank the importance of the solutions.

The third step ranks the possible solutions determined in the second step against the objectives. Mosrie (1980) adopted the ranking system used in the second step whereas Stolovitch's (1978) procedure used simpler mathematical calculations.

In the fourth step the solutions decided by the first three steps are implemented. The required resources are allocated to the solution meeting the highest priority need. The effectiveness of the implementation is based on the needs identified by the first two steps.

The performance effectiveness is evaluated by the personnel who are closely involved with the implementation. In some instances, as in education, the teachers who implement the procedures lack the expertise to evaluate the outcome (Watson, 1979). Involvement of the personnel defining the needs, in the process of evaluating the performance effectiveness, will provide a sense of accomplishment and inspire greater efforts at every successful step (Mosrie, 1980).

Following Kaufman's steps is not a blueprint to an ideal situation. As changes take place continually so does the needs assessment. Hence, the process of needs assessment has to be on a continuous basis to maintain the least discrepancy between the existing situation and the ideal one. As mentioned before, needs assessment is not restricted to education. Kaufman's systematic approach was used in this research.

In the late 1970's importing of apparel goods increased. By 1980 the number of imports doubled (AAMA, 1989). One of the major factors for the textile/apparel industries manufacturing these products outside the U.S. or importing them was reduced labor rates. Labor intensive industries such as the textile/apparel industry are the most affected by this trend of importing. Due to the problem of the large number of imports and pressures on cost and profit, the apparel industry had a specific need to stay competitive.

Recent technological advances helped to reduce the effects of the differences in labor rates in the U.S. and developing nations (Hunter, 1990). A solution of implementing CAD into all phases of apparel product development is one step in the QR strategy to stay competitive in the world market.

CHAPTER V

Methods

The purpose of this study was to identify the utilization of CAD graphics in textile/apparel product development. Additionally the purpose was to determine the effect that CAD graphics systems has on the textile/apparel industry and identify future needs and uses of CAD graphics by the textile/apparel industry. The instrument was evaluated for validity through a pilot test conducted on three CAD managers/operators (each of them with at least one year of CAD experience). The collection of data was conducted in January 1992 - February 1992.

The methods chapter includes (1) a description of the sample, (2) the development of the instrument, (3) collection of data, and (4) the data analysis.

Description of the sample

The sample consisted of 117 CAD graphics users from the United States and Canada. The sample was identified by user lists from CAD graphics companies and also names of companies mentioned in articles from the review of literature.

Development of the Instrument

The questionnaire was intended to identify the utilization of CAD graphics in the design and marketing phases of textile/apparel product development, to determine the effect of the uses of CAD graphics systems on textile/apparel product development,

and to identify future needs and uses of CAD graphics in the textile/apparel industry. Questions were developed by an indepth review of literature, suggestions/critiques from CAD users and experts, and by the researcher's thorough knowledge of the capabilities of CAD graphics, based on five years of industry related experience in the field.

To further develop the questionnaire, a pretest was administered. The questionnaire, a cover letter explaining the nature of the study, and a pre-paid preaddressed return envelope were sent to three CAD managers/operators who had at least one year of CAD experience. All three questionnaires were returned with comments related to clarity and general construction of the questions. The questionnaire was revised according to their comments.

Description of the Final Questionnaire

The revised instrument was then administered to the CAD graphics sample determined from CAD company user lists and companies mentioned in articles from the review of literature. Not all CAD companies contacted were willing to submit their user lists because of privacy reasons.

The final instrument consisted of 29 questions relating to general demographic, CAD graphic application, the effects CAD has on the industry, and questions to determine future needs and uses of CAD graphics (Appendix A). The final instrument was divided into two areas: general information and CAD Graphics application questions. General information included demographic questions such as size of company, primary product designed or manufactured, years of industry experience,

annual salary level, gender, highest level of education, previous CAD experience, system's experience, time it took to become efficient on current CAD graphics system(s), and company benefits with the introduction of CAD graphics. Application questions included uses of CAD graphics, specific daily applications and uses, and wishes for future improvements of CAD graphics systems.

Data Collection

A total of 117 questionnaires were sent in January of 1992 to either a predetermined individual who was the CAD manager/operator or addressed to the CAD manager/operator of design and marketing. The questionnaires were visibly coded in the upper right hand corner to make a follow up letter possible.

A cover letter suggesting the importance of the completion and return of the questionnaire was included (Appendix B). A sweepstakes ticket for an entry to a free drawing for a subscription to a computer graphics magazine was also included as an incentive to return the completed questionnaire. A return envelope with prepaid postage was provided for ease of mailing to those companies residing in the U.S. Prepaid postage on the return envelopes of those residing in Canada was not possible.

A second mailing went out four weeks after the first mailing. Another questionnaire was included, again with a postage prepaid return envelope, cover letter, and sweepstakes entry. The second cover letter reminded the prospective participant of the previously sent questionnaire (Appendix C), stressing the importance of completion and return.

Analysis of Data

The data used in this study were quantitative. The analysis consisted of descriptive statistics to determine frequencies and percentage distribution for all sections of the questionnaire. Total number of questionnaires sent out was 117; 48 were returned. Two of the questionnaires were returned as undeliverable and two other questionnaires which were returned could not be used because they were inadequately completed by the user for company privacy reasons. Therefore, 44 questionnaires were used for the analysis of data. This yielded an acceptable 39 % response rate.

A higher return rate would have been more acceptable for this research but unfortunately the questionnaires were not returned possibly due to the fact that 1) company policy forbade the disclosure of such information, 2) CAD managers/operators were very busy with a new line during the time the research was conducted, and 3) the questionnaire did not reach the appropriate person.

CHAPTER VI

Results and Discussion

The results of the study are presented in this chapter. Included in the results are a description of the population and results of the data analysis for each objective.

Description of Demographics

The population of CAD graphics operators and managers was comprised of 44 respondents. Frequency distribution of the company size and primary product designed or manufactured are shown (see Table 1).

Responses to the company size were divided equally between small companies up to 100 employees, and moderate companies, 101 to 600 employees, The remaining responses, 22.7 % were from large companies of 601 and over employees.

From the review of literature it was found that most larger companies were more likely than smaller ones to buy CAD graphic systems for design and marketing because of the cost of the initial investment (Van De Bogart, 1988a). The results from this research showed that both small and moderate companies had purchased (30 of the 44 who responded) more systems than larger companies. This could be due to the fact that complete user lists from the more expensive CAD graphics systems were not available to the researcher.

TABLE 1

Company Size and Primary Product Frequency Distributions

Company Size	Frequency	Percent
Large (601 employees & above)	10	22.7
Medium (101 - 600 employees)	15	34.1
Small (up to 100 employees)	15	34.1
Unanswered	04	9.1
Total	44	100.0

Primary Product		
Bedding/Wall covering	01	1.6
Belts/asscessories	03	4.8
CAD service bureau	01	1.6
Childrenswear	07	11.3
Hosiery/socks	04	6.5
Intimate apparel	02	3.2
Menswear	08	12.9
Outerwear/athletic wear	06	9.7
Private label	03	4.8
Sportswear	04	6.5
Sweaters/Knitwear	13	21.0
Textile development	04	6.5
Womenswear	06	9.7
Total	62	100.0

It should be noted that some CAD operators/managers reported more than one primary product was designed or manufactured by their companies. Sixty-two cases were analyzed for frequency distribution. The highest reported primary product sweaters/knitwear. Menswear was second, followed by childrenswear. Womenswear

and outerwear/athleticwear were reported by 9.7 % of the respondents. Textile development and hosiery/socks were reported as primary product by 6.5 %. Private label, belts/accessories, intimate apparel, bedding/wall coverings and CAD service only were reported by less than 5 % of the respondents.

The results of this study were in agreement with the review of literature. More CAD systems were said to be purchased for designing basic goods and textiles than for more fashion oriented products (Staples, 1990). The results of this study showed that 21 % of the respondents produced sweaters/knitwear. This is probably due to the fact that graphing sweaters is a tedious process in which a CAD system is capable of producing faster results than manual graphing.

The respondents' highest level of education and the years he/she worked in current position are shown in Table 2. The highest reported level of education was a bachelors degree with 65.9 % of the responses. Associates degree was next, followed by some college education. Master's degrees were reported by about 7 % of the respondents.

Although no literature specifies the educational level of a CAD operator/manager, the population results seem to be in the norm with the general feeling of today's world that a college education is necessary in order to secure a job. The study showed that 100 % of the population had at least a two-year degree from an institution of higher education.

When asked how long the respondent had worked in his/her current position, the category of 1 to 4 years had 50 % of the responses. The category of 5 to 9 years

TABLE 2**Educational Level and Number Of Years Designer Worked in Current Position**

Highest Level of Education	Frequency	Percent
Some college education	05	11.4
Associate's degree	07	15.9
Bachelor's degree	29	65.9
Master's degree	03	6.8
Total	44	100.0

Years Worked In the Current Position		
Less than 1 year	06	13.6
01 - 04 years	22	50.0
05 - 09 years	10	22.7
10 - 15 years	04	9.1
16 - 20 years	02	4.5
Total	44	100.0

came next, followed by the category of less than 1 year. The categories of 10 to 15 years and 16 to 20 years were reported by less than 10 % of the respondents.

The typical impression from industry seems to be that there is a fast turn-over of employees. An expected finding in this population is the 1 to 4 years length (50 %) of time the CAD manager/operator has been in his/her current position. This could also be due to the fact that the company has only had their system for that length of time and therefore their particular job is a new position.

The respondents' number of years of industry experience are shown in Table 3. One to 4 years of industry experience was the highest reported response. The

TABLE 3**Industry Experience**

	Frequency	Percent
01 - 04 years	14	31.8
05 - 09 years	13	29.6
10 - 15 years	12	27.3
16 - 20 years	03	6.8
21 + years	03	4.6
Total	44	100.0

category of 5 to 9 years was next, followed by 10 to 15 years. The category of 16 to 20 years and the category of 21 + years had less than 7 % of the responses.

The number of years of industry experience of most CAD users has not been specified in the literature. In this study, 31.8 % of the respondents had 1 to 4 years of industry experience. Again, this could be due to the fact that the CAD system has only been in the company for that time and that the respondent was hired or promoted into that particular position.

Responses for actual job title were so diverse that in order to analyze the data, groupings were developed by the researcher. The significant job title of those who filled out the questionnaire was of management status. (45.5 %). Next was artist/designer/CAD operator, followed by vice president. President and assistant designer were reported by less than 7 % of the respondents (see Table 4).

The annual salary level of the 44 respondents are shown in Figure 1. The category of \$31,000 to \$40,000 had the highest response rate with 29.5 % of the responses. The category of \$41,000 to \$60,000 had 25 percent of the responses

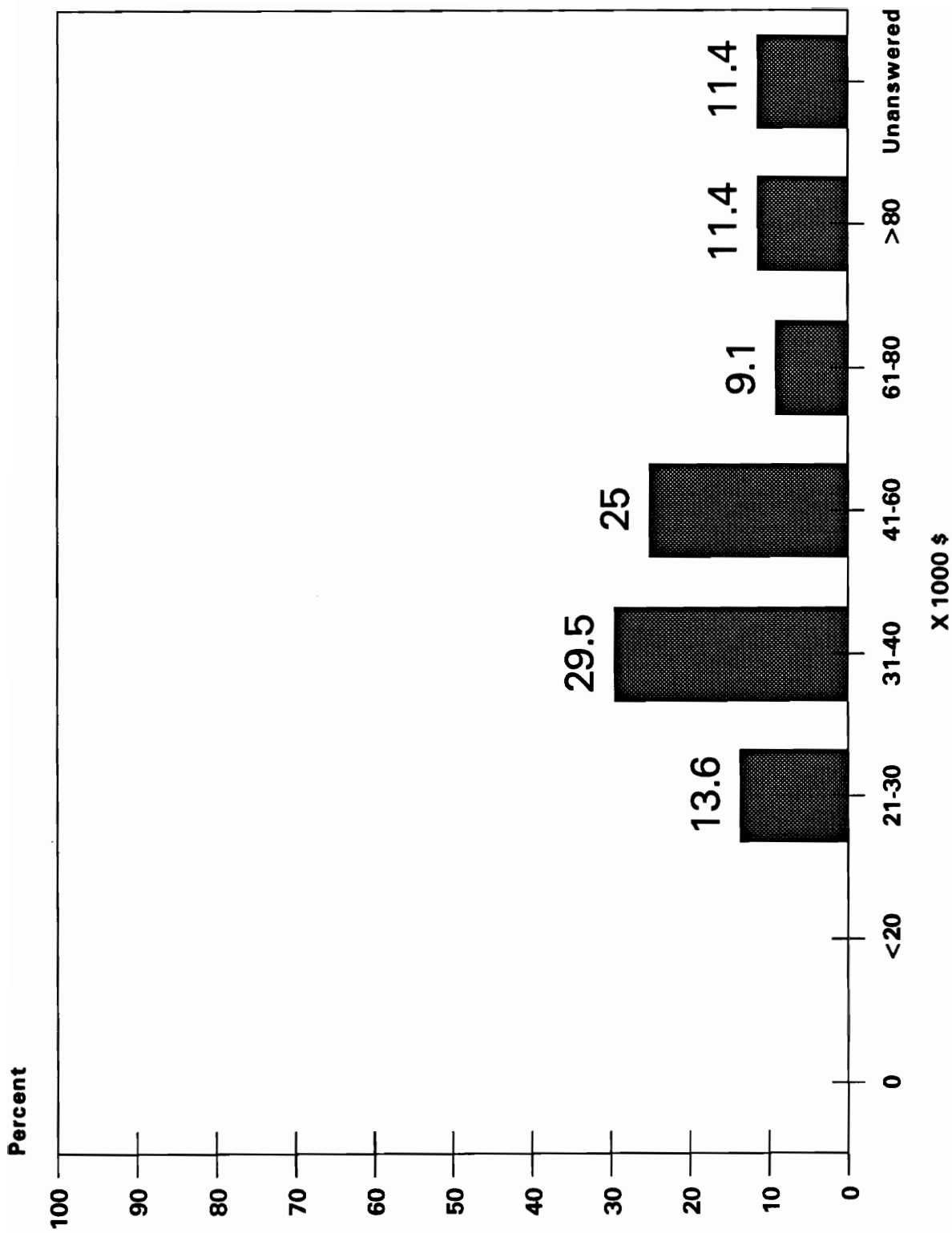


Figure 1. Salary Level

TABLE 4**Job Title**

	Frequency	Percent
Assistant designer	02	4.6
Stylist, artist, designer, CAD operator	15	34.1
Head, director, supervisor, manager - all levels	20	45.5
Vice president	04	9.1
President	03	6.8
Total	44	100.0

followed by the category of \$21,000 to \$30,000. The category of over \$60,000 was reported by about 10 % of the respondents.

The actual annual salary levels of CAD operators/managers was not in the literature. This study found the salary level in the range of \$31,000 to \$60,000. Since a great percentage of the population were of management status these salaries are in the norm for the level/type of position held. The researcher has worked in such a capacity and therefore knows the salary ranges for this type of position. This result shows great potential for college graduates in Clothing and Textiles.

The gender of the respondents is shown in Figure 2. Seventy-five percent of the respondents were female. Although no literature states the gender of most CAD managers/operators, the researcher's experience in training CAD operators in graphic systems used in textile/apparel design and marketing reflect more female operators than male.

The respondents' ages are shown in Figure 3. The age category that received the highest response rate was 30 to 39 followed by age category of 25 to 29 years, and

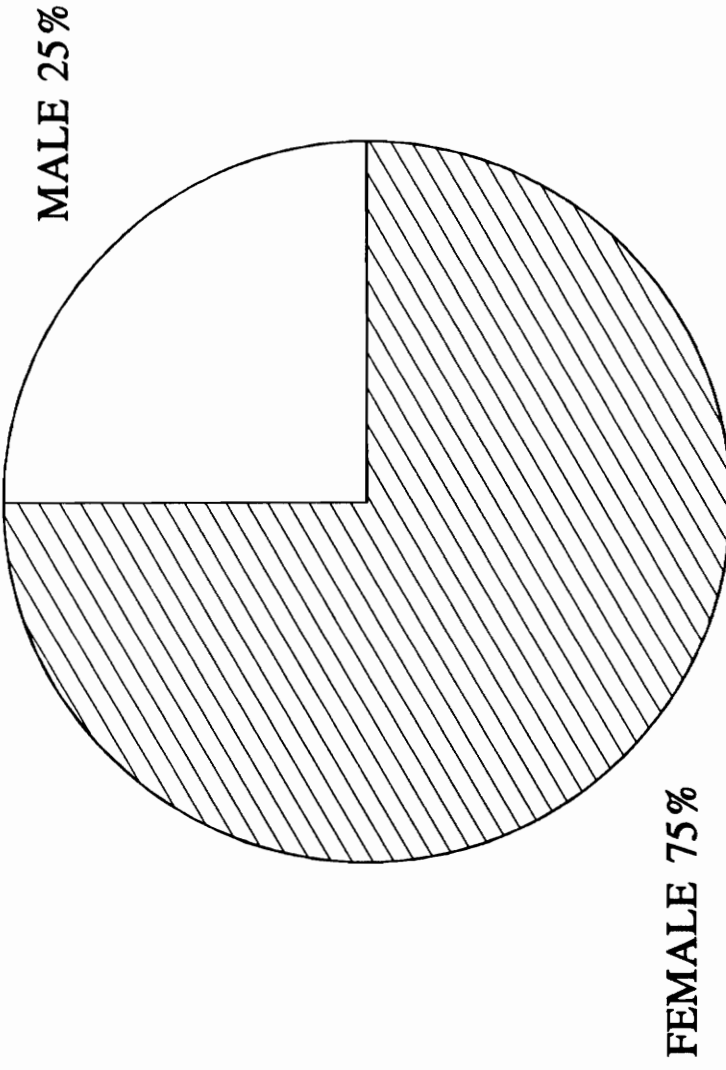


Figure 2. Gender

the age category of 40 to 49. The other age categories received less 10 % of the responses.

The respondents' answer to the type of prior CAD graphics experience other than with their present company are shown in Table 5. "No prior experience" had the highest response rate with 56.8 % responses. "Prior work experience" was next, followed by a course in college.

TABLE 5

Prior CAD Experience Other Than The Present Company

	Frequency	Percent
No prior experience	25	56.8
Course in trade school	01	2.3
Course in college	07	15.9
Seminars	02	4.6
Prior work experience	12	27.3
Worked for a CAD graphics vendor	02	4.6
Other	02	4.6
Total	44*	111.5*

*Option was given to check as many answers as applicable

Responses to the question of CAD experience on other systems are shown in Table 6. The majority of the respondents reported no other experience, possibly due to the newness of the technology. Multiple system experience (more than 1) was next, followed by experience on only one other system.

Responses to the type of CAD graphics system(s) of each company are shown in Table 7. It should be noted that companies could have more than one type of system and respondents were asked to list all CAD graphic systems in their company used for design and/or marketing. The highest reported system used was the

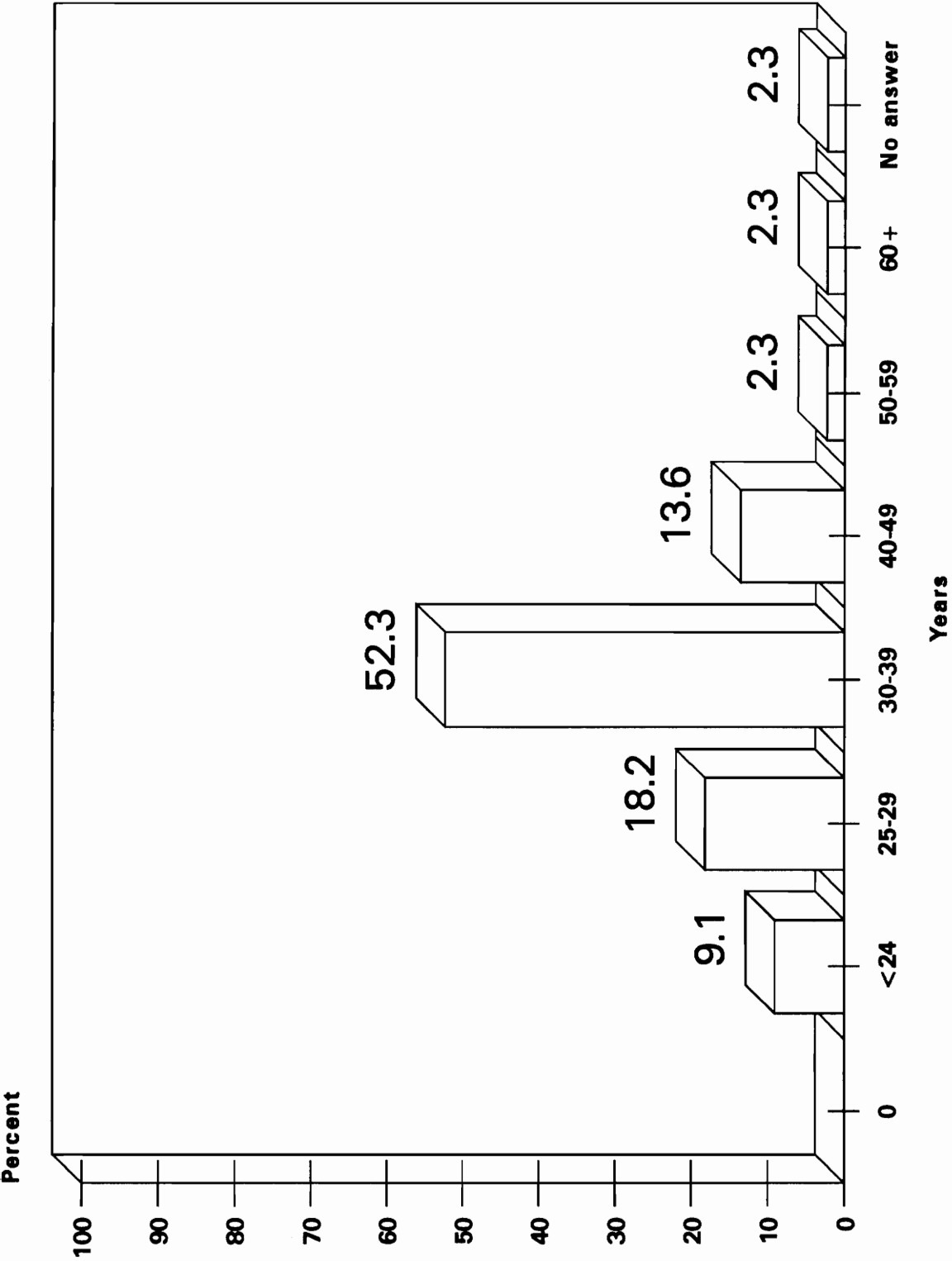


Figure 3. Age

TABLE 6

Other CAD Experience

	Frequency	Percent
In one other system	07	15.9
In multiple systems	09	20.5
No other experience	28	63.6
Total	44	100.0

Preview/Premiere system. The CDI and Microdynamics systems were next, followed by Shima Seika with 25 % of the responses. All other systems were reported by less than 20 % of the respondents.

Although no literature states which system is more likely to be used in the area of CAD graphics in the textile/apparel industry it should be noted that not all CAD vendors supplied user lists for this study. It is assumed that the company which gave the most complete user list would be the system which is most used. The study showed that 47.7 % of the respondents had the Preview/Premiere system and that both CDI and Microdynamics had an equal share of the systems. This is in line with the companies who gave the more complete list or the names of companies listed in the review of literature.

Responses to the number of systems are also shown in Table 7. The highest reported number of systems was more than one system (this includes multiple stations of one type of system and single stations of more than one type of system). This study showed that more than half the population had more than one system. Based on the researcher's experience, most companies would purchase more than one system since it is difficult for many individuals to share one system.

TABLE 7**CAD Graphics Systems in the Company**

Type of System	Frequency	Percent
CDI	17	38.6
Gerber	05	11.4
Infodesign	04	9.1
Microdynamics	17	38.6
Mechanix	08	18.2
Modacad	01	2.3
Preview/Premiere	21	47.7
Shima Seika	11	25.0
Other	07	15.9
Total	98*	206.8*

System	Frequency	Percent
Single system	20	45.5
Multiple system	24	54.5

*Option was given to check as many answers as applicable

The number of personnel trained on their CAD system(s) are shown in Table 8. The highest reported category was 2 to 4 persons trained. The category of one person trained was next, followed by the category of 5 to 9 persons trained. All other categories had less than a 7 % response rate.

Personnel who actively work on the system are shown in Table 9. The highest reported category was 2 to 4 persons. The category of 1 person was next with 36.4 of the responses. All other categories reported less than a 14 % response rate.

TABLE 8

Personnel Trained on the System

Number of Personnel	Frequency	Percent
00 - 01	09	20.5
02 - 04	24	54.6
05 - 09	07	15.9
10 - 19	03	6.8
20 - 39	01	2.3
Total	44	100.0

TABLE 9

Personnel Actively Working on the System

Number of Personnel	Frequency	Percent
00 - 01	16	36.4
02 - 04	20	40.5
05 - 09	06	13.6
10 - 19	02	4.6
Total	44	100.0

There is no indication in the literature as to how many people actively work on CAD systems in a company. It is likely that most companies would have the same number of people working on the system that they had trained due to the cost involved in training. This study showed 40.5 % had 2 to 4 people who actively worked on their system(s).

The number of hours the respondents work on their CAD system per day are shown in Table 10. The category of 5 to 8 hours per day had the highest response

rate with 54.6 % of the sample. The category of 1 to 4 hours had 25.0 % of the responses, followed by the category of 9 hours and over.

TABLE 10

Number of Hours Per Day Spent on the CAD System

Hours	Frequency	Percent
01 - 04	11	25.0
05 - 08	24	54.6
09 and over	07	15.9
Unanswered	02	4.6
Total	44	100.1

Responses to the question of how long it takes to become proficient on a CAD graphic system are shown in Table 11. The category of 1 to 3 months had the highest reported response rate with 61.4 % of the respondents. The category of 4 to 6 months was next with 25.0 % of the responses. All other categories had a response rate of less than 7 %.

The literature shows that it takes approximately 3 to 6 months to become proficient on a CAD system (Van De Bogart, 1988b). However, based on the researcher's experience, it depends upon the system and its capabilities. Normally the more expensive the system the more complicated it is to learn. This study showed that most took 1 to 3 months to become proficient. The results may be due to the fact that one of the less complicated and less expensive systems was the system used by the majority of the respondents. Also, the results may be due to the fact that only part of the software of a system was purchased (i.e. only knit software was purchased).

TABLE 11**Training Period to Become Proficient on a CAD Graphics System**

Time Period	Frequency	Percent
Less than 1 month	03	6.8
01 - 03 months	27	61.4
04 - 06 months	11	25.0
07 - 11 months	02	4.6
12+ months	01	2.3
Total	44	100.0

Utilization of CAD Graphics**Objective 1:**

Identify the utilization of CAD graphic systems in the design and marketing phases of textile/apparel product development.

Frequencies and percentage distributions were calculated for questions related to this objective. CAD graphic systems applications responses are shown in Table 12. Respondents were asked to choose the top five applications in which their system(s) was used. It should be noted that not all respondents chose all five applications.

Responses to the top applications were textile designs and/or colorations received the highest response rate (61.4 %). Development of storyboards for in-house and/or buyer/marketing presentations was next, followed by garment styling/designing. All other choices received less than 5 % of the responses. The respondents' second choice for use of their CAD system was development of storyboards for in-house and/or buyer/marketing presentations which was reported by 22.7 % of the

TABLE 12**CAD Graphics Applications**

Applications	Rating*				
	(1)	(2)	(3)	(4)	(5)
Fashion sketching/illustration	4.6	6.8	9.1	15.9	6.8
Textile design and/or coloration	61.4	11.4	11.4	2.3	0.0
Creation of technical data for textile machinery	2.3	15.9	20.5	6.8	2.3
Garment styling/designing	11.4	9.1	4.6	20.5	6.8
Applying textiles to silhouettes	0.0	15.9	15.9	9.1	4.6
Hang tag, label and logo development	0.0	2.3	0.0	4.6	13.6
2-D draping texture mapping	0.0	2.3	0.0	6.8	0.0
3-D draping/texture mapping	0.0	0.0	0.0	0.0	0.0
Development of first pattern from draped image	0.0	0.0	0.0	0.0	0.0
Development of storyboards for in-house and/or buyer marketing presentations	15.9	22.7	13.6	9.1	15.9
Catalog generation	2.3	4.6	2.3	2.3	9.1
Desk top publishing	0.0	2.3	0.0	2.3	0.0
*Ratings: (1) =75% -100%			(4) = 1% =24%		
(2) =50% - 74%			(5) = 0%		
(3) =25% - 49%			(6) = No Response		

respondents. Applying textiles to silhouettes and garment styling/designing came next with almost 15.9 % of the responses. The respondents' third choice for use of their CAD graphics system was garment styling/designing with 20.5 % of the responses. Applying textiles to silhouettes was next with 15.9 % of the responses, followed by the development of storyboards for in-house and/or buyer marketing presentations.

Respondents were also asked to write in any additional applications which were not mentioned in the above question. Responses to this question were mainly related to the marketing area. Respondents identified store layouts by color and/or pattern, flyers and presentation booklets for retail stores, sales booklets, color card booklets for buyers, pictorial references of purchases in a seasonal program, pictures of photo samples, and photographic imaging and retouching as other application for which they use their CAD graphics system.

The major findings of this study concluded that textile design and/or colorations were the major uses for CAD graphics systems. Print colorations, colorations of sketches and illustrations, development of images for presentation boards, and knit colorations were the most common tasks performed on the respondents CAD graphic systems. This corresponds to the review of literature since textile colorations were mentioned to be very tedious and expensive and the CAD graphics system is perfect in helping the designer in such work (Kosh, 1989b).

Respondents were asked to rate on a scale of 1 to 5 the percentage of usage of their CAD graphics system for specific tasks. The results are shown in Table 13. It should be noted that some respondents did not give an answer to some tasks so a number 6 was used to identify no response. The highest reported response was to print colorations with almost sixty percent reporting that task being performed on their system for 75 to 100 % of the time. Colorations of sketches and illustrations was next for more than one half the responses, followed by development of images for presentation boards and knit colorations. All other tasks received less than 35 % of the responses.

TABLE 13**Usage of CAD Graphics Systems**

Uses	Rating*					
	(1)	(2)	(3)	(4)	(5)	(6)
Color matching from monitor color to printer color book	27.3	20.5	11.4	15.9	20.5	4.6
Scanning/videoing in sketches, fabrics magazine clippings, etc.	22.7	18.2	9.1	14.1	11.4	4.6
Development of flat spec. drawings directly in system	15.9	9.1	6.8	27.3	34.1	6.8
Alteration of illustrations or spec. drawings from scanned in images	13.6	18.2	18.2	18.2	25.0	6.8
Development of trims	13.6	4.5	9.1	22.7	43.2	6.8
Colorations of sketches and illustrations	54.6	9.1	11.4	11.4	9.1	4.6
Adding stitching and/or trim details to sketches and illustrations	20.5	9.1	6.8	25.0	27.3	11.4
Yarndye colorations	15.9	20.5	18.2	18.2	22.7	4.6
Development of yarndyes directly in system (weaving)	9.1	9.1	9.1	15.9	50.0	6.8
Development of loom data information and/or other technical information	11.4	0.0	2.3	6.8	60.0	11.4
Print coloration	59.1	11.4	9.1	11.4	4.6	4.6
Development of original prints directly in system	34.1	18.2	13.6	9.1	20.5	4.6
Development of prints from scanned in objects/motifs	20.5	25.0	25.0	15.9	9.1	4.6
Development of entire repeats for prints	15.9	15.9	18.2	22.7	20.5	6.8
Development of color separations for prints	9.1	6.8	4.6	6.8	68.2	4.6
Knit colorations	45.5	11.4	4.6	6.8	22.7	9.1
Graphing of knit swatches and/or applying knit stitch simulation	29.6	9.1	2.3	18.2	34.1	6.8
Graphing of entire knit bodies	31.8	11.4	4.6	6.8	38.6	6.8

Uses	Rating*					
	(1)	(2)	(3)	(4)	(5)	(6)
Development of technical data for knitting machine	20.5	0.0	13.6	4.6	52.3	9.1
Draping/texture mapping	0.0	11.4	4.6	9.1	65.9	9.1
Development of first pattern from draped/mapped image	6.8	4.6	2.3	0.0	77.3	9.1
Font/letter development	15.9	4.6	4.6	25.0	43.2	6.8
Development of hang tags, labels and logos	13.6	4.6	11.4	27.3	34.1	9.1
Catalog generation	15.9	2.3	2.3	2.3	65.9	9.1
Desk top publication	9.1	2.3	2.3	6.8	68.2	9.1
Development of images for presentation boards	45.5	25.0	9.1	6.8	4.6	9.1
Animation	6.8	0.0	2.3	4.6	77.3	9.1

*Ratings: (1) =75% -100%
(2) =50% - 74%
(3) =25% - 49%
(4) = 1% =24%
(5) = 0%
(6) = No Response

Effects of CAD Graphics

Objective 2:

Determine the effects that CAD graphics systems have on textile/apparel product development.

Ways in which the companies have benefitted by the introduction of CAD graphics into the design and marketing phases of textile/apparel product development are shown in Table 14. It should be noted that respondents were asked to choose as many items as applicable. The highest reported benefit was a shortened response time in development of idea in design cycle. The benefit of allowing more time for

TABLE 14

Benefits of CAD Graphics System

	Frequency	Percent
Shortened the response time of development of idea in design cycle	42	95.5
Eliminated all sample making of garments	03	6.8
Eliminated some sample making of garments	25	56.8
Elimated the use of freelance artist	19	43.2
Allowed more time for additional ideas to be presented than before the purchase of the CAD graphics system(s)	31	70.5
Eliminated all hand painted textile renderings	14	31.8
Elimated some hand painted textile renderings	25	56.8

additional ideas to be presented than before the purchase of the CAD system was next with more than 70 % of the responses, followed by eliminating some hand-painted textile renderings and eliminating some sample making of garments which were reported by more than 50 % of the responses. The benefit of eliminating the use of freelance artist was next, followed by eliminating all hand painted textile rendering.

Respondents were asked to write in any additional company benefits from the purchase of their CAD graphics system. Responses were related to saving costs in eliminating annual salaries of assistants, saving costs in eliminating mistakes since colored fabric samples could be seen on the screen instead of having mill samples developed, and saving costs in Federal Express since images could be transmitted over the phone lines to the Orient. Other benefits stated were that it increased the work volume from designers, helped to create excitement in the design department which in turn resulted in better and more original designs, increased business efficiency/productivity, and allowed for more diversification of business.

The benefit of a shortened response time of development of idea in design cycle was the major benefit of the population and received 95.5 % of the responses. This also corresponds with the review of literature which indicated that the primary reason companies have purchased CAD systems is to reduce the response time of product development in order to have a quick response strategy of bringing goods to the market (Kosh, 1989a).

Future Needs and Uses of CAD Graphics

Objective 3:

Identify future needs and uses of CAD graphics in the textile/apparel industry.

Respondents were asked to write in areas they thought CAD graphic systems must improve in order to make their job more efficient. Most responses were related to better color control, matching and selection, better resolution in printing and faster printing, and larger printout capabilities. Also in the area of printing some listed the ability to print and work on the system at the same time and cheaper costs for the supplies for the printer. Other responses relating to interfacing suggested the ability to interface to other software, interface to different textile machinery, and also the ability to telecommunicate. Responses related to the changes in the computer's ability were for more memory, more buffer capabilities, better resolution, and more storage capabilities. One respondent wanted the computer to speak. In the area of software enhancements, respondents wanted better scaling/manipulation without distortion, speed of certain functions, better and more efficient texture mapping/draping, ease of sketching, ability to design larger print repeats and more complicated textiles, and more marketing capabilities which would include page

complicated textiles, and more marketing capabilities which would include page - handed people since all data tablets were made for right-handed people.

Better color control, matching and selection, and better printing capabilities were the major future needs/wants of CAD graphics users. The study results correspond to the review of literature since color control, matching and selection and printing capabilities were said to be still behind in the area of CAD graphics. For these reasons some textile/apparel companies are still hesitant to purchase CAD graphic systems (Kosh, 1989c).

CHAPTER VII

Summary, Implications and Recommendations

In this chapter, the procedures and findings are summarized and implications discussed. Recommendations for future research are also presented.

Summary

Investing in new technology to be efficient, productive, and more competitive has become a necessity in most industries, the labor intensive ones in particular. In the textile/apparel industry imports have doubled since 1980 (AAMA, 1989). Due to the large influx of imports and pressures on cost and profit, the textile/apparel industry is making a serious effort to stay competitive in the world market. One of the major factors for textile/apparel industries manufacturing their product outside the U.S. or importing them is lower off-shore labor rates. Recent technological advances help to reduce the effects of differences in labor rates in the U.S. and the developing countries (Hunter, 1990). One of these technological advances is CAD graphics, used for design and marketing of textile/apparel product development.

The impetus for this study was to determine the utilization of CAD graphics in the design and marketing phases of textile/apparel product development. Other purposes of this research were to determine the effects of CAD graphics systems on the textile/apparel industry and identify future needs and uses.

Since all the participants of this study were CAD system users it is assumed that either knowingly or by accident the first four steps of Kaufman's problem solving

process of needs assessment has been implemented by all the companies. In other words, the companies have identified and implemented the system which would fulfill their individual requirements. The fact that a number of companies have systems from different CAD manufacturers indicate they may be in the process of evaluating the performance effectiveness. It could indicate that different requirements were needed for several departments and no one system handled all their requirements.

The major findings of this study concluded that textile design and/or colorations, and colorations of sketches were the major uses for CAD graphics systems since this is the most costly and tedious area of textile/apparel product development. The shortening of the response time of development of idea in the design cycle was found to be the major benefit for using a CAD graphics system. Future needs and uses were found to be mainly in the area of better color control, matching and selection, better resolution in printing, and faster, larger printout capabilities.

The results clearly show that regardless of the company size, the idea of using CAD systems to make their production process more efficient is growing in popularity. Since the technology is relatively new, only a small portion of the work force is formally trained to operate such advanced systems. The potential need for personnel with a general working knowledge of CAD systems will increase as the industry strides into the world of advancing technology.

Implications

This study was undertaken to give insight into how CAD graphics systems are being used and the importance they have in the textile/apparel industry. From the results some implications can be drawn, which apply to textile/apparel companies, CAD graphic suppliers, and to educational institutions.

The textile/apparel industry is changing with the evolutions of technology. The prudent companies are incorporating the new technologies to stay current and competitive. The technology of CAD graphics, can be used to increase productivity and to help shorten the response time in the design cycle in order to implement the quick response strategy. CAD graphics can be interfaced to some textile machinery and other automated systems to increase productivity and create a computer integrated manufacturing (CIM) environment.

Suppliers of CAD technology need to continue to develop software/systems which will be easier and more efficient for the CAD operator/manager in the design and marketing phases of apparel product development. It is up to suppliers of CAD technology to keep up with the ever changing industry which needs a quick response strategy to stay alive.

Since CAD graphics technology is here to stay, it is imperative that educational institutions which offer degrees in the area of textile/apparel design and marketing incorporate CAD graphics into their curriculum in order to prepare students for industry jobs in the area of CAD graphics. This research showed the high salary potential for CAD operators/managers and therefore should be an incentive for

students to become proficient in CAD graphics. Also, the results show that most CAD operators/managers are college educated. Therefore, textile/apparel companies should look at schools and universities which offer courses in CAD graphics for perspective employees.

Suggestions for Further Study

Other research could be done in the area of comparing different systems and also in the area of adequacy of training. This study only looked at utilization in one aspect of new technology, CAD graphic systems for design and marketing of textile/apparel product development. Further research could be done in the area of CAD expertise in patternmaking, grading, marker making, and cutting systems.

Also, further research is needed specifically in the area of interfacing CAD graphics for textiles to textile machinery. Additional research could determine how the applications of CAD graphics and the interfacing to textile machinery could benefit textile/apparel production.

This study could be repeated over time to monitor changes in the utilization of CAD graphics systems in design and marketing phases of textile/apparel product development.

REFERENCES

- American Apparel Manufacturers Association. (1989). Impact of computer-aided design on apparel/fashion design. Arlington, VA, Management Systems Committee: Author.
- Beard, J. (1990, February 10). Computers weave a new fashion. New Scientist, pp. 48-50.
- Belleau, B. D. & Bourgeois, E. B. (1991). Computer-aided apparel design in university curricula. Journal of Home Economics, 83(3), 28-30.
- Bendell, T. (1988). Taguchi methods, Proceedings of the 1988 European Conference. Elsevier Applied Sciences, London.
- Bradshaw, J. (1972, March 30). The concept of social need. New Society, pp. 640-643.
- Cedrone, L. (1991, January). CAD/CAM marches on. Bobbin Magazine, pp. 82-86.
- Dagro, P. M. (1989). Louisiana apparel manufacturers attitudes toward computer-aided design/manufacture and competitiveness. Unpublished master's thesis. Louisiana State University and Agricultural and Mechanical College, Baton Rouge.
- Dworkin, N. (1991, February). Survival of the fastest. Knitting Times, pp. 21-24.
- Fader, J. L. (1990, June). PDS acceptance and implementation. Apparel Manufacturer, pp. 14-20.
- Fraser, A. (1985, July). Designers, patternmakers & production managers evaluate CAD/CAM. Bobbin, pp. 35-44.

Friedman, L. (1989, February). The CAD revolution, domestically speaking. Bobbin Magazine, pp. 101-102.

Friedman, L. (1990, April). New developments in computer-aided draping. Apparel Manufacturer, pp. 12-14.

Friedman, L. (1991, April). CAD/CAM technology paints a new picture. Bobbin Magazine, pp. 86-89.

Global Communications. (1992, April). Apparel Industry Magazine, pp. 40-46.

Gordon, R. D. (1989, February). Trends in automatic marking. Bobbin Magazine, pp. 72-76.

Henderson, H. R. (1986, April). The CAD frontier. Apparel Industry Magazine, pp. 48-53.

Hirschhorn, S. (1983, January). Computerizing to compete. Bobbin Magazine, pp. 166-171.

Huck J., & Hedrick, A. (1990). Introducing apparel design students to computer-aided design: A lab manual for Autocad [Summary]. Proceedings of the Association of College Professors of Textiles and Clothing, 136.

Hunter, A. (1990). Quick response in apparel manufacturing a survey of the American scene. Manchester, England: The Textile Institute.

Jarnow, J. A., Guerreiro, M., & Judelle, B. (1987). Inside the fashion business. New York: Macmillan.

Kallal, M. J. (1989). Integrating CAD graphics training with creative design topics. Proceedings of the Association of College Professors of Textiles and Clothing, 138.

- Kaster, M. (1991, February 8). CAD-CAM is coming to a store near you. Daily News Record, p. 36.
- Kaufman, R. A. & English, F. W. (1979). Needs assessment: concept and application. Englewood Cliffs, N.J.: Educational Technology Publications.
- Keating M. (1992, February). Quick response through CAD/CAM electronic graphical interchanges. SAFLINC TALC QR Review, pp. 6-7.
- Kincade D. H. & Cassill N. L. (1990). Quick response strategies: segmenting the apparel industry [Summary]. Proceedings of the Association of College Professors of Textiles and Clothing, 28.
- Knoll, D. S. (1990a). Autocad in pre-production apparel design [Summary]. Proceedings of the Association of College Professors of Textiles and Clothing, 135.
- Knoll, D. S. (1990b). Autocad in the curriculum: Pre-production Design. The Association of College Professors of Textiles and Clothing Special Publication #2, pp. 30-32.
- Knoll, D. S. (1990c). Computers in the study of clothing & textiles: current use and future trends. Unpublished doctoral dissertation, University of Arkansas, Fayetteville.
- Koch, K. E. (1990). CAD in the clothing and textile classroom: one approach to course development. The Association of College Professors of Textiles and Clothing Special Publication Special Publication #2, pp. 5-8.
- Kosh, K. (1989a, February). How cad fits in the design process, part one. Bobbin Magazine, pp. 67-70.

- Kosh, K. (1989b, March). How cad fits into the design process, part two. Bobbin Magazine, pp. 44-46, 52-54 .
- Kosh, K. (1989c, March). Making CAD technology perfect. Bobbin Magazine, pp. 48.
- Kosh, K. (1990, August). Pattern quality, MU and CAD/CAM systems. Apparel Manufacturer, pp. 11-16.
- Law, P. (1983). Educational application of computers: a descriptive study of home economics educators in american colleges and universities. Dissertation Abstracts International, 44, 1713-A.
- Macdonald, J. & Piggott, J. (1990). Global quality the new management culture. Mercury, pp. 6-10, 16-19, 32-37, 91-101.
- Martel, C. R. (1990, January). Three-dimensional thinking. Apparel Manufacturer, pp. 8, 12-16.
- Mazzarco, M. (1990, April 5). More designers try computers, but they're not for everyone, yet. Women's Wear Daily, pp. 8-9, 25.
- Microdynamics, Inc. (1990). Product Guide. Dallas, TX: Author.
- Miller, P. B. (1989, March). Trim fit for design. Bobbin Magazine, pp. 58-64.
- Miller, P. B. & DeJonge, J. (1987, February). University explore computer aided design by microcomputer. Bobbin Magazine, pp. 127-128.
- Miller, P. B., & Racine, A. (1988, September). Less means more in CAD. Bobbin Magazine, pp. 222-224.
- Mosrie, D. (November, 1980). Assessing school needs: a practical approach. NASSP Bulletin, pp. 64-67.

- Rosenthal, J. (1989). Using paint systems to teach computer-aided textile design and fashion design. The Association of College Professors of Textiles and Clothing Proceedings: Combined Central Eastern & Western Regional Meetings, 55.
- Rutberg, S. (1990, April 5). Updating CAD, new tools for tomorrow's fashion designers. Women's Wear Daily, pp. 7.
- Sheldon, G. J. (1988a). The impact of technology on apparel designer training. Clothing and Textiles Research Journal, 6,(4), 20-25.
- Sheldon, G. J. (1988b). Proceedings of the National meeting of the Association of College Professors of Textiles and Clothing, 144.
- Sheldon, G. J., & Regan, C. L. (1990). Computer-aided design in higher education. Journal of Home Economics, 82(3), 35-40.
- Staples, N. J. (July, 1990). Computer use for apparel pattern making. Apparel Manufacturer, pp. 14-20.
- Steinhaus, N. H. (1988). Apparel-related tutorials designed to teach Autocad. Proceedings of the combined Central, Eastern and western Regional Meetings of the Association of college professors of textiles and clothing, 36.
- Stolovitch, H. D. (1978, August). Needs assessment in the classroom, pinpointing priority problems. Educational Technology, 18, pp. 443-459.
- Swanson, K. K. (1987). Computer-aided design in apparel manufacturing: 1987 update. Unpublished Master's thesis. Colorado State University, Fort Collins.
- Thacker, R. M. (1989). A new CIM model. Society of Manufacturing Engineers, Dearborn, Michigan.
- The future is now. (1991, February). Knitting Times, pp. 34-39.

- Trimby, M. J. (1979, December). Needs assessment models:a comparison.
Educational Technology, pp. 24-28.
- Truth in Fashion. (1991, September). Glamour, p. 237.
- Van De Bogart, W. (1988a, May). Changing CAD. Apparel Industry Magazine,
pp. 44-49.
- Van De Bogart, W. (1988b). Designing for the times. Bobbin Magazine, pp. 58-64.
- Van De Bogart, W. (1988c, September). New CAD world dawns for designers.
Women's Wear Daily/Daily News Record, pp. 34-36.
- Van De Bogart, W. (1990, July). High-tech arrives on the fashion scene. Macintosh-
aided Design, pp. 10-18.
- Waddell, G. (1988, November). Fashion design by computer. Apparel International,
pp. 5-7.
- Watson, K. K. (1979). A four-step model for implementation of needs assessment in
two Iowa school districts. Education, 102(3), 250-253.
- Weintraub, E. (1987, July). Initial steps to quick response. Bobbin Magazine, pp. 18,
20.
- Wilhelm, W. T. (1983, December). CAD systems update. Bobbin Magazine,
pp. 156-158.

APPENDICES

October 28, 1991

Dear :

Virginia Tech is conducting a survey to determine skill needs of CAD graphics users in designing/marketing. Because of your expertise you have been selected to preview the questionnaire which will be revised based on your comments. The revised questionnaire will then be sent to CAD managers/operators in the United States and Canada.

Please fill out the questionnaire and make comments and/or suggestions on each question you feel should be changed. I am enclosing a self-addressed stamped envelope for your convenience in returning the questionnaire. You will be contacted in late November for a quick interview regarding this questionnaire.

Your prompt response to this inquiry will be greatly appreciated. Thank you for your help.

Sincerely,

**Suzanne M. Venkataraman
Masters Candidate**

**Carolyn L. Moore, Ph.D.
Graduate Committee Chairman**

Dear CAD Manager/Operator:

Recently a questionnaire seeking your opinion on computer graphics used in the design/marketing phases of apparel product development was mailed to you. If you have already completed and returned the questionnaire, please accept our sincere thanks. If not, please do so today (questionnaire enclosed). Since this questionnaire was sent to a small group, it is extremely important that your response be included in the study.

When you return the questionnaire please fill out the enclosed coupon to enter your name in a **free drawing for a one year subscription to COMPUTER GRAPHICS WORLD!** Hurry, for the drawing will be held on February 17, 1992.

Thank you for your prompt response.

Sincerely,

Suzanne M. Venkataraman
Graduate Student

Dr. Carolyn Moore
Graduate Advisor

June 24, 1992

Dear Ms. Collins:

We thank you for participating in our CAD Graphics research by promptly returning the questionnaire sent to you in January 1992. We would like to inform you that **your name/company** was chosen in the drawing for the **free subscription to Computer Graphics World**.

You should expect to receive your first issue of Computer Graphics World within two months. Again, **thank you** for your cooperation and **congratulations!**

Sincerely,

Suzanne M. Venkataraman
Graduate Student

Dr. Carolyn Moore
Graduate Advisor

CAD GRAPHICS QUESTIONNAIRE

The following survey is confidential. Please answer all questions to the best of your knowledge. If CAD graphics is being used in other offices within your company, for design and/or marketing and you are familiar with how the system(s) is being used, please answer all questions related on that knowledge otherwise answer questions in relation to your direct office only.

GENERAL INFORMATION

1. Are you a CAD graphics user in design and/or marketing?
☐ yes ☐ no

If you answer NO to this question, please skip all other questions and return the questionnaire in the enclosed envelope. Thank you.

2. What is the primary product designed or manufactured by your company?

3. Total number of employees in your company (at all locations)? _____

4. What is your company's average gross annual volume of business in dollars?

5. How many years of industry experience do you have?

☐ less than 1 year ☐ 1 - 4 years ☐ 5 - 9 years
☐ 10 - 15 years ☐ 16 - 20 years ☐ 21 +

6. How long have you worked for your present company?

☐ less than 1 year ☐ 1 - 4 years ☐ 5 - 9 years
☐ 10-15 years ☐ 16 - 20 years ☐ 21 +

7. Please state your actual job title? _____

8. At present do you hold a supervisory position? ☐ Yes ☐ No

If you are involved in interviewing, what criteria do you use to select/hire operators to work on your CAD system(s)?

9. What was your position before your company purchased your CAD graphics system?

10. Were you hired specifically to work on your company's CAD graphics system?

☐ yes ☐ no

If yes, why do you feel you were selected for the position?

11. What is your current annual salary level?

☐ under \$20,000 ☐ \$21 - \$30,000 ☐ \$31 - \$40,000
☐ \$41 - \$50,000 ☐ \$51 - \$60,000 ☐ over \$60,000

12. What is your age?

☐ under 24 years ☐ 25 - 29 years ☐ 30 - 39 years
☐ 40 - 49 years ☐ 50 - 59 years ☐ 60 + years

13. What is your gender?

☐ male ☐ female

14. What is your highest level of education?

- | | |
|-------------------------------------------------|-----------------------------------------------------------|
| <input type="checkbox"/> Less than high school | <input type="checkbox"/> High school education |
| <input type="checkbox"/> Trade school education | <input type="checkbox"/> Some college education |
| <input type="checkbox"/> Associate's degree | <input type="checkbox"/> Bachelor's degree |
| <input type="checkbox"/> Masters degree | <input type="checkbox"/> PhD. or advanced graduate degree |

15. Have you had previous CAD graphics experience other than with your present company?
(check as many as applicable)

- | | |
|------------------------------------------------------|-----------------------------------------------------------|
| <input type="checkbox"/> no prior experience | <input type="checkbox"/> course in trade school |
| <input type="checkbox"/> course in college | <input type="checkbox"/> seminars |
| <input type="checkbox"/> prior work experience | <input type="checkbox"/> worked for a CAD graphics vendor |
| <input type="checkbox"/> other, please specify _____ | |

16. If you have had prior CAD graphics experience on what CAD graphics system(s) have you had prior experience?

<u>Type of system</u>	<u>Months/Years of Experience</u>
<input type="checkbox"/> CDI	_____
<input type="checkbox"/> Gerber	_____
<input type="checkbox"/> Infodesign	_____
<input type="checkbox"/> Lectra	_____
<input type="checkbox"/> Microdynamics	_____
<input type="checkbox"/> Mechanix	_____
<input type="checkbox"/> ModaCad	_____
<input type="checkbox"/> Monarch Computex	_____
<input type="checkbox"/> Preview/Premiere	_____
<input type="checkbox"/> Shima Seika	_____
<input type="checkbox"/> other (please specify) _____	_____

17. How many CAD graphics system(s) does your company have and in what department(s) is it used in your company?
DO NOT answer this question for patternmaking, grading, and marking systems.

<u>Type of system</u>	<u>No. of Stations</u>	<u>Name the Dept/area</u>
<input type="checkbox"/> CDI	_____	_____
<input type="checkbox"/> Gerber	_____	_____
<input type="checkbox"/> Infodesign	_____	_____
<input type="checkbox"/> Lectra	_____	_____
<input type="checkbox"/> Microdynamics	_____	_____
<input type="checkbox"/> Mechanix	_____	_____
<input type="checkbox"/> ModaCad	_____	_____
<input type="checkbox"/> Monarch Computex	_____	_____
<input type="checkbox"/> Preview/Premiere	_____	_____
<input type="checkbox"/> Shima Seika	_____	_____
<input type="checkbox"/> other (please specify) _____	_____	_____

18. How many people have been trained on your system(s)?

☐ 1 ☐ 2-4 ☐ 5-9 ☐ 10-19 ☐ 20-39 ☐ 40+

19. How many people actively use your system(s)?

☐ 1 ☐ 2-4 ☐ 5-9 ☐ 10-19 ☐ 20-39 ☐ 40+

20. How many hours a day do you work on your CAD graphics system?

☐ 1-4 hours ☐ 5-8 hours ☐ 9- over

21. How long does it take to become efficient on your CAD graphics system(s)?

☐ 1-3 months ☐ 4-6 months ☐ 7-11 months
☐ 12+ months ☐ do not know

22. Within the next five years, does your company plan to purchase additional equipment and/or CAD graphics systems (for design/marketing only)?

☐ yes ☐ no ☐ do not know

If yes, then what equipment or other purchases do you think your company may make?

- ☐ updated printers
- ☐ update input devices (scanners, video cameras, etc.)
- ☐ updated computer hardware
- ☐ additional software to be used on current system(s)
- ☐ optical disk storage devices
- ☐ more CAD stations of current system(s)
- ☐ another type of CAD graphics systems?
- ☐ other, please specify _____

23. In what ways has your company benefitted by the introduction of CAD graphics into the design and/or marketing phases of apparel product development? (Check as many as applicable.)

- ☐ shortened the response time of development of ideas in design cycle
- ☐ eliminated all sample making of garments
- ☐ eliminated some sample making of garments
- ☐ eliminated the use of freelance artist
- ☐ allowed more time for additional ideas to be presented then before the purchase of the CAD graphics system(s)
- ☐ eliminated all hand painted textile renderings
- ☐ eliminated some hand painted textile renderings
- ☐ do not know

24. In what other ways has your company benefitted from the purchase of your CAD graphics system(s)?

CAD GRAPHICS APPLICATION QUESTIONS

25. Please rank in numeric order (1-3) the top three uses of your CAD graphics system(s). (1 = Most; 3 = Least)

- ☐ as an idea/creative tool
- ☐ as a decision making tool
- ☐ as a presentation and/or marketing tool

26. Please rate in numeric order (1-5) the top five applications of your CAD graphics system(s).

- ☐ fashion sketching/illustration
- ☐ textile design and/or colorations (prints, yarndyes or knits)
- ☐ creation of technical data for textile machinery (prints, yarndyes or knits)
- ☐ garment styling/designing
- ☐ trim development
- ☐ applying textiles to silhouettes
- ☐ hang tag, label and logo development
- ☐ 2-D draping/texture mapping
- ☐ 3-D draping/texture mapping
- ☐ development of first pattern from draped image
- ☐ development of storyboards for in-house and/or buyer marketing presentations
- ☐ catalog generation
- ☐ desk top publishing

27. Please state any other uses of your CAD graphics system which has not been mentioned in Question 26.

28. Using the scale below, please indicate the percentage of the usage of your CAD graphics system(s) for each task.

- 1 = 75-100%
- 2 = 50-74%
- 3 = 25-49%
- 4 = 1-24%
- 5 = 0

color matching from monitor color to printer color book	1	2	3	4	5
scanning/videoing in sketches, fabrics, magazine clippings, etc.	1	2	3	4	5
development of flat spec drawings directly in system	1	2	3	4	5
alteration of illustrations or spec drawings from scanned in images	1	2	3	4	5
development of trims	1	2	3	4	5
colorations of sketches and illustrations	1	2	3	4	5
adding stitching and/or trim details to sketches and illustrations	1	2	3	4	5
yamdye colorations	1	2	3	4	5
development of yamdyes directly in system (weaving)	1	2	3	4	5
development of loom data information and/or other technical info.	1	2	3	4	5
print colorations	1	2	3	4	5
development of original prints directly in system	1	2	3	4	5
development of prints from scanned in objects/motifs	1	2	3	4	5
development of entire repeats for prints	1	2	3	4	5
development of color separations for prints	1	2	3	4	5
knit colorations	1	2	3	4	5
graphing of knit swatches and/or applying knit stitch simulation	1	2	3	4	5
graphing of entire knit bodies	1	2	3	4	5
development of technical data for knitting machinery	1	2	3	4	5
draping/texture mapping	1	2	3	4	5
development of 1st pattern from draped/mapped image	1	2	3	4	5
font/letter development	1	2	3	4	5
development of hang tags, labels and logos	1	2	3	4	5
catalog generation	1	2	3	4	5
desk top publication	1	2	3	4	5
development of images for presentation boards	1	2	3	4	5
animation	1	2	3	4	5

29. In what areas do you feel CAD graphics system(s) must improve in order to make your job more efficient?

Thank you for your help with this questionnaire. Please return it in the enclosed envelope.

VITA

Suzanne M. Venkataraman (born Suzanne M. Lavoie) was born on July 19, 1963 in Manchester, New Hampshire. She graduated from Manchester West High school in 1981. In 1987, she graduated cum laude with a B.S. Degree in Clothing & Textiles with an emphasis in apparel design from Framingham State College in Massachusetts. While attending her last year at Framingham State College, Ms. Venkataraman worked as a patternmaker/grader for Manchester Knitted Fashions., There, she was first introduced to computer-aided design and operated an Investronica CAD system.

In August 1987, she continued her studies in Clothing & Textiles as a graduate student at Virginia Tech until December 1989. During 1987-1989, Ms. Venkataraman worked as a graduate assistant in the Research & Development Lab where she learned to operate the Lectra CAD system. She also worked as a teaching assistant for Apparel Design I.

In January 1989 - January 1991 Ms. Venkataraman worked for Microdynamics as a Demonstrator/Customer Education Specialist on the Microdesign system. The author was also self-employed as a CAD consultant and freelance CAD artist from 1990 to 1992. In June 1990, the author married Srinivasan Venkataraman. In January 1991 the author joined CMT Enterprises as the CAD Director of Design/marketing and worked there until returning to Virginia Tech to complete her Master of Science Degree with a Major in Clothing and Textiles. In May 1992, the author gave birth to a daughter, Chantel Marie. The author has continued to be self-employed as a CAD consultant and freelance CAD artist.

**CAD GRAPHICS UTILIZATION IN THE DESIGN AND MARKETING
PHASES OF TEXTILE/APPAREL PRODUCT DEVELOPMENT**

by

Suzanne M. Venkataraman

(ABSTRACT)

The purpose of this research was to identify the expertise of CAD graphics operators/managers in the design and marketing phases of textile/apparel product development. Additionally, the purposes were to determine the effect of CAD graphics on product development in the textile/apparel industry, and to identify future needs and uses of CAD graphics in the industry.

A questionnaire was sent to 117 CAD graphics operators/managers. The results from the questionnaire were obtained through frequency and percentage distributions.

The major findings of this study concluded that textile design and/or colorations and coloration of sketches were the major uses for CAD graphics systems. The shortening of response time of development of idea in design cycle was the major benefit of using a CAD graphics system. Future needs and wants were found to be mainly in the areas of better color control, matching and selection, better resolution in printing, and faster, larger printout capabilities.