THE IMPACT OF COMPUTER AIDED DRAFTING TECHNOLOGY
ON INDUSTRIAL EDUCATION CURRICULUM
IN BRITISH COLUMBIA SECONDARY SCHOOLS

by

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B.Sc., University of British Columbia, 1973

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

in
THE FACULTY OF GRADUATE STUDIES
Department of Education

We accept this thesis as conforming
to the required standard

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STATEMENT OF THE PROBLEM

The purpose of this study was to identify the prerequisite skills most appropriate to training and/or employment in computer aided drafting. Specific objectives of the study were concerned with:

1. The prevalence of CAD in specific industries.
2. The relationship between the size and/or type of CAD system and the training required to operate it.
3. The background and training of individuals operating CAD systems.
4. The preferences of employers as to the education of their CAD operators.
5. The preferences of CAD training institutions as to the education of CAD training candidates.
6. The methods by which individuals in industry received CAD training.
7. The methods of CAD training preferred by employers.
8. The importance of certain skills relative to CAD employment or training.
9. The importance of certain secondary school drafting curriculum items relative to CAD training or employment.
10. The identification of secondary school curriculum areas to be modified to suit the needs of industry and CAD training institutions.
PROCEDURES

The survey questionnaire method was used to obtain data for this study. Two parallel, closed-form questionnaires were developed from a review of related literature and an analysis of current drafting standards and techniques. One questionnaire was sent to all training institutions in British Columbia offering courses in CAD. The other questionnaire was sent to sixty-five businesses in British Columbia identified as users of CAD technology.

The responses were analysed to provide information on the impact of CAD technology on secondary school curriculum. The importance of particular items was determined through calculation of mean priority or ranking levels.

FINDINGS

The businesses surveyed were primarily involved in mechanical and electronics drafting followed by structural, architectural, and cartographic. Training institutions were concerned with architectural and civil drafting followed by mechanical and structural. Data indicated that CAD was being used in all areas of drafting.

CAD system descriptions indicated that a large number of businesses and training institutions were using personal computer based CAD systems that were less expensive and easier to operate than larger mainframe or dedicated systems.

Educational institutions indicated that the majority of their CAD training candidates were upgrading themselves and that they preferred candidates with a good drafting background. Businesses indicated that most of their CAD operators were draftspersons retrained for CAD. Few CAD operators had received formal CAD training although employers indicated a hiring preference for draftspersons with formal training in CAD.
Both businesses and training institutions involved with CAD considered manual drafting skills and good problem solving ability to be the most important prerequisites for CAD training or employment. With respect to specific drafting skills, there was consensus on the importance of individual items. Dimensioning to CSA standards was considered most important followed by the three dimensional representations typified in sketching, pictorial, drawing, auxiliary views, and developments.

Both surveys indicated that curricular change to reflect the changing technology was necessary and should include the introduction of computer aided drafting at the secondary level as well as more drafting course time and more emphasis on computational and communication skills.

CONCLUSIONS

1. Drafting, especially computer aided drafting, should be approached as a necessary skill for a wide variety of occupations and not as a vocation in itself. This would require a conscious effort to open secondary school drafting programs to all students, not just those in industrial programs.

2. Drafting educators should acquaint themselves with the changing technology of drafting including contact with post secondary training institutions and representative industry.

3. Secondary school drafting programs should introduce students to computer aided drafting.

4. More emphasis should be placed on dimensioning to CSA standards and on areas of drafting that involve viewing an object in three dimensions.

5. Secondary school curriculum should be modified to include more drafting time and place more emphasis on computational and communication skills.
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ACKNOWLEDGEMENTS

I would like to express my appreciation for the advice and guidance offered by my Faculty Advisor, Professor R. LeDuc, and thanks also to Professor W. Logan and Dr. J. Gaskell, the other members of the thesis committee, for their assistance in developing this study.

I also wish to thank Mr. D. Ogilvie and Mr. D. Nowoselski for their assistance with computer programs and word processing. To Mr. L. Robinson, my sincere appreciation for his efforts on my behalf and to Ms. J. Lowe my thanks for her excellent typing skills.

My special thanks to my wife, Karen, whose cooperation and encouragement made this work possible.
CHAPTER ONE

INTRODUCTION

Background to the Problem:

Since the early 1970's, governments of many industrialized nations, recognizing the benefits of computer aided design and manufacturing to their economies, have promoted its adoption by both state and private enterprise. The automated factory, made possible by advances in microchip technology, has become more available at increasingly less cost to a greater number and wider variety of businesses. Millions of dollars have been spent in Europe, the United Kingdom, Japan, and the United States to encourage the development and adoption of this technology by industry, creating a coincident increase in the demand for technical expertise. The development of required training and education for this technology has been left to the CAD/CAM vendors, universities, technical institutes, and trade schools with little or no assistance from government. As a result, education and training for CAD/CAM have become a priority in these countries.

The Canadian government, recognizing the need for expertise in these areas, has encouraged provincial educational institutions to develop appropriate training programs through its Skills Growth Fund and other programs. In British Columbia, there are sixteen institutions presently offering a variety of high technology oriented courses. Most of these institutions have been assisted through federal and provincial grants to develop courses in computer aided design, drafting, and manufacturing through the purchase and installation of CAD systems.
The most popular high technology programs, and the ones that promise the most opportunity for employment in British Columbia, are those that offer computer aided drafting. In most cases, this training is offered as a part of a drafting technology, engineering, or similar program, although there is considerable demand for offerings of computer aided drafting as an upgrade course for engineers, architects, designers, draftsmen, and other professionals.

There appears to be little distinction between computer aided design and computer aided drafting and it should be noted that most institutions are offering computer aided drafting along with their regular courses in design. As the existing technology becomes more integrated, more systems will become available that incorporate the design parameters and manufacturing control with the drafting software. For the purpose of this study, design was considered to be concerned with engineering analysis rather than the act of conceptualizing.

At the secondary school level, educators experience what can be described as a "trickle-down effect" with regard to high technology innovation and similar advances. The computer education available at the university level in the early 1960's has, in twenty years, trickled down to the secondary school level. Word processing, which was once available only at colleges and trade schools, is now being taught at the grade seven level in some British Columbia school districts. The same analogy may apply to the computer aided drafting technology. If this technology is to trickle down into the secondary schools, as it appears to be doing, a revision of present drafting curriculum becomes increasingly important. Even without adopting this technology at the secondary level, skills
presently being taught should be examined as to their suitability for the technology of the workplace or further training. Manual drafting, as a vocation, is rapidly disappearing, but the need for appropriate drafting skills may be more important now, for an increasing number of occupations, than ever before.

This study will examine two stages of influence on curriculum. The first area is that of recognition of changes in technology and incorporating them into the curriculum. As Hildebrand (1974) states,

"... if industrial arts drafting programs are to remain effective and current, it is essential that the Industrial Arts educator scrutinize and incorporate new practises and innovations of industry into the drafting programs." (p. 1)

The second stage is introspective: to examine the present curriculum to determine which areas are most important with respect to the requirements of industry and post secondary education. Hildebrand also supports this, asking,

"What have these changes meant for the drafting educator? They have indicated a need for careful analysis of course content in an attempt to select those elements most relevant in light of current industrial needs." (p. 4)

Further support is offered by Case (1971),

"... it is necessary for industrial educators to keep abreast of the rapid advancements in the field of technology. Not only must they be cognizant of the changes taking place in industry, they must also find means of implementing these technological changes to update the curricula." (p. 1)

Purpose of the Study:

The purpose of this study is to identify, through a survey of industries and educational institutions, the prerequisite skills most appropriate to training and/or employment in computer aided drafting.
Specific objectives of the study are:

1. To determine the prevalence of CAD in specific industries.
2. To determine if any relationship exists between the size and/or type of CAD system and the training required to operate it.
3. To examine the background and training of those individuals presently operating CAD systems.
4. To determine if employers have any preferences as to the educational background of future CAD operators.
5. To determine if CAD training institutions have any preferences as to the educational background of the individuals they teach.
6. To determine the predominant methods by which individuals in industry received their CAD training.
7. To determine which method of CAD training is preferred by employers.
8. To determine the importance of certain psychomotor, cognitive, and industrial skills relative to CAD employment or training.
9. To determine the importance of present secondary school drafting curriculum items relative to CAD employment or training.
10. To identify areas of secondary school curriculum requiring modification to suit the perceived needs of industry and CAD training institutions.

**Significance of the Study:**

Post secondary training institutions and representative industries were asked for information concerning the operation of their CAD systems and the relative importance of certain skills and curriculum items to further training or employment in computer aided drafting. The findings
will enable an informed revision of present curriculum in drafting and a
variety of related subjects. It will also allow educators to better inform
students about specific requirements for CAD related occupations and will help
to strengthen the relationship between industry and educational institutions
in British Columbia.

Assumptions:
The results of this study are based on the assumption that certain factors
would not have a significant effect on the validity of the information gathered.
Specifically, these assumptions are:

1. That the industries sampled were representative of those industries
   in British Columbia that employ CAD personnel.
2. That the educational institutions sampled were representative of
   those British Columbia institutions offering training in CAD.
3. That the survey participants were honest, competent, and informed
   in their responses.
4. That the survey instruments did collect the information for which
   they were intended.
5. That the researcher would be unbiased and accurate in his reporting.

The study also assumed the following conditions:

1. That the information gathered would be of assistance in revising
   curriculum in British Columbia secondary schools.
2. That CAD technology is a significant factor in determining curriculum.
3. That curriculum change in this context would be beneficial to students,
   education, and industry.
4. That informed opinion would be a useful measure or indicator of the
   prerequisite skills for CAD.
Delimitations:

The following limitations were applied to this study:

1. The survey of CAD operators was limited to those industries in British Columbia that utilize computer aided drafting systems. Compilation of the sample was done through the assistance of the British Columbia Innovations Office, the Drafting Technology Department at Cariboo College, and Technology West Magazine.

2. The survey of CAD training institutions was limited to those institutions in British Columbia that offered computer aided drafting as a course in itself or as a part of the training for a related discipline and that were actively instructing students in CAD.

3. The survey questionnaires were mailed in April, 1985 and information gathered over a two month period. Results are relative to conditions present during this time.

4. Questionnaires that were not returned within the established time frame of the study were not included.

Definition of Terms:

Computer Aided Drafting (CAD) -- drafting done with the aid of a computer where entry of data is made primarily through graphic construction at the terminal and output is made through an electronic plotter.

Computer Aided Design -- for this study, design done with the aid of a computer where entry of data enables an analysis of specific design parameters.

Computer Aided Manufacturing (CAM) -- computer control of an integrated machining process, usually via a CAD terminal.
Computer Integrated Manufacturing (CIM) -- complete control of the engineering, design, and manufacturing process through a computer terminal.

Course -- organized subject matter in which instruction is offered within a fixed time period and for which credit toward graduation or certification is usually given.

Computer -- any machine capable of accepting information, performing numerical and logical manipulations and displaying the results.

Curriculum -- the planned composite effort of any school to guide pupil learning toward predetermined learning outcomes.

Hardware -- the mechanical, magnetic, electrical, and electronic devices from which a computer is constructed.

HVAC -- acronym for heating, ventilating, and air conditioning.

Industry -- for this study, any business employing personnel to operate CAD systems. The combination of organizations and facilities that, through the effective coordination of capital, management, and labour, produces goods to meet the needs and desires of society.

Industrial Education -- for this study, education relating to the methods, processes, and materials of industry.

Professional -- for this study, a person with post-secondary education in an applied discipline.

Software -- computer programs and collections thereof, including compilers and assemblers which can be used to generate other programs.

Technology -- industrial science; the science or systematic knowledge of the industrial arts, especially as applied to manufacturing.

Vocational Education -- education relating to the acquisition of specific skills for an occupation.
Method of Procedure:

The following procedure was used to conduct this study:

1. Sixty-five firms utilizing CAD systems in British Columbia and fifteen educational institutions offering training in computer aided drafting in British Columbia were selected for the survey sample populations.

2. Two parallel, modified, closed-form questionnaires were mailed with a cover letter and a stamped return envelope to the selected firms and institutions.

3. The results from the returned questionnaires were compiled and graphed to permit analysis.

4. Conclusions and recommendations concerning curricular revision were made according to the results of the survey.

Summary:

The use of computer aided drafting and design technology in industry is steadily increasing in British Columbia. As a result, drafting personnel are being replaced by CAD technologists and other professionals with CAD skills. Post secondary educational institutions have been encouraged to provide the necessary CAD skills but secondary school curriculum has remained unchanged. This study was designed to identify secondary school curriculum items that should be changed or adopted to meet the needs of CAD training institutions and employers.

Structure of Study:

The balance of the study is divided into four more chapters plus Bibliography and Appendices. Chapter Two, following, presents a review of
the literature dealing with curriculum development in Industrial Education, current research and research methods in Industrial Education, and periodical literature of interest. Chapter Three discusses the methods and procedures used in the study. The findings of the study are presented in Chapter Four and include bar graphs of the survey data. Chapter Five summarizes the study and presents specific conclusions and recommendations. The Appendices include cover letters, questionnaires, directories of CAD training institutions and firms using CAD, and selected comments and CAD system descriptions from returned questionnaires.
CHAPTER TWO

REVIEW OF RELATED LITERATURE

The review of the literature is divided into three areas. The first of these is concerned with curriculum development and the relationship between industry and education. The second area is concerned with recent research and research methods in industrial education, particularly in the fields of drafting, computer graphics, and related topics. The third area concentrates on technical literature, journals, and periodicals having to do with computer aided drafting and similar technological innovations, especially in relation to education.

Curriculum Development:

Every curriculum researcher seems to have a different concept or definition of curriculum to the extent that Eisner (1975) suggests that consistency in curriculum development theory would be a major accomplishment. For the purposes of this study, a number of current theories and influences were reviewed with the intention of providing a workable theoretical and practical framework for curricular revision in Industrial Education.

Stenhouse (1975) offers three current definitions for curriculum,

"Curriculum is 'all the planned experiences provided by the school to assist the pupils in attaining the designated learning outcomes to the best of their abilities.'" (Neagley and Evans 1967, 2);

"Curriculum is the planned composite effort of any school to guide pupil learning toward predetermined learning outcomes." (Inlow 1966, 7);

"In view of the shortcomings of the currently popular definition, it is here stipulated that curriculum is a structured series of
intended learning outcomes. Curriculum prescribes (or at least anticipates) the results of instruction." (Johnson 1967, 130).

He then offers his own tentative definition of curriculum,

"A curriculum is an attempt to communicate the essential principles and features of an educational proposal in such a form that it is open to critical scrutiny and capable of effective translation into practice." (p. 4)

Expanding on this, he adds,

"A curriculum is the means by which the experience of attempting to put an educational proposal into practice is made publicly available. It involves both content and method, and in its widest application takes account of the problem of implementation in the institutions of the educational system." (p. 5)

Hickling (1979) focuses on those who define curriculum as a plan,

"For a description of what curriculum is, we turn to Young (1977), who defines curriculum as "... a plan outlining the objectives and content of a subject which is available to learners in school." (p. 8) Resnick (1975) states that "... a curriculum can be thought of as a series of activities explicitly designed to change the knowledge and competence of those who engage in it." (p. 36) And Heasley 1974) views curriculum as "... a plan of experiences designed by and for educators to nurture various aspects of the total development of children." (p. 44)

All of these definitions are somewhat circular, similar to the old adage that curriculum is "what is taught". This writer feels that a definition of curriculum should also indicate that curriculum is always influenced by an external culture to the benefit of that culture. Bowles and Gintis (1976) suggest that such a relationship exists in western society.

"We have been able to show more than a correspondence between the social relations of production and the social relations of education at a particular moment. We have shown that changes in the structure of education are associated historically with changes in the social organization of production. The fact that changes in the structure of production have parallel changes in schooling establishes a strong prima facie case for the causal importance of economic structure as a major determinant of educational structure." (p. 224)

It is this external influence that develops or changes curriculum.
Curriculum will continuously evolve to reflect the culture of the society that it serves. Ralph Tyler (1978) also alludes to this, stating,

"As society demands more of our schools we must be more inventive in devising feasible programs -- based, as Rubin indicates, on rational policies -- that will meet the new conditions."

"... attack serious educational problems thoughtfully [sic], systematically, and persistently, using more effectively the available resources. This is an evolutionary process like those in the past that have made our schools responsive to continuing social change."

(p. 186-7)

As our society becomes more technological, there is a tendency for curriculum to become more humanistic in response to the associated socio-logical problems, but the demand for relevance in education intensifies. Peterson and Park (1975) sense the possible loss of humanistic values depending on how education reacts to this pressure.

"Career education, the most expansive human resources development program the government has ever proposed, could, depending on the value systems which it espouses, be the near final step in subordinating the education system to the production system. It is possible that historians of the future will look upon our time as another Dark Age, this time blanketed by industry rather than the church.

There are, however, alternatives. It is almost inevitable that, as systems grow, their boundaries begin to overlap and they merge into supersystems. This is not necessarily bad. The growing interchange between education and the other sectors of society is potentially beneficial. The question is, can education enter into collaborative efforts -- yet preserve humanistic values and goals?" (P. 283)

The shift away from classical education in Western civilization probably began in the 17th Century but the inclusion of industrial curricula only began in the mid-1800's. It is interesting to note that the last major change of great significance at the secondary level was the addition of vocational education at this time. This was in direct response to increasing industrialization and the need for a competent workforce. Wirth (1966) explaining the situation at the turn of the century,
'... new courses of a technical nature were demanded as the increasingly complex technology and larger bureaucratic institutions required new levels of skill that could not be acquired incidentally on the job.' (p. 204)

John Dewey (1938) explains the lack of relevancy of traditional education, stating,

"The notion that some subjects and methods and that acquaintance with certain facts and truths possess educational value in and of themselves is the reason why traditional education reduced the material of education so largely to a diet of predigested materials." (p. 46)

Dewey looked upon traditional education as being 'cultural' and he thought that vocational education, if approached in a humanistic, liberal way, could engender a much broader understanding of that culture. Wirth (1966) explains,

"Dewey used the term semivocational to indicate that no pretensions would be made to turn out expert technicians. The high school should present studies that would permit the exploration of interests and capacities to youth who approached it as merely an avenue to work. A range of vocational experiences should be provided. In addition, every student, regardless of his job orientation, should be well grounded in non-vocational subject matter. An intellectual adjustment to the political, economic, religious, cultural, and social aspects of life also had to be made. The specialization and complexity of modern industry made it ever more difficult for men to see their work in terms of the social whole. The goal he projected was an education that would equip students to emerge from the schools with a broad understanding of the nature of industry and technology, a respect for the dignity of work, and an awareness of the social implications of change. They would have some insights into the nature of the economic system, and of the roles of management and labour unions." (p. 230)

Today, the external culture that so profoundly affects our educational goals is changing at an ever increasing rate such that educators are faced with preparing students for occupations that may not even exist yet. To accomplish this they must stay abreast of changes in their subject matter, keeping the curriculum relevant and providing as broad an information base as possible for their students. Trump and Miller (1977) in a paper on the
future of Industrial Arts claim that,

"... the dominant objective of Industrial Arts should be that of providing an understanding of American industry and an awareness of its changing technology. Programs using this as the basic objective are identified with a technology approach. In its simplest form this approach redefines the old approach of 'a degree of skill' as an understanding of the necessity for skillful use of tools rather than skill in the use of tools." (p. 84)

These views are not new in the field of curriculum development. Bruner (1960) in The Process of Education proposes that,

"... the curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying principles that give structure to the subject. Teaching specific topics or skills without making clear their context in the broader fundamental structure of a field of knowledge is uneconomical in several deep senses." (p. 30)

Perhaps Bruner is reiterating some of Whitehead's Aims of Education (1929),

"The result of teaching small parts of a large number of subjects is the passive reception of disconnected ideas, not illumined with any spark of vitality. Let the main ideas which are introduced into a child's education be few and important, and be thrown into every combination possible." (p. 2)

One of the problems of implementation relative to technologically imposed curricular change (appropriate to Industrial Education) is discussed by Stenhouse (1975).

"It seems to be fair and helpful to describe as reference groups those groups outside the school which create and curate knowledge and skills and values. Reference is indeed made to them as sources of standards...."

"... there is an implication that in the pressure of school situations teachers may develop within the educational process cultures which, to a greater or lesser degree, lose touch with the reference group cultures they are meant to represent to the pupils." (p. 13)

These comments may be especially applicable to the secondary school situation which can be so resistant to change. There is very little incentive for teachers, especially Industrial Education teachers, to update their programs or their teaching methods and yet it is so important for
them to do so. Even at the turn of the century, Carlton (1908) stated,

"Both industry and the students are injured by the isolation of the high school, the college, and the university from the practical affairs of the industrial and commercial world." (p. 92)

He even went so far as to suggest that,

"All teachers should work a portion of the time, in order that they may come into actual contact with the industrial and economic life and problems of today." (p. 92)

Dewey (1938) also maintained that educators should have first-hand experience or knowledge of their subject areas.

"... education in order to accomplish its ends for both the individual learner and for society must be based on experience — which is always the actual life experience of some individual." (p. 89)

Trump and Miller (1977) qualify their view on the necessity of upgrading Industrial Education teacher qualifications, stating,

"If the proposals for an Industrial Arts curriculum based on technology are incorporated into the comprehensive secondary school program, Industrial Arts will undoubtedly take on a new image. Its position in general education will be solidified and its integration with other subject-matter areas will be axiomatic. It will necessitate retraining of teachers and the opening of the Industrial Arts curriculum to the entire school." (p. 85)

Burns and Brooks (1970), concerned about the time lag involved with the introduction of new material in education, also point to the need for in-service retraining,

"Perhaps all of this demands new approaches to teacher training and certainly some system of in-service retraining of teachers and administrators. If financial obstacles prevent schools from utilizing proper methods and instructional materials, then some basis for financial assistance to school districts must be initiated." (p. 10)

Malcolm Skilbeck (1975) expands on the concerns of Burns and Brooks, cautioning against policies of tradition,

"One way of overcoming the staleness and mindless conservatism that result when schools refuse to examine, reflect upon, and appraise the societies in which they are functioning is to introduce a universal
programme of in-service education. Apathy and narrowness are natural consequences of isolation and neglect. The teacher who is left alone to 'get on with it' can all too easily continue throughout his career to reproduce the attitudes, techniques and information with which he himself was imbued as a student." (p. 31)

It appears, then, that the interests of society, students, and the educational system would be best served through continuing in-service teacher training and that it must become a priority of school systems to provide incentive for teachers to participate in that training.

Although there is recurrent mention of using external sources for curriculum innovation in education there is also implied caution. Educators are advised, for various reasons, to be acutely aware of the reasons that they use to justify changes in the curriculum. As Apple (1979) warns,

"In whose interest is certain knowledge (facts, skills, and propensities and dispositions) taught in cultural institutions like schools?" (p. 16)

"... historically, curriculum theory and development has been strongly connected to and influenced by economic needs and changes." (p. 68)

"... the consciousness of curriculum workers themselves as well as other educators can be seen as latently political and often somewhat conservative. This is, they use forms of thought that at least partially stem from and can tacitly act to maintain the existing social and economic substructure and distribution of power in a corporate society such as our own." (p. 118)

Elise Boulding (1978) concurs with Apple offering the following insight,

"... educators in their daily work are far more affected by ... the technological futurists. The technologists operate inside megabureaucracies and produce solutions to the problems of human welfare that frequently worsen human conditions." (p. 57)

Francis Keppel (1969), a former U.S. Commissioner of Education also warns about change in education,
"Change is not automatically for the better. In education's history new fads and cults have often given the appearance of progress while failing to transform education for the good of society. It is imperative to review all programs for change with a critical eye for the consequences, particularly in a time of revolution, when the pace of change discourages pause for reflection." (p. 73)

In conclusion, it appears that there is a delicate tension between curriculum developers who prefer a broader, more generalized approach to curriculum change and various outside influences who demand specialization. The most logical framework for curricular change in Industrial Education would acknowledge the directions of the society it serves with emphasis on identifiable prerequisites and keeping students vocational options maximized. Educators and curriculum theorists cannot predict the future and should be wary of changing curriculum to meet predictions. The functioning member of our society must be prepared to continuously educate himself as the demands of the workplace change. He can only accomplish this if educators are prepared to do the same.

Related Research in Industrial Education:

The related research is divided into two areas. The first area is concerned with similar research methods and the second area reviews current research in drafting curriculum.

Similar Research Methods:

For this area of related research, the writer made a visual search of the University Microfilms International Dissertation Abstracts for both master's and doctoral dissertations. All titles from 1967 to 1984 under Industrial and Vocational Education were examined and those dealing with curriculum development or teaching practices in relation to industrial requirements were selected. Almost all of these utilized a survey of industry which was often accompanied by a comparative survey of education.
A number of these were reviewed for the purpose of developing an appropriate questionnaire and finding the most appropriate methods and procedures for conducting a similar survey.

There are relatively few research studies in Industrial Education and even fewer that are involved in surveying industry. The questionnaire, however appears to be the most popular and the most successful survey method used in Industrial Education curriculum development.

Hoover (1967) designed and mailed parallel questionnaires to selected metalworking industries and to colleges offering courses in metalworking. His survey concluded that there was a discrepancy between the instruction offered at the colleges and the knowledge and skills required by industry. He also noted that new processes were taught by lecture, plant visit, and contemporary publication and that these processes were only conditionally being met and that Industrial Arts teacher education institutions were not changing to meet the needs of industry.

Pardini (1967) made a similar study to Hoover's that compared the metalworking processes used in industry with those being taught in Industrial Arts teacher education. His recommendations suggested the expansion of course content through the use of educational media, resource people, and industrial visitations.

Berry (1967) used a questionnaire check list sent to selected manufacturing industries and companies in New England to identify course content for Industrial Arts which was reflective of current industrial technology. Most notable of his findings was that less than 10% of industry was using new processes such as numerical control.
Rinck (1968) developed an open form questionnaire for identification of curricular items related to aviation repair and service courses. His procedure involved a jury of representative people from aviation schools and aviation industry who ranked the importance of the topics selected for inclusion in the questionnaire. After revision, the questionnaire was sent to representative industries. He concluded that there was little difference between the requirements of industry and what was being taught in the technical and secondary schools.

Moon (1968) surveyed industry in the state of Oregon to identify principal process operations used in industry that could be considered curricular components of an Industrial Education curriculum that reflected the technology. The following selected conclusions and recommendations are applicable to this study:

"-The technological phase of the Industrial Arts curriculum should not only be oriented to the materials of industry but also to the technological concepts which are related to the process operations of industrial technology.

- The technological concepts upon which the Industrial Arts curriculum should be based are to be found in the principal process operations of the Forming, Casting, and Molding, Shaping by Cutting, Assembly, and Auxiliary areas of industrial activity.

- The Industrial Arts laboratory should be designed to permit the application of these technological concepts.

- The curriculum and the laboratory facilities for Industrial Arts should have a multi-range of activities and be so flexible that they can readily change to keep pace with a changing technology.

- It is recommended that the curricular components identified in this study be considered as elements of the Industrial Arts curriculum that will reflect the technology." (p. 128-9)

Hildebrand (1974) mentions a study done by Richard Wilson for the Industrial Education Department at the Iowa State University,
Wilson surveyed 297 industries, architects, and firms for the purpose of determining the number of architectural draftsmen needed in the state of Iowa and to identify the skills and knowledge in which the draftsmen exhibit competency. His findings indicated that employers desired draftsmen to be proficient in verbal communications, spelling, listening, and note taking. It was felt that advanced arithmetic, plane geometry, basic algebra, as well as various drafting practices, were also essential." (p. 29)

Baker (1970) conducted a survey of Industrial Arts teacher education institutions and industry to determine the degree of utilization of computer technology. He determined that the computer was widely accepted and used in business applications but in Industrial Arts teacher education it was virtually ignored. He found that it was extremely difficult to secure qualified personnel to teach computer classes with industrial applications.

A survey of the consumer electronics service industry was conducted by Seigler (1970) to determine the knowledge and skill requirements to be considered in the development of a training program for service technicians. Thorton (1971) used a survey of industrial plastics firms to enable the selection of course materials for specific industrial plastics courses and to plan a curriculum for training teachers and technicians in industrial plastics. Polette (1972) sent questionnaires to industry and to teacher education institutions to determine areas of agreement concerning the development of a woodworking power machine maintenance curriculum.

White (1975) conducted a study of curriculum developers in Industrial Education. He surveyed and compared a national population of developers with a representative population from a single state. Some of his findings are relevant to this study. He noted that there was little time available for curriculum development, that selecting content was a major problem, and that information was difficult to obtain. Porshia (1975) also used a
questionnaire to determine core curriculum needs for an industrial technology program in the areas of building and construction, drafting and design, machine tools, automotive, electronics, printing, and metal fabrication. He surveyed personnel directors in industry and departmental administrators of industrial technology programs at colleges and universities.

The problem of keeping curricular materials up to date has been addressed by some researchers. Morgan (1978) utilized a questionnaire that dealt with possible future changes in the skills and knowledge required for jobs in the automotive manufacturing industry and Weiking (1979) developed a trend indicator to enable forecasting of future changes in job requirements for the automotive industry and allow educators suitable lead time for programme changes. As Pickle (1983) states,

"While Industrial Education curriculum and methodology must be continually modified to reflect the technological developments occurring in industry, the updating process has been hindered as the rate of technological change in industry has accelerated." (p. 25)

The use of a jury in the development of a questionnaire or in the analysis of the survey results appears to be fairly common. Moore (1979) used a panel of experts to develop a survey questionnaire for the metal manufacturing industries in the state of Maine. The results of the survey were used to establish a priority order of competencies in a metals curriculum. Parmalee (1979) also used a jury of qualified people to validate the items of his questionnaire before surveying manufacturers of aviation/avionics equipment. His survey was designed to determine electronics topics required for study by service technicians.

Awotunde (1982) used a questionnaire mailed to public utilities and manufacturing companies to determine the characteristics of in-plant
training. He concluded that, regardless of the type of company or its size, training decisions were based upon skill shortages, changes in technology, and company growth.

Although the preceding studies were selected for their common use of the survey technique in determining Industrial Education curricula, there is recurrent mention of certain items pertinent to this study. The first of these is the fact that almost all of the studies were done because of technological change. The second recurring item is the acknowledgement of the increasing rate of technological change and third is the implied inability of present curriculum development methods to deal effectively with the rapid change in technology.

In summary, the preceding studies will attest to the popularity and success of the survey method of research in Industrial Education. Curriculum development in Industrial Education is virtually impossible without input from representative industry and the most important curriculum development tool at this time appears to be the survey questionnaire. Drafting Curriculum Research:

For this area of literature review, an Educational Resources Information Center (ERIC) search was made and the Comprehensive Dissertation Abstracts were used.

Merl Case (1971) mentions two studies concerned with computer graphics. Hornbuckle (1967) did a study on the designing of equipment with the aide of a computer and Barber (1967) made a study of instructional methods required to implement reliable manufacturing and computer systems. Case mentions that his initial search revealed a minimal amount of research concerning computer graphics, especially in education, but a great quantity of
periodical literature. He concludes his literature review with the following:

"A number of good curriculum studies have been made for other areas of Industrial Arts, but few were found which relate to teaching the new methods of drafting. In light of the limited number of research studies on computer graphics, they are of minimal use in the development of computer graphics curriculum.

The literature review does indicate that there needs to be a change in our drafting curriculum to incorporate the current practices used by industry. It is a responsibility of the teacher educator to take the lead in the development and improvement of curriculum for the preparation of teachers in this area of Industrial Arts." (p. 41)

Case (1971) utilized two questionnaires; one for industrial educators and one for personnel working with computer graphics in industry. The results of his study allowed him to state a number of conclusions, implications, and recommendations. Some of these have been selected for their relevance to this study.

"-Insufficient funds and lack of facilities were the primary reasons for not offering computer graphics courses within the Industrial Arts department.

-A majority of the schools have equipment available, with the exception of a plotter and control, to teach a course in computer graphics.

-A number of the participating institutions did not have an instructor within the Industrial Arts department qualified to teach computer graphics.

-The primary application of computer graphics in industry is to depict engineering drawings.

-Speed, cost-saving, and accuracy are the primary reasons for the use of computer graphics in industry.

-Computer graphics, as a new method of defining items graphically, does not preclude the need for a basic understanding of projection.

-If Industrial Arts departments are to attain their objective of interpreting contemporary industry, curriculum must be revised to reflect those processes being utilized by industry." (p. 128-135)
Hildebrand (1974) made a comparison of industrial drafting practices with those taught in Industrial Arts for the purpose of determining the relevance of curriculum to industrial practice. He constructed two questionnaires; one for industry and one for Industrial Arts teacher education institutions. He was interested in knowing where industry acquires draftsmen, how educators keep themselves and their curriculum up to date, what differences there were between industrial and curricular drafting practices, and which areas of drafting were changing enough to warrant curriculum content revision.

Hildebrand's conclusions are pertinent to the direction of this study.

"1. Drafting students need a general understanding of all facets of industrial processes with special emphasis on application of drafting knowledge, principles, and practices.

2. English, mathematics, statistics, and problem solving and creative abilities are a must for any person employed in industrial drafting.

3. All new equipment, materials, processes, and practices which can financially be provided should be introduced in the Industrial Arts drafting program. Current areas such as autoshift drafting tables, calculators, computers, metric measurement and dimensioning, and the reproduction processes (microfilm and microfiche) are especially important.

4. With Industrial Arts institutions directly or indirectly training approximately one-fourth of all industrial draftsmen, it is essential for Industrial Arts institutions to establish a close working relationship with industry. A system for curriculum development and/or revision should be developed to ensure that Industrial Arts institutions maintain a close approximation of industrial practices." (p. v)

Hildebrand recommended that further study be directed towards the use of computer graphics in industry and its effect on Industrial Arts drafting curriculum and also that a system for drafting curriculum revision be
developed to keep course content current with industrial practices.

Ward (1979) surveyed industrial concerns for the purpose of developing curriculum for a Drafting and Design Technology Program for a Northwest Florida junior college. His recommendations were quite similar to those of Hildebrand.

"1. Drafting and Design Technology educators should make concentrated efforts to develop and maintain communications with local industrial concerns.

2. Industrial expertise should be considered a potential resource for program development and should be used to supplement and upgrade drafting and design technology programs.

3. Follow-up studies should be conducted periodically to establish criteria for determining the effectiveness of drafting and design technology programs as perceived by industry personnel employing graduates of such programs.

4. Periodic updating of programs should be accomplished through the use of questionnaires.

5. Drafting and Design Technology educators should stay current with industrial developments and progress." (p. 68)

Pickle (1983) surveyed high technology industries and industrial technology educational institutions in order to identify a high technology curriculum. He found that there was a significant difference between industrial needs for high technology and the courses being offered at representative educational institutions. The most conducive course for implementing a high technology program in the curriculum was identified as Computer Aided Design.

Ayers (1971) conducted a survey of technical schools and industry in Ohio to confirm that the schools did provide sufficient skills in Mathematics and Science for drafting technicians to meet industrial requirements. Groom (1982) used computer graphics as a teaching tool for first-
semester engineering graphics. The treatment group learned additional information and improved their attitude toward computer graphics while performing as well as the control group on short-term weekly quizzes and better on the long-term examination.

Very few studies have been done that pertain directly to the drafting curriculum at the secondary school level. One of these has been done by Tedesco (1974) who surveyed senior high schools and architectural firms in Orange County, California to compare the drafting techniques being taught with those being used professionally. He found significant differences in lettering practices with regard to speed, legibility, and style techniques. Architects were more concerned with codes, calculations, specifications, and construction methods while drafting teachers placed more emphasis on perspective, rendering, and presentation drawings.

Another secondary school study was made by McMillan (1981) which found a positive correlation between drafting and mathematical abilities. She also noted that there was no difference between male and female students in their mathematical or drafting abilities.

**Periodical Literature of Interest:**

There is a vast amount of periodical literature dealing with computer aided drafting and related technology but very little of it is concerned with the skills or training involved. This writer examined the abstracts presented in all back issues of the Canadian Manufacturer's Association CAD/CAM newsletter to locate articles that dealt with the impact of this technology on education. Other periodicals that presented related articles included Industrial Education, Technology West, Canadian Repro-Draft, Byte, Engineering Digest, Design Engineering, Fine Homebuilding, Computing Now, and Popular Computing magazines. Newspaper articles from the Vancouver Sun were also included in this survey.
Keenan (1982) in an article on student CAD training stated that pilot CAD training programs at five vocational technical schools in Minnesota resulted in more complete drafting graduates. The exposure to CAD reduced the amount of on-the-job training required and provided them with more marketable skills. The program was initiated when a committee of people from education and industry identified computer graphics as an area of vocational training necessary to meet the requirements of local industry. Instructors find the CAD systems easy to learn and highly motivational for students. The I.T.T. Technical Institute in Dayton, Ohio also found that potential employers wanted graduates with CAD skills. (Engraf newsletter, June, 1984).

Brummel (1984) in a description of student drafting programs in Ontario mentions the introduction of CAD at the secondary level. The objective with CAD was to introduce and acquaint students with CAD systems potential and remove the mystique of the equipment rather than shortcut on technique or instruction. Apparently the introduction was successful as an article in The Vancouver Sun newspaper reported in May, 1985, that the Accugraph Corp. of Toronto had closed a deal with the Ontario Ministry of Education to develop a bilingual CAD package for the province's schools.

An advertisement for the Vancouver Vocational Institute in the February, 1985, edition of Canadian Repro-draft magazine makes the following claim:

"Among the 500 best jobs for the future, according to a McGraw-Hill publication of the same name, is that of a computer aided drafting technician. Author Marvin Creton estimates some 300,000 of these technicians will be required in the U.S. over the next ten years. Drawing from the U.S. figure, we can anticipate Canada's need at about 30,000. Then, there are thousands more architects, engineers,
interior designers, and pattern makers who will need computer-aided drafting in their work. The demand for this skill is staggering." (p. 11)

The article mentions that the college anticipates the eventual linking of their CAD system with the computer aided manufacturing equipment in its machine shop. This appears to be the technological trend in industry. Blauth (1981) predicts that CIM (computer-integrated manufacturing) will provide the greatest potential technology for improving industrial productivity in the 1980's, using the synergism of CAD and CAM. He concludes his address with the following statement:

"The integration of engineering's CAD database with manufacturing's CAM database will yield the ultimate benefit to productivity by encouraging "designing for manufacturability' and by optimizing production efficiencies." (p. 19)

Jadrnicek (1984), Adlard (1984), and Lardner (1983) all mention the advent of CIM as the replacement for CAD/CAM. Lardner maintains that the transition into CIM will be the key to regaining manufacturing competitiveness and Adlard also mentions increased ability to compete in world markets. Computer integrated manufacturing will still require CAD skills.

Olling (1983), in a study of numerical control education in the U.S., acknowledges the threat of automation to the unskilled worker and directs the educational system to disseminate new technological developments to the labour force as quickly as possible. He states,

"Education, where problems ultimately arise from industrial, economic, and social changes, must find ways of preparing its students to meet these ever-changing conditions and demands. The society, where industrial facilities become highly automated, needs more knowledge power than physical power particularly in the area of Computer Aided Design and Computer Aided Manufacturing (CAD/CAM)." (p. 22)
"A deliberate and systematic effort must be made not only to keep pace with but to anticipate the increased educational demands of the changing industrial world." (p. 24)

Pipes (1982) in a supportive assessment of the applications of CAD/CAM technology also identified a major problem of education and training in this technology in the United Kingdom. Bartholemew (1983) surveyed the technological education available in British Columbia. Labour market predictions that indicated a shortage of skilled workers over the next decade prompted an assessment of the implications of high technology and the implementation of a number of appropriate training programs.

Summary:

The review of the literature established that a variety of influences determine the curricula of our schools. Business interests, in general, were proponents of more specialized curriculum while curriculum developers favoured a more moderate and flexible approach. The distinction between curriculum that is reflective of society and one that is specialized is not clear. Educators were urged to develop curriculum that provided a broad base of information and skills that would allow a continuum of learning throughout their students' lives.

Studies of curriculum content in Industrial Education were primarily concerned with keeping course material current and relative to the needs of local industry. The research seemed designed to increase specialization for local industry, at least at the post secondary level. The questionnaire survey was the predominant and most economical method of gathering information from industry and educators for these studies.

The number of studies dealing with drafting curriculum was very small and most were concerned in some way with adjusting to the rapid changes in drafting technology. Only two studies were located that dealt with
drafting curriculum in secondary schools and neither of these was concerned with changes in the technology. There were no studies located at this time that were concerned with secondary school curriculum adaptation to the changing technology of drafting.

Current periodical literature indicates a growing need for drafting technicians with CAD skills and a demand for the appropriate training programs. Using CAD in their drafting programs, instructors find increased motivation and better job opportunities for their students.
CHAPTER THREE

METHODS AND PROCEDURES

The main purpose of this study was to identify the prerequisite skills and knowledge most appropriate for training and/or employment in computer aided drafting and to make recommendations for the necessary secondary school curricular revision. The data was obtained through the use of survey questionnaires sent to sixty-five British Columbia firms using CAD technology and to fifteen educational institutions offering training in computer aided drafting.

Construction of the Questionnaire:

The questionnaires were developed through comparison with the survey instruments used in similar studies. The topics were selected from an analysis of curriculum guide, drafting textbook, and standard manual items. The writer made a number of revisions after interviewing college and university instructors, CAD software developers, CAD operators, high technology personnel, and CAD vendors as well as completing a 120 hour college CAD course. The two questionnaires are virtually identical except for wording appropriate to the respondents. The intention was to elicit the same type of information from two different populations. Final revisions were made on the recommendations of the thesis committee.

In order to generate the greatest response to the survey, the questionnaire was kept as brief as possible and used only closed form ranking or multiple choice questions. Provision was made for respondents to add items or to make comments or suggestions.
A pilot study was made to test the questionnaire. The respondents were a college CAD instructor, a CAD operator, a CAD software developer, and a CAD system vendor. All of the respondents were interested and cooperative. Interviews after the completion of the questionnaire did not generate any further revision.

The questionnaires were designed to obtain the following information:

1. The areas of drafting where CAD use is more prevalent.
2. The size and/or type of the CAD systems in use.
3. The ease of operation of the different CAD systems.
4. The amount of money invested in the CAD systems.
5. The education of the people operating CAD systems.
6. The educational background of candidates for CAD training.
7. The methods whereby CAD operators received their CAD training.
8. The most suitable methods to receive CAD training.
9. The preferences of industry as to the education or experience of their CAD operators.
10. The importance of certain manual, cognitive, and industrial skills relative to successful CAD training or employment.
11. The importance of certain drafting skills and techniques relative to CAD training or employment.
12. The areas of secondary school curriculum to be emphasized or modified to better prepare students for careers involving CAD.

Selection of the Sample Populations:

The sample of businesses using CAD systems in British Columbia was extremely difficult to assemble. British Columbia industry is primarily resource based. Forestry, mining, fishing, and tourism constitute the
largest portion of the provincial economy. The recession of recent years has done little to encourage investment in new technology and government attempts of encourage secondary industry have had little success. As a result, the number of companies utilizing CAD technology in British Columbia is predictably small.

There is no directory of businesses in British Columbia that use CAD. In order to do this study, a directory had to be assembled. The British Columbia Innovations office offered the mailing list for the now defunct Western Foundation for the Advancement of Industrial Technology. British Columbia Research did have a fairly large sample of high technology oriented companies but could not divulge proprietary information, and most CAD system vendors had confidential customer lists. Through employer lists provided by some of the colleges and careful scrutiny of advertisements in engineering and high technology magazines a modest directory was assembled. The sixty-five businesses selected do not represent a random sample, however, they do represent the majority of such businesses in British Columbia.

The fifteen institutions offering CAD training represent the total number that offer such courses in British Columbia. One more has since invested in this technology, but will not be offering courses until this fall. This information is readily available at most secondary school counselling offices.

Procedure:

The questionnaires, together with a cover letter and a stamped, addressed return envelope, were sent to the sixty-five businesses and the fifteen educational institutions on April 10, 1985. After four weeks,
follow-up letter with another questionnaire and stamped return envelope was sent to those who had not responded to the first questionnaire. Any questionnaires returned after June 10, 1985 were not included in the study. For valid results, the percentage of return of questionnaires from the two populations was tentatively set at 60%

**Treatment of Data:**

The returned questionnaires were tabulated and the results presented in graphical format to permit comparison between the two populations. Where questions required the ranking of particular items according to importance or preference, the value of 1 was given to the most important or most preferred and the value of 5 was given to the least important. When calculating the mean level of importance or preference, values between 1.0 and 2.0 would indicate an item of high importance while a value between 4.0 and 5.0 would indicate low importance. The comparison between populations was not the intent of the study but is added to increase the understanding of the problem.
CHAPTER FOUR

PRESENTATION OF FINDINGS

The purpose of this study was to determine, through a survey of industry and educational institutions, the prerequisite skills and knowledge for training and/or employment in the field of computer aided drafting. Two parallel, closed form questionnaires were sent to representative businesses and educational institutions and the returned data tabulated and analyzed. The survey was intended to identify areas of curricular strengths and weaknesses in the secondary school system and also to acquaint educators with technological trends in industry. The data from the two populations was tabulated separately to show possibly divergent points of view.

Survey Response:

Sixty-five businesses in British Columbia, identified as users of CAD technology, were sent questionnaires. Of these sixty-five, four firms or six percent were no longer in business and the questionnaires were returned. The figure of six percent corresponds very well to a recent article in the business section of The Vancouver Sun which mentioned that six percent of British Columbia industry had left the province in the last year. Of the remaining sixty-one businesses, fifty or 82% returned the questionnaires. Nine of these (15% of the sample) were not direct users of CAD (some were software developers or consultants), nine more were in the process of evaluating or installing CAD systems, and the remaining thirty-two (52% of the sample) provided completed questionnaires.

Nine of the fifteen educational institutions (60%) returned completed
questionnaires. The sample of fifteen institutions represents the total number of institutions offering CAD training of any kind at this time in British Columbia. Included with the six non-respondents are all three British Columbia universities. This may be a result of the timing of the study which coincided with the end of the academic year. Unfortunately the results may tend to be somewhat biased in favour of the regional colleges whose returned questionnaires form the greater part of the institutional data. A graph of the survey response is included as Figure 1.

**Areas of CAD Use:**

The businesses surveyed indicated that their major use of CAD was for mechanical and electronics drafting. Both of these areas received 50% response. (Many of the businesses surveyed indicated involvement in more than one area of drafting producing a survey total that exceeds 100%)

The next major area was structural (37%), followed by architectural and cartographic (survey, mapping, topography) with 34% each. A few businesses had specific uses for CAD not included in the survey. These include two firms involved in naval architecture, one in fluidics, and one in producing process flowsheets.

The educational institutions had similar emphasis in their CAD training courses. Architectural and civil drafting both received 56% response, followed by mechanical and structural at 44% each. Process piping was the only area of CAD training not included in the survey to be mentioned by an institution. The graphics and HVAC (heating, ventilation, and air conditioning) areas received low response from both populations.

The data for this question should not be used to indicate the prevalence of CAD in specific fields; rather it should indicate that CAD is being used.
**Figure 1.** Survey response rate.

**Figure 2.** Areas of CAD use.
in virtually all areas of drafting. The tabulated responses from the business survey only serve to describe that sample population. Similarly, the response from the training institutions describes the emphasis of its CAD courses. A graph of the response to this question is included as Figure 2.

**CAD System Description:**

The question dealing with the type of CAD system being used was designed mainly to determine the degree to which personal computers were being used for CAD purposes in industry and for training purposes. Few businesses or educational institutions can afford the massive investment required for dedicated or mainframe CAD systems. The personal computer based CAD systems appear to be performing nearly as well as the large systems and at much less cost.

Fourteen businesses (44%) and five institutions (56%) indicated that their systems were personal computer based. Rather than attempting to describe the various combinations of hardware and software in use, this writer has included an appendix of CAD system descriptions offered by the questionnaire respondents. This will be of much more use to educators in determining CAD system and training requirements. Figure 3 presents the graph of the response to this question.

**CAD System Ease of Operation:**

It was originally thought that there might be a relationship between the size or complexity of a CAD system and the relative ease of operating it. Many of the early mainframe CAD systems were plagued with programming problems and were difficult to operate in comparison to the personal computer systems that are entering the market now. The response to this question
### Figure 3. CAD system description.

<table>
<thead>
<tr>
<th>Type of System</th>
<th>Percentage of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC-based, single user</td>
<td>31%</td>
</tr>
<tr>
<td>PC-based, multi-user</td>
<td>13%</td>
</tr>
<tr>
<td>Minicomputer based</td>
<td>19%</td>
</tr>
<tr>
<td>Dedicated system</td>
<td>11%</td>
</tr>
<tr>
<td>Mainframe system</td>
<td>6%</td>
</tr>
</tbody>
</table>

### Figure 4. CAD system ease of operation.

<table>
<thead>
<tr>
<th>Ease of Use</th>
<th>Percentage of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very easy to use</td>
<td>9%</td>
</tr>
<tr>
<td>Relatively simple</td>
<td>11%</td>
</tr>
<tr>
<td>Moderately difficult</td>
<td>16%</td>
</tr>
<tr>
<td>Difficult</td>
<td>33%</td>
</tr>
<tr>
<td>Frustrating</td>
<td>9%</td>
</tr>
</tbody>
</table>
indicates that this may be the case. Figure 4 illustrates that most of the CAD systems in the survey sample are considered as relatively easy to operate but there is a small number of each group that suggest some degree of difficulty. When these individual questionnaires were analyzed, it appeared that 88% of the businesses and 67% of the educational institutions that expressed difficulty in operating their CAD systems had large mainframe or dedicated systems. Only 14% of the businesses and 11% of the educational institutions utilizing personal computer based CAD systems expressed any difficulty of operation.

**CAD System Costs:**

The cost of a CAD system is relative to the number of work stations that it can support. The large mainframe and dedicated systems have the power to handle a large number of users simultaneously and, for considerably less cost, personal computers can be networked to perform almost as well. Those survey respondents who indicated system costs in excess of $75,000 included two with networked personal computer systems. The important aspect of this portion of the survey is the large number of businesses (40%) and educational institutions (44%) with CAD systems in operation for less than $25,000. System costs are indicated in Figure 5.

**CAD Training Candidates:**

The educational institutions responding to this question indicated that the majority of the individuals seeking training in computer aided drafting had skills or training in a related area and were upgrading themselves. Draftspersons were mentioned most often (78%) followed by professionals and others (teachers). The professionals and others have been assessed together because all of the others mentioned in the questionnaires were professionals of some sort. (See Figure 6)
<table>
<thead>
<tr>
<th>Income Range</th>
<th>Per Cent of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than $10,000</td>
<td></td>
</tr>
<tr>
<td>$10,000 to $25,000</td>
<td></td>
</tr>
<tr>
<td>$25,000 to $50,000</td>
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</tr>
<tr>
<td>$50,000 to $75,000</td>
<td></td>
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<tr>
<td>over $75,000</td>
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</tr>
<tr>
<td>continuing lease</td>
<td></td>
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</table>

Figure 5. CAD system cost approximations.

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Per Cent of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>high school graduate</td>
<td>44%</td>
</tr>
<tr>
<td>draftsperson</td>
<td></td>
</tr>
<tr>
<td>technician/technologist</td>
<td>22%</td>
</tr>
<tr>
<td>computer specialist</td>
<td></td>
</tr>
<tr>
<td>professional</td>
<td>22%</td>
</tr>
<tr>
<td>other</td>
<td>22%</td>
</tr>
</tbody>
</table>

Figure 6. CAD training candidate background.
CAD Operator Background:

Businesses indicated that their CAD operators were usually draftspersons retrained for their CAD systems. None of the respondents had obtained CAD draftspersons directly from an educational institution. The other individuals using the CAD systems were engineers, architects, designers, and technicians. (See Figure 7)

CAD Operator Training:

Only 12% of the business survey indicated that their operators had received their training through an educational institution. The rest had obtained training through self-teaching, in-house courses, vendor courses, or a combination of these. This is an indication of the lack of availability of appropriate courses for employees at the time that the training was required. Most of these people would have needed training before there were any courses available publicly. In support of this, most of the businesses surveyed indicated that they would prefer to hire a draftsperson with CAD skills. Figure 8 indicates the training of present CAD operators and Figure 9 indicates the hiring preferences of the businesses surveyed.

Business Hiring Preferences for CAD Operators:

The time and cost of training a person to operate a CAD system would be expected to influence an employer to hire a draftsperson already trained in CAD, yet a surprising number indicated that they would prefer to train a good draftsperson, technician, or professional on the firm's CAD system. The mean ranking for this item is just slightly in favour of a CAD draftsperson, followed closely by a regular draftsperson or technician/technologist. (See Figure 8a)
Figure 7. CAD operator background.

Figure 8. CAD operator training.
<table>
<thead>
<tr>
<th></th>
<th>Mean Ranking Level</th>
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<tbody>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>draftsperson</td>
<td>5</td>
</tr>
<tr>
<td>CAD draftsperson</td>
<td>4</td>
</tr>
<tr>
<td>technician/technologist</td>
<td>3</td>
</tr>
<tr>
<td>computer specialist</td>
<td>2</td>
</tr>
<tr>
<td>professional</td>
<td>1</td>
</tr>
<tr>
<td>other</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Mean Ranking Level</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>high school graduate</td>
<td>5</td>
</tr>
<tr>
<td>draftsperson</td>
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<tr>
<td>technician/technologist</td>
<td>3</td>
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<tr>
<td>computer specialist</td>
<td>2</td>
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<tr>
<td>professional</td>
<td>1</td>
</tr>
<tr>
<td>other</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8a. Hiring preferences of businesses using CAD.

Figure 8b. Candidate preferences of CAD training institutions.
Candidate Preference of CAD Training Institutions:

Institutions indicated that they strongly preferred to teach computer aided drafting to regular draftspersons. Instructors obviously do not have a choice of who they teach. This aspect is usually controlled through the admission requirements of the institution, however they probably find it more rewarding to teach the intricacies of their CAD system to someone with some background in drafting or design. (See Figure 8b)

CAD Training Methods Preferred by Educational Institutions:

Question 6 of the questionnaire sent to educational institutions asked for respondents to indicate the best method of receiving CAD training. Figure 9 presents the response to this question. The tabulated data is similar to the data from Question 1 in that it only serves to describe the sample population. The respondents in this case were obviously biased in favour of their particular method of training. The sample's high proportion of regional colleges mentioned previously is reflected in the 78% response to this training method. It is notable that the institutions sampled did give credit to vendor's courses and in-house training as viable methods of CAD training. Even self-teaching received an 11% response.

Importance Ranking of Selected Manual, Cognitive, and Industrial Skills:

The CAD operator may require certain skills that are not necessary for manual drafting. In an effort to determine if this is so and to identify such skills, businesses and educational institutions were asked to rank the importance of certain selected skills in relation to CAD training or employment. The skills were loosely categorized as manual,
Figure 9. CAD training preferences of educational institutions.

Figure 10. Importance ranking of selected manual skills relative to CAD training or employment.
cognitive, or industrial and the respondents were asked to rank the importance of the items in each category. Following the ranking, respondents were asked to identify the single most important skill, if any, from the previous categories. In order to accommodate the inclusion of certain skills not mentioned, a blank response labelled "other" was added to the manual and cognitive categories.

To present a visual image of the ranking for this question, bar graphs were prepared that show horizontal bars whose length corresponds directly to the mean level of importance accorded that skill. An item of very little importance could receive a mean ranking of 5.00 and would not generate a bar on the graph. An item of high importance could receive a mean ranking of 1.00 and would generate a full length bar on the graph. (A similar treatment of data was used to generate the bar graphs in Figure 8a and Figure 8b)

For the manual skills category, both businesses and training institutions cited manual drafting as the most important prerequisite skill followed by keyboard skills, perspective drawing and word processing, in that order of rank. The ranking was the same in both surveys as shown in Figure 10.

Figure 11 shows the ranking of selected cognitive skills. Although both surveys considered analytic geometry to be the most important, they differed slightly on their second choice. Businesses considered computational skills as next in importance while the training institutions selected communication skills. Both surveys considered computer programming to be the least important cognitive skill.
Figure 11. Importance ranking of selected cognitive skills relative to CAD training or employment.

Figure 12. Importance ranking of selected industrial skills relative to CAD training or employment.
Many educators and businesses feel that a knowledge of industrial methods and processes is very important for a draftsperson. A number of such areas of industrial knowledge were placed in a third category of selected industrial skills in order to determine if there was any specific area that should receive emphasis in preparing students for CAD. The ranking of these items was radically different between surveys. Businesses considered the electronics area to be of most importance followed very closely by machining and metal fabrication. Least important were millwork and cabinetmaking skills. This writer feels that the ranking of these particular skills by business is relative to the areas of industry that the businesses are involved in. An analysis of the response to this particular question does indicate that this is the case. A comparison of the response to Question 2, (which describes the areas of CAD use), to the ranking of these skills by business does indicate a strong correlation. As with the response to Question 2, the ranking of this category only serves to describe the survey population.

The ranking of industrial skills by the training institutions similarly indicates course emphasis, again corresponding very closely to the response to Question 2. The educational institutions surveyed indicated residential framing and finishing skills to be the most important, followed by machining, metal fabrication, millwork, and cabinetmaking. Electronics skills were considered least important for CAD training. (See Figure 12)

Of all the skills mentioned, the single most important skill was considered to be manual drafting by both the business survey (53%) and the training survey (67%). A number of items were mentioned here that could all be loosely categorized as problem solving abilities. These include
adaptability, spatial analysis, design techniques, thinking ability, etc. If these are grouped together they form 33% of the training survey response and 32% of the business survey response to this question.

To summarize the response to this question, both businesses and training institutions involved with CAD consider manual drafting skills and good problem solving ability to be the most important prerequisites for CAD training or employment.

**Importance of Selected Drafting Skills in Relation to CAD Training or Employment:**

Question 9 of the survey asked respondents to indicate the importance, relative to CAD training or employment, of certain drafting skills presently being taught as part of the drafting curriculum in British Columbia secondary schools. These skills were selected from the 1977 British Columbia Industrial Education Curriculum Guide.

A rank of 5 indicated the skill to be of low importance and a rank of 1 indicated the skill to be very important. The mean priority rating of each item was calculated for both surveys and displayed in bar graph format in Figure 13. As shown on the graph, businesses and training institutions were remarkably consistent in their assessment of drafting skill importance. The only areas of marked contrast were cam and gear development (0.56 difference) and vernier protractor reading (0.53 difference).

The advent of computer aided drafting technology has made the acquisition of certain drafting skills a questionable pursuit. It would seem that such fine motor skills as tracing, inking, lettering, and drawing consistent linework would be of much less importance in drafting courses. The response to Question 9 indicates that this is true to a certain degree. What is more
Figure 13. Importance ranking of selected drafting skills taught in B.C. secondary schools in relation to CAD training or employment.
important in this question is the importance given certain other items. Dimensioning to CSA standards was given the highest priority rating, followed very closely by pictorial drawing (isometric/oblique), auxiliary views, revolutions, perspective drawing, and freehand sketching. All of these items, except for dimensioning, require the ability to think in three dimensions. In other words, drafting educators should be emphasizing the three dimensional aspect of drafting; the fact that the image on paper represents a solid object that can be manipulated and viewed from different angles, not necessarily the traditional orthographic angles.

Secondary School Curricular Change or Emphasis Identified as Being Beneficial to Student CAD Training or Employment:

Figure 14 displays the tabulated response to Question 10 of the survey questionnaire. CAD training institutions and businesses using CAD were asked to identify which areas of the secondary school curriculum, if any, that they would change or emphasize to better prepare students for further training and/or careers in CAD. The introduction of computer aided drafting at the secondary level was identified by 78% of the institutions and 72% of the businesses as the best method of preparing students. This was followed by the introduction of more drafting courses. The business survey indicated that a knowledge of industrial processes was just as important as more drafting courses while the training institutions were more concerned with better Math and English skills. The low response by both surveys to continuing with present programs indicates a need for some curricular revision in this respect.
Figure 14. Secondary school curricular change or emphasis identified as being beneficial to student CAD training or employment.
Purpose of the Study Reviewed:

The survey indicated that:

1. Computer aided drafting was in use for virtually all disciplines. In business and in the training institutions. A large proportion of the businesses surveyed were involved in electronics. The training institutions surveyed did not make electronics drafting a major part of their curriculum.

2. Large dedicated or mainframe CAD systems can be more difficult to operate than personal computer based systems. Personal computer based systems were generally considered simple or easy to use.

3. The individuals presently operating CAD systems were usually regular draftspersons retrained for CAD.

4. Employers would prefer to hire draftspersons with CAD skills.

5. CAD training institutions prefer to train draftspersons or people with some background in drafting or design.

6. Most CAD operators had taught themselves or received training through a CAD system vendor or through in-house training.

7. Employers would prefer that CAD training be left to appropriate training institutions.

8. That manual drafting skills and problem solving ability were the most important manual and cognitive skills for CAD and that necessary industrial skills were specific to the type of business involvement.

9. That secondary school drafting courses should be revised to place more emphasis on dimensioning to CSA standards and the three dimensional aspects of drafting.
10. That secondary schools should introduce computer aided drafting, offer more drafting courses, and emphasize good computational and communication skills.
The purpose of this study was to survey representative businesses using computer aided drafting technology and to survey institutions offering training in computer aided drafting in order to assess the impact of this technology on secondary school curriculum. A closed-form style questionnaire was sent to sixty-five businesses and fifteen institutions involved with CAD and the returned data tabulated and presented in bar graph format to facilitate easier interpretation of the results. The questionnaire was designed to ascertain the training and background of CAD personnel, the type of CAD equipment in use, the areas of drafting using CAD, the training and hiring preferences of business, the importance of various skills, and the areas of secondary school curriculum to be changed or emphasized to reflect the technology. The survey instrument was tested and revised before being distributed to the survey participants.

The review of the literature was divided into three areas. The first area reviewed the philosophical background to curriculum development. Educators were urged to keep curriculum up-to-date on the basis that curriculum content should reflect the needs of the society that it serves. A broad base of knowledge and skills was considered more important than specialization because of the rapidly changing requirements of technology and the resulting obsolescence of specialized skills.

The second area of review was concerned with related research in Industrial Education. A relatively small number of studies have been done
that are concerned with curricular revision in Industrial Education. Most of these utilize a survey of local industry to ascertain the status or needs of present curriculum. Survey studies in drafting curriculum development were mainly concerned with the impact of the changing technology of drafting, but not at the secondary level. The review established the survey questionnaire as the predominant method of identifying curricular development items in Industrial Education.

Periodical literature indicated a need for appropriate training in computer aided drafting fields and mentioned a number of successful programs.

The survey of businesses in British Columbia utilizing CAD required the compilation of a CAD directory as no published compilation could be found. This directory as well as one for CAD training institutions in British Columbia is included as an appendix to this study.

The survey generated an 82% response rate from industry and a 60% response from training institutions. A number of returned questionnaires from business could not be used as the respondents did not yet have a CAD system in operation. Removing these businesses from the sample generates a 75% response rate.

The survey was sent, together with a covering letter and stamped return envelope on April 10, 1985. Non-respondents were sent another questionnaire, together with a cover letter and stamped return envelope on May 10, 1985. Questionnaires received after June 10, 1985 were not included in the survey.
Conclusions:

The survey indicated that businesses in a wide variety of endeavours are using computer aided drafting systems and that they are retraining their present drafting and professional personnel to operate the systems. They do indicate, however, that they would prefer to hire individuals, predominantly draftspersons, with computer aided drafting skills should they require CAD operators. Training institutions are offering computer aided drafting courses with emphasis on traditional areas of drafting and prefer to teach individuals with good background in manual drafting or related areas. Manual drafting skills and good problem solving abilities were identified in both surveys as the major prerequisites for CAD success. Selected British Columbia secondary school drafting curriculum items were rated and both surveys placed more importance on dimensioning to CSA standards and viewing objects three dimensionally than on other areas. Curricular change to reflect the changing technology was deemed necessary and included the introduction of computer aided drafting at the secondary level as well as the inclusion of more drafting course time and more emphasis on computational and communication skills.

Recommendations:

To the extent that business interests and post secondary educational requirements are indicative of the need for curriculum modification at the secondary level, the results of the survey would support the following recommendations:

1. That students and educators be counselled to approach drafting, especially computer aided drafting, as a necessary skill for a wide variety of occupations and not as a vocation in itself. This would require a conscious effort to open secondary school
drafting programs to all students, not just those in industrial programs.

2. That drafting educators in British Columbia secondary schools should acquaint themselves with the changing technology of drafting.

3. That wherever economically possible, secondary school drafting programs should introduce students to computer aided drafting. The choice of system should reflect the growing trend in industry to utilize personal computer based systems.

4. That drafting educators should maintain contact with post secondary training institutions in an effort to standardize secondary drafting curriculum emphasis.

5. That the increased number of course-hours necessary to accommodate the recommendations of this study could be included in an industrial technology course at the senior secondary level. This course could focus on industrial methods and processes, applicable codes and standards, and on the development of appropriate mathematics and communication skills for design.

6. That secondary school drafting courses become more involved in developing the computational and communication skills necessary for post-secondary drafting programs.

7. That secondary drafting courses place more emphasis on the areas of drafting that involve viewing or manipulating an object in three dimensions as opposed to the traditional orthographic representation. These would include pictorial (isometric/oblique) projections, parallel and radial line developments, producing views by revolution, perspective drawing, and freehand sketching.
8. That secondary drafting courses place more emphasis on dimensioning to CSA standards and on following specific codes and standards in the preparation of drawings.

9. That the British Columbia secondary school Industrial Education guide should be amended to include content based on the recommendations of this study.

The review of the literature for this study indicated a tension existing between proponents of specialization in education and other more moderate factions. While there are obvious political overtones to this debate (the interests of the worker and business are seldom the same) this writer feels that the adoption of the preceding recommendations would be in the best interests of those concerned and would allow enough flexibility to keep drafting curriculum current and responsive to change.

Areas for Further Study:

The development of this study suggested a number of areas for further investigation:

1. A survey of individuals operating computer aided drafting systems in order to assess the extent of their skills and responsibilities.
2. A study to determine the extent to which computer aided production technology has changed skill requirements and employment demand.
3. A study of the success rate of individuals enrolling computer aided drafting technology programs in British Columbia in relation to the admission standards of the institution and to the academic standing of the individual.
Bibliography:


Tedesko, M.D. "Drafting Practices in Orange County Architectural Firms as Compared to Those Taught in Orange County Senior High School." Unpublished Master's thesis. California State University, Long Beach, 1974.


APPENDIX "A"
APPENDIX "B"
CAD Training Skill Survey

Name of Person Completing Survey: ____________________________

Position: ____________________________

Name of Training Institution: ____________________________

Comments Concerning Survey: ____________________________

__________________________________________________________________

__________________________________________________________________

__________________________________________________________________
CAD TRAINING SKILL SURVEY

1. Which areas of drafting do you emphasize in your CAD courses?
   ( ) Mechanical
   ( ) Electrical/Electronics
   ( ) Survey/Mapping/Topographic
   ( ) Civil
   ( ) Structural
   ( ) HVAC
   ( ) Architectural
   ( ) Other (please specify) .........................

2. Which of the following would best describe your CAD system?
   ( ) small, personal computer based, single user.
   ( ) personal computer based, multi-user.
   ( ) minicomputer based, multi-user.
   ( ) dedicated computer system.
   ( ) large mainframe system.

3. How would you describe the ease of operation of your CAD system?
   ( ) very easy to use, self teaching, many prompts.
   ( ) relatively simple, some orientation required.
   ( ) moderately difficult, programming knowledge helpful.
   ( ) difficult, extensive training required.
   ( ) frustrating, many programming problems.

4. What would be the approximate cost of your system?
   ( ) less than $10,000
   ( ) $10,000 - $25,000
   ( ) $25,000 - $50,000
   ( ) $50,000 - $75,000
   ( ) over $75,000
   ( ) continuing (lease or upgrading)

   Briefly describe your system in the space below.

5. Which of the following would best describe the training or background of most of your candidates for CAD training?
   ( ) high school graduate
   ( ) draftsperson (from industry)
   ( ) technician or technologist (i.e.-a BCIT graduate)
   ( ) computer specialist (computer scientist, analyst, programmer or similar)
   ( ) professional (engineer, architect, etc.)
   ( ) other (please specify) .........................
6. Which of the following would describe the best way(s) in which a person could receive CAD training?
( ) self taught
( ) community college drafting with CAD
( ) technical institute CAD courses
( ) university courses in CAD
( ) post graduate courses in CAD
( ) CAD system supplier courses in CAD
( ) in-house courses in CAD

7. Of the following, rank in order of preference from 1 to 6 those individuals that you would prefer to train on your CAD system.
( ) high school graduate
( ) draftsperson (from industry)
( ) technician or technologist (i.e.-a BCIT grad.)
( ) computer specialist (computer scientist, programmer, analyst, or similar)
( ) professional (engineer, designer, architect, or similar)
( ) other .............................................

8. In order to be more successful at computer aided drafting, it may be beneficial or even necessary to possess certain knowledge or skills before undertaking any CAD training. Following are three groups of related skills. Please rank the importance of these skills relative to preparation for CAD training. (where 1 is the most important and 5 is the least important)

   Manual Skills
   ( ) - keyboard skills
   ( ) - manual drafting skills
   ( ) - perspective drawing/rendering
   ( ) - word processing
   ( ) - other .............................................

   Cognitive Skills
   ( ) - computational skills
   ( ) - communication skills (composition, reading) etc.
   ( ) - analytic geometry skills
   ( ) - computer programming
   ( ) - other .............................................

   Industrial Skills
   ( ) - welding and metal fabrication
   ( ) - machining (milling, turning, shaping, etc.)
   ( ) - residential framing and finishing
   ( ) - millwork and cabinetmaking
   ( ) - basic electricity and electronics

In each of the groups above, you have indicated one skill as more important than the rest. Which, if any, of these would you consider to be the single most important skill?

..............................................
9. Following is a list of some of the skills being taught in drafting at the senior secondary level in B.C. schools. On a scale from 1 to 5, indicate the importance of these skills relative to preparation for CAD training.

<table>
<thead>
<tr>
<th>Skill Description</th>
<th>high - IMPORTANCE - low</th>
</tr>
</thead>
<tbody>
<tr>
<td>- cam and gear development</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- dimensioning to CSA-standards</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- isometric and oblique drawing</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- vernier protractor reading</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- drawing residential plans to code</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- lettering to a consistent standard</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- plotting topographic maps</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- freehand sketching</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- tracing and inking neatly</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- calculating dihedrals geometrically</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- drawing consistent and easily reproducing lines</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- parallel and radial line developments</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- secondary auxiliary views</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- developing views by revolution</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
<tr>
<td>- perspective drawing</td>
<td>( ) ( ) ( ) ( ) ( )</td>
</tr>
</tbody>
</table>

10. Which of the following would be the best method of preparing students in secondary schools for further training and/or careers in CAD?

( ) continue with present programs
( ) place more emphasis on mathematics.
( ) modify programs to include more English and Math.
( ) programs should include more computer programming.
( ) industrial methods and processes should be emphasized.
( ) more courses in drafting.
( ) computer aided drafting should be taught.
( ) other .........................................................

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY. YOUR CO-OPERATION IS GREATLY APPRECIATED.
APPENDIX "C"
CAD Operator Skill Survey - Industry

Name of Person Completing Survey: ______________________

Position: ______________________

Company: ______________________

Comments Concerning Survey: ______________________

______________________________

______________________________

______________________________
CAD OPERATOR SKILL SURVEY - INDUSTRY

1. Which areas of drafting are you involved in?
   ( ) Mechanical
   ( ) Electrical/Electronics
   ( ) Survey/Mapping/Topographic
   ( ) Graphics/Rendering/Pictorials
   ( ) Civil
   ( ) Structural
   ( ) HVAC
   ( ) Architectural
   ( ) Other (please specify)  

2. Which of the following would best describe your CAD system?
   ( ) small, personal computer based, single user.
   ( ) personal computer based, multi-user.
   ( ) minicomputer based, multi-user.
   ( ) dedicated computer system.
   ( ) large mainframe system.

3. How would you describe the ease of operation of your CAD system?
   ( ) very easy to use, self teaching, many prompts.
   ( ) relatively simple, some orientation required.
   ( ) moderately difficult, programming knowledge helpful.
   ( ) difficult, extensive training required.
   ( ) frustrating, many programming problems.

4. What would be the approximate cost of your system?
   ( ) less than $10,000
   ( ) $10,000 - $25,000
   ( ) $25,000 - $50,000
   ( ) $50,000 - $75,000
   ( ) over $75,000
   ( ) continuing (lease or upgrading)

   Could you give a brief description of your present system in the space below?

5. Which of the following would best describe the training or background of most of your CAD operator(s)?
   ( ) draftsperson retrained for CAD.
   ( ) CAD draftsperson
   ( ) technician or technologist
   ( ) computer specialist (computer scientist, programmer, analyst, or similar)
   ( ) professional (engineer, architect, etc.)
   ( ) other (please specify)  

6. Which of the following would best describe the way in which most of your CAD operators received their CAD training?

( ) self taught
( ) community college drafting with CAD
( ) technical institute CAD courses
( ) university courses in CAD
( ) post graduate courses in CAD
( ) CAD system supplier courses in CAD
( ) in-house courses in CAD

7. Of the following, rank in order of preference from 1 to 6 the individuals that you would hire or select to operate your CAD system.

( ) draftsperson (to be trained on your system)
( ) CAD draftsperson (college trained)
( ) technician or technologist (i.e. - a BCIT grad.)
( ) computer specialist (computer scientist, programmer, analyst or similar)
( ) professional (architect, designer, engineer, or similar)
( ) other ........................................

8. In order to be more successful at computer aided drafting, it may be beneficial or even necessary to possess certain knowledge or skills before undertaking any CAD training. Following are three groups of related skills. Please rank the importance of these skills relative to preparation for CAD training. (where 1 is the most important and 5 is the least important)

Manual Skills
( ) - keyboard skills
( ) - manual drafting skills
( ) - perspective drawing/rendering
( ) - word processing
( ) - other ........................................

Cognitive Skills
( ) - computational skills
( ) - communication skills (composition, reading)
( ) - analytic geometry skills
( ) - computer programming
( ) - other ........................................

Industrial Skills
( ) - welding and metal fabrication
( ) - machining (milling, turning, shaping, etc.)
( ) - residential framing and finishing
( ) - millwork and cabinetmaking
( ) - basic electricity and electronics

In each of the groups above, you have indicated one skill as more important than the rest. Which, if any, of these would you consider to be the single most important skill?

........................................
9. Following is a list of some of the skills being taught in drafting at the senior secondary level in B.C. schools. On a scale from 1 to 5, indicate the importance of these skills relative to preparation for CAD training.

<table>
<thead>
<tr>
<th>Skill Description</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td>cam and gear development</td>
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<tr>
<td>dimensioning to CSA standards</td>
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<tr>
<td>isometric and oblique drawing</td>
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<tr>
<td>vernier protractor reading</td>
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<tr>
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<tr>
<td>plotting topographic maps</td>
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<tr>
<td>tracing and inking neatly</td>
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<td>calculating dihedrals geometrically</td>
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<td>drawing consistent and easily reproducible lines</td>
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<td>parallel and radial line developments</td>
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<td>secondary auxiliary views</td>
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<td>developing views by revolution</td>
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<td>perspective drawing</td>
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10. Which of the following would be the best method of preparing students in secondary schools for further training and/or careers in CAD?

( ) continue with present programs
( ) place more emphasis on mathematics
( ) modify programs to include more English and Math
( ) programs should include more computer programming
( ) industrial methods and processes should be emphasized
( ) more courses in drafting
( ) computer aided drafting should be taught
( ) other ..................................................

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY. YOUR CO-OPERATION IS GREATLY APPRECIATED.
CAD system descriptions as reported in survey questionnaires:

- "IBM-PC XT and IMB-PC AT installed with Futurenet DASH-1.2 for electronics and AutoCAD 2 for mechanical package."

- "Hewlett Packard EGS 200 system with HP DMP-42 plotter."

- "Auto-Troll AD-380 system consists of Sperry-Univac CPU, 3 terminals, a flatbed plotter, a hard-copier, and a tecwriter."

- "Two IBM-PC's; Tall Grass 12 megabyte hard disk, DMP-42 plotter, mouse and digitizer, with AutoCAD software."

- "HP 1000 (512K) computer, HP 7925 (120 megabyte) disc drive, six HP 2648A terminals, using Holguin CAD software, version 2000."

- "Intergraph system with VAX 11-730 CPU, colour INTERACT station, VERSATEC 8236 plotter."

- "IBM-PC, ECAD software, Houston Instrument DMP-52 plotter."

- "CALMA GDSII graphics system, includes Data General Eclipse computer dedicated to CHIPS I.C. design application; 2 dual screen work stations and one digitizing station."

- "Software is Design Oriented Graphics System (DOGS) from PAFEC Ltd., with three Westward #2019 terminals, a Prime 2250 computer, three Houston Instruments digitizers, and one Houston Instrument DMP-52 plotter."

- "An Apple II using ROBOCOM II software and a Roland DXY 880 plotter."

- "Intergrated Graphics Design System."

- "Eagle PC (IBM-PC compatible) with Houston Instrument DMP-42 drum plotter and digitizer tablet."

- "512K, 16-bit graphic processor, 2-80MB hard disks, 800-1600 BPI 9 track tape drive, three graphic work stations, 19" storage refresh, 2 alphanumerics for text input, 60" x 44" digitizer, 1 electrostatic 22" plotter, 1 76" x 46" flatbed plotter."

- "ACCUCAD 2D software running on VAX 11-750, Tektronix 4109 terminal, HP drum plotter."
- "IBM-PC XT, 640K RAM, Zenith colour monitor, HP 7475A plotter."

- "IBM-PC with AutoCAD software, digitizer, and 11" x 17" plotter."

- "640K IBM-PC with 2 - 360K disc drives, Electrohome colour monitor, 8087 math coprocesser, DMP-42 Houston Instruments plotter, Technique architectural software."

- "CEADS-CAD 2000, HP 1000 A600 with 512K, 65 Mb disc drive, HP 2623A raster station, HP 7580A plotter."

- "IBM-PC AT with colour graphics card, Houston Instruments single pen plotter, colour monitor, and 10Mb hard disk drive, house and digitizer pad."

- "4Mb Prime 650 with 600Mb disk storage, 13 graphics terminals."

- "CEADS CAD-2000 software version 1.07, using HP 1000 A-900 CPU, HP 7912 65Mb hard disk, HP 2623A terminals, and a HP 7585B plotter."

- "Systemhouse 2.5D design and drafting system using HP1000 mini-computer."

- "HP 1000F CPU, nine terminals, Holguín and Assoc. software."

- "2 standalone micro-based high resolution stations, master storage, ink plotter/printer."

- "IBM-PC AT with AutoCAD software and plotter."

- "Hardware: RNA - 32 bit desktop Super-Micro, 2Mb RAM, 40Mb hard disk, 7000 Complot digitizer, Houston Instruments plotter, in-house software."

- "Texas Instrument PC's linked in a 360M (ETHERNET) local area network, 20Mb hard disk, printer, plotter, also three IBM-PC's using AutoCAD software."

- "HP1000 CPU with 7 stations, using CEADS CADD 2000 software from Holguín and Assoc., El Paso, and P.A.D.S. from Advenco Consultants, Coquitlam."

- "Data General MV10000 CPU, disk and tape drives, Tektronix 4107 work stations, H.P. plotters, printers, ANVIL 4000 software."

- "Technique software, Apple IIe computers, H.P. plotter."
APPENDIX "E"
SELECTED COMMENTS FROM QUESTIONNAIRES

- "CAD is an electronic "tool" used in the application of drafting. This survey tends to deal with it by disciplines or work specialities (industrial skills) which I believe does not apply. We have upgrade students such as architects, engineers, and draftsmen from all areas of expertise in one class taking CAD. Our system has no specific didication."

- "I hope this survey will help to somehow organize secondary level drafting programs to prepare students for formal CAD courses. A college CAD consortium should be organized to ensure a consistent level of training and quality in the CAD education program. This would also bring together all the various programs and equipment for a broader ranged CAD survey."

- "The survey seems oversimplified in order to make it general in application. Our motto for CAD training, "Teach an engineer to use the computer - you can't teach a computer technician to be a designer."

- "Too long."

- "Failed to concentrate on organizational and management skills essential to CAD efficiency."

- "A useful survey. I think CAD should be kept for the college level with an emphasis on standards and drawing analysis at the secondary level."

- "CAD systems are ever-changing beasts. The personal "drawing management skills" which must be developed are extensive. I believe any attempt to teach a student "CAD skills" would be detrimental to his/her career for two main reasons:

1) This time could be better spent acquiring a good technical training. This is a much greater asset than knowing the mechanics of producing a drawing.

2) The individual will inevitably have to be retrained to the particular office's CAD standards and procedures."

- "Seems to be asking the right sorts of questions."

- "The trend in computer aided drafting is to single independant microprocessor based work stations that are easy to learn and inexpensive. In the near future CAD will replace manual drafting, so secondary schools should teach drafting on CAD stations."
"Your system costs are low. A CAD system is a tool not unlike a
drawing board; being able to operate a drawing board does not mean
you can draw."

"... there are already more CAD draftspersons than CAD systems in
British Columbia. Why train so many kids for such a small job
market? CAD systems are prohibitively expensive and will continue
to be for some time to all but the largest of corporations. In
any event, a CAD system that requires extensive training is a
poorly designed system. What we need are people trained in the
basics of design. Anybody can draw. And even with today's crude
CAD systems anybody can draw well with only a few hours training.
TEACH DESIGN."
APPENDIX "F"
INSTITUTIONS IN BRITISH COLUMBIA OFFERING
TRAINING IN COMPUTER AIDED DRAFTING

COLLEGES:

CAMOSUN COLLEGE
1950 Lansdowne Road
Victoria, B.C.
V8P 5J2
(Drafting Department Head)

CAPILANO COLLEGE
2055 Purcell Way
North Vancouver, B.C.
V7H 3H5
(Drafting Department Head)

CARIBOO COLLEGE
P.O. Nox 3010
Kamloops, B.C.
V2C 5N3
(Mr. Gene Turney, Drafting Department Head)

KWANTLEN COLLEGE
P.O. Box 9030
Surrey, B.C.
V3T 5H8
(Mr. John Morrison, Instructor Industrial Drafting/CAD)

MALASPINA COLLEGE (Fast Track)
900 Fifth St.
Nanaimo, B.C.
V9R 5S5
(Mr. Cliff Hinton)

NORTHERN LIGHTS COLLEGE
11401 8th St.
Dawson Creek, B.C.
V1G 4G2
(Mr. D. Berotte, Drafting Instructor)

VANCOUVER COMMUNITY COLLEGE
1155 E. Broadway
Vancouver, B.C.
(Mr. Ron Atkinson, Drafting Department Head)

TECHNICAL INSTITUTES:

BRITISH COLUMBIA INSTITUTE OF TECHNOLOGY
3700 Willingdon Ave.
Burnaby, B.C.
V5G 3H2
(Mr. A.P. Adamo)

CENTRE FOR ADVANCED RESOURCE TECHNOLOGY
1789 Ogilvie St.
Prince George, B.C.
V2N 1W7
(Drafting Department Head)

VOCATIONAL INSTITUTES:

PACIFIC VOCATIONAL INSTITUTE
3650 Willingdon Ave.
Burnaby, B.C.
V5G 3H1
(Mr. Gary Cullen, Instructor)

UNIVERSITIES:

UNIVERSITY OF BRITISH COLUMBIA
Dept. of Mech. Engineering
Vancouver, B.C.
V6T 1W5

UNIVERSITY OF VICTORIA
Computer Aided Drafting
P.O. Box 1700
Victoria, B.C.
V8W 2Y2

SIMON FRASER UNIVERSITY
Computer Aided Drafting
Engineering Science
Burnaby, B.C.
V5A 1S6

TRADE SCHOOLS:

DOWCO CAD SCHOOL
504 Cottonwood
Coquitlam, B.C.
(Mr. Hugh Dobbie, President)
APPENDIX "G"
INDUSTRIES USING COMPUTER AIDED DRAFTING

Mr. John Whalen
MICROLIGHT COMPUTER SYSTEMS LTD.
4438 Valencia
North Vancouver, B.C.
V7N 4B1

ALPHA SCIENTIFIC RESEARCH CORPORATION
1545 Columbia St.
North Vancouver, B.C.

Mr. Tom Pelton, President
PELTON ENGINEERING
3991 Smugglers Cove
Victoria, B.C.
V8N 4M1

Drafting Department Head
A.E. CONCRETE PRECAST PRODUCTS
Box 1265
Coquitlam, B.C.
V3J 6Z9

Mr. Bryan Dixon
APPLIED CAD/CAM COMPUTING
142 W. 15th.
North Vancouver, B.C.
V6J 4L7

Engineering Department
ARMOUR, BLEWETT & PARTNERS
353 Water St.
Vancouver, B.C.
V6B 1B8

Mr. Anders Ahlgren
ASTROGRAPHIC INDUSTRIES LTD.
7541 134A St.
Surrey, B.C.
V3W 7B3

Mr. W. Trevor Bishop
B.C. RESEARCH
3650 Wesbrook Mall
Vancouver, B.C.
V6C 2L2

Ms Mary Lou Perry
CADCO GRAPHICS LTD.
525 Seymour St.
Vancouver, B.C.
V6B 3H6

Mr. Paul Siluch
HEWLLIT PACKARD
10691 Shellbridge Way
Richmond, B.C.
V6X 2W8

Mr. David McDonald
ACCUGRAPH CORPORATION
50 Gervais Drive, Ste 204
Don Mills, Ontario
M3C 1Z3

Mr. Richard Lengden, System Manager
NEWNES MACHINE SHOP
Front St.
Salmon Arm, B.C.
V0E 2T0

Engineering Department
ALCAN BUILDING PRODUCTS
620 Audley Blvd.
New Westminster, B.C.
V3M 5P2

Mr. John B. Coop, System Manager
Interactive Graphic Systems
KILBORN ENGINEERING (B.C.) LTD.
1380 Burrard St.
Vancouver, B.C.
V6Z 2H9

Engineering Department
ASSOCIATED FOUNDRY LTD.
Box 9005
Surrey, B.C.
V3T 4X3

Drafting Department
AEL MICROTEL LTD.
7018 Lougheed Hwy.
Burnaby, B.C.
V5A 1W3
Mr. James K. Torrance  
Drafting Supervisor  
B.C. HYDRO & POWER AUTHORITY  
970 Burrard St.  
Vancouver, B.C.  
V6Z 1Y3

G.W. Miller  
B.C. TELEPHONE COMPANY  
10-3777 Kingsway  
Burnaby, B.C.  
V5H 3Z7

R.E. Wareins  
MERLIN ENGINEERING GRAPHICS  
101A - 255 West 1st.  
North Vancouver, B.C.  
V7M 3G8

Gary W. McCue, Manager  
CAD/CAM Systems  
BURRARD YARROWS CORPORATION  
109 E. Esplanade  
North Vancouver, B.C.  
V7L 1A1

Mr. Brian Stroup  
Chief Engineer  
C.A.E. MACHINERY  
3550 Lougheed Hwy.  
Vancouver, B.C.  
V5M 2A3

Engineering Department  
CANOCEAN RES.  
610 Derwent Way  
New Westminster, B.C.  
V3M 5P8

R. Relkie  
WESTCOAST TRANSMISSION LTD.  
1333 West Georgia St.  
Vancouver, B.C.  
V6E 3K8

James C. Barnum, Partner  
CARLBERG, JACKSON, PARTNERS  
301 - 6th St.  
New Westminster, B.C.  
V3L 3A7

Terry Wong, Project Engineer  
CONTROL TECHNOLOGIES, INC.  
Ste. 310 - 325 Howe St.  
Vancouver, B.C.  
V6C 1Z7

Mr. Ken Lord, Hardware Supervisor  
DYNAMIC CONTROL SYSTEMS  
#204 - 13662 104A Ave.  
Surrey, B.C.  
V3T 1Y8

Mr. Ralph Struve  
ELTRON ENTERPRISES LTD.  
7583 Vantage Place  
Delta, B.C.  
V4G 1A5

Engineering Department  
H.A. SIMONS LTD.  
425 Carroll St.  
Vancouver, B.C.  
V6B 2J6

Drafting Department Head  
BAILEY & ROSE  
716 - 850 West Hastings St.  
Vancouver, B.C.  
V6C 1E2

Mr. Roger Toren  
C.R. TOREN LTD.  
Ste. 206D - 3700 Gilmore Way  
Burnaby, B.C.  
V5G 4M1

Engineering Department  
CANADIAN AIRCRAFT PRODUCTS LTD.  
2611 Viscount Way  
Richmond, B.C.  
V6V 1M9

Mr. John A. Volc  
CAD System Manager  
ROBERT ALLAN LTD.  
1496 W. 72nd Ave.  
Vancouver, B.C.  
V6P 3E3

Mr. Grian Gorbell  
Systems Management  
CARIN DESIGN  
261 E. 1st St.  
North Vancouver, B.C.  
V6L 1B4

Mr. Roger Bayley, Partner  
CHANDLER KENNEDY ARCHITECTURAL GROUP  
7th Floor - 609 West Hastings St.  
Vancouver, B.C.  
V6B 4W4
Manager
DRAFTING SERVICES
1100 W. 7th Ave.
Vancouver, B.C.
V6H 1B4

Mr. Nick Fenger, Manager
F.N. FENGER & ASSOCIATES LTD.
Ste. 303 - 660 Fort St.
Victoria, B.C.
V8W 1G8

C.E. Carlson
HARRISON CARLSON PEARCE
955 Richards
Vancouver, B.C.
V6B 3B8

Mr. A.C. Hartley
HARTECH, COMPUTER GRAPHICS RESOURCES, LTD.
15075 Spences Court
Surrey, B.C.
V3S 5Z8

Engineering Department
HAWKER-SIDDELEY CANADA LTD.
Box 4200
Vancouver, B.C.
V6B 4K6

Mr. R.D. Smith, General Manager
INDALEA, DIVISION OF INDAL
1930 Kingsway
Port Coquitlam, B.C.
V3C 1S7

Mr. Gerald Cassel, Sales Manager
INTERWORLD ELECTRONICS
1348 Marine Drive
North Vancouver, B.C.
V7P 1T4

Mr. Rex Cadwaladr
L.D.P. & E. HOLDINGS
34375 Cyril St.
Abbotsford, B.C.
V2S 2H5

Mr. Don Stewart
LLOYD CONTROLS LTD.
3046 Westwood St.
Port Coquitlam, B.C.
V2C 3L7

Mr. K.G. Whale
NATIONAL RESEARCH COUNCIL
3904 2. 4th Ave.
Vancouver, B.C.
V6R 1P5

Mr. Douglas Soon, Manager
PACIFICANA DISTRIBUTORS
127 E. 15th
North Vancouver, B.C.
V7L 2P7

Mr. Rob Sutton
R. & S. MACHINE WORKS LTD.
1878 Kent Ave.
Vancouver, B.C.
V5P 2S7

Mr. Jim Ross, Project Manager
INTERNATIONAL SUBMARINE ENGINEERING LTD.
2605 Murray
Port Moody, B.C.
V3H 1X1

Hank Tung, C.E.T.
CAD Group Leader
KOCKUMS CANCAR INC.
Box 4200
Vancouver, G.C.
V6B 4K6

Kyomi Hama, Drafting Supervisor
MACDONALD DETTWILER & ASSOC. LTD.
3751 Shell Road
Richmond, B.C.
V6X 2Z9

Ms. Denise Foxall, Software Manager
PACIFIC MICROCIRCUITS LTD.
1645 140th St.
White Rock, B.C.
V4A 4H1

Ms. Denise Foxall, Software Manager
PACIFIC MICROCIRCUITS LTD.
1645 140th St.
White Rock, B.C.
V4A 4H1

Engineering Department
PIRELLI CABLES INC.
13340 76th Ave.
Surrey, B.C.
V3W 2W1

Mr. Rich Matthews
Director of Computer Applications
R.E. HULBERT & ASSOCIATES
215 14th St.
West Vancouver, B.C.
V7T 2P9
Mr. Jack Heyrman, President
SEATRONICS TECHNOLOGIES LTD.
Ste. 111 - 3700 Gilmore Way
Burnaby, B.C.
V5G 4M1

Mr. Ted Broekhuizen
Chief Draftsman
Ports & Marine Department
SWAN WOOSTER ENGINEERING
1525 Robson St.
Vancouver, B.C.
V6G 1C5

Engineering Department
WESTERN CANADA STEEL LTD.
450 S.E. Marine Drive
Vancouver, B.C.
V5X 2T2

Chang Lim, Chief Engineer
WINDSOR MACHINE CO. LTD.
5771 Production Way
Langley, B.C.
V3A 4N5

Mr. Manfred Hoff
ROBAR IND. LTD.
12945 78th Ave.
Surrey, B.C.
V3W 2X8

Mr. B. Johnston, Vice President
- Graphic Systems
SYSTEMHOUSE LTD.
900 W. Hastings St.
Vancouver, B.C.
V6C 1E5

Engineering Department
WEISER INC.
6700 Beresford St.
Burnaby, B.C.
V5E 1Y2

Engineering Department
WESTERN ROBOTICS
1768 E. Hastings St.
Vancouver, B.C.
V5L 1S9