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# A comparative study of the perceived educational needs of Iowa Merged Area VII manufacturers and Iowa technical educators

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A COMPARATIVE STUDY OF THE PERCEIVED
EDUCATIONAL NEEDS OF IOWA MERGED AREA VII
MANUFACTURERS AND IOWA TECHNICAL EDUCATORS

A Dissertation
Submitted
In Partial Fulfillment
of the Requirements for the Degree
Doctor of Industrial Technology

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# ABSTRACT

This research was a descriptive pilot study that compared the perceptions of Iowa Merged Area VII manufacturers and Iowa technical educators regarding technical curricula, occupational skill certification, and drafting practices as these relate to Associate Degree programs in Mechanical Drafting and Design Technology. The problem was to determine what should be taught in two year technical curricula in Mechanical Drafting and Design Technology. The purpose of the study was to compare the perceived educational needs of Iowa Merged Area VII manufacturers and Iowa technical educators regarding the content of Mechanical Drafting and Design Technology curricula. The populations used for this study were manufacturing industries located in Iowa Merged Area VII, and technical educators currently teaching in community colleges in the state of Iowa. Two independent samples were used for this research consisting of survey responses from the selected population of Merged Area VII manufacturing industries, and survey responses from technical educators in the state of Iowa. A survey instrument was developed in two versions, one for Iowa Merged Area VII manufacturing industries, and one for Iowa technical educators. Both versions of the survey instrument differed only in the content of the cover letter, instructions for completing each section of the instrument, and in the presence or absence of Section 1 eliciting

demographic data from manufacturers. A research hypothesis ($H_1$: $\mu_1 \neq \mu_2$) was established for each of the individual items in Section 2, Associate Degree Curriculum Components; Section 3, Drafting Practices; and Section 4, Occupational Skill Certification (excluding Item 4.9) of the survey instrument. The null hypothesis ($H_o$: $\mu_1 = \mu_2$) that corresponded to the research hypothesis ($H_o$: $\mu_1 \neq \mu_2$) for each item in Sections 2, 3, and 4 (excluding 4.9) of the survey instrument was tested by comparing the mean of all industry responses for each item with the mean of all educator responses for the same item using a two-tailed $t$ test at the .05 level of significance. The results of the statistical analysis of the data were used to develop a curriculum in Mechanical Drafting and Design Technology that reflects a balance between the opinion of industry and educators, and that meets the expressed educational needs of Iowa Merged Area VII manufacturers.

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# CHAPTER I

## INTRODUCTION

American educators have come under increasingly strident pressure from industry, business, and government ("Will the workforce work?," 1992) to teach students new, process-oriented skills that will help them function effectively in a " . . . working world that will become ever more knowledge driven and information intensive" (Lemonick, 1992, p. 60). In particular, post-secondary technical schools and community colleges are being asked to develop curricula that place a greater emphasis on the needs of the workforce (Buzzell, 1994b; "Calls for," 1993). This emphasis is particularly appropriate since the U. S. Department of Commerce predicts that, by the year 2000, 75% to 80% of all new jobs will be for graduates of Associate Degree programs from two-year technical schools, rather than from four year institutions (Feldman, 1994; "Technicians hottest," 1992)

The new process-oriented skills must be developed within the larger context of domain-specific skills taught in a rigorous academic framework (Bamford, 1993b). According to the Secretary's Commission on Achieving Necessary Skills (SCANS), three types of process-oriented skills are essential. These are basic literacy skills, thinking skills, and personal skills ("What work requires," 1991). Basic skills include reading, writing, arithmetic and mathematics, listening, and speaking. Thinking skills involve creative thinking, visualization, problem-solving, decision-making and reasoning. Personal skills entail such affective behaviors as responsibility, self-esteem, sociability, self-management, and integrity.

In the SCANS model, the basic skills form the foundation for the development of several competencies that are regarded by many as essential to success and effectiveness in the new manufacturing workplace ("What work requires," 1991). These competencies consist of the broad categories of resources, interpersonal skills, information, systems, and technology. Moreover, each of these competencies may be developed in several levels of proficiency ranging from preparatory to specialist.

The SCANS skills and competencies are clearly more process-oriented than they are occupation or domain-oriented, and are, thus the common-denominator skills and competencies that are required of all employees, regardless of specific occupational title (Owen & Sprow, 1994c). However, the SCANS skills and competencies must still be developed within the context of, and in addition to, the skills required for a specific occupation (Feldman, 1994).

The education of students with skills and competencies that emphasize process in addition to the traditional domain-specific or occupational skills represents a significant departure from traditional vocational-technical educational practices and program content (Jacobs, 1993).

Considering the significance of the departure from past practices and content, a number of questions have arisen. What should be taught? How should what is to be taught be determined? How should it be taught? Who should teach it? What should be the context of the educational process? And, in what type of educational experience are these skills and competencies best developed and delivered?

## Statement of the Problem

Under the impetus of massive global socio-economic restructuring and change (Cetron, Rocha, & Luckins, 1988; Koska & Romano, 1988), the rapidly evolving high-performance manufacturing workplace has essentially redefined the knowledge and skills needed by manufacturing workers. As a result, American business and industry have increasingly called upon schools and colleges to place renewed emphasis upon the education and training of work-ready technical employees (Jacobs, 1993).

According to the Department of Labor ("What work requires," 1991), to be work-ready technical employees require "workplace know-how" (p. xv) that includes two components. The first component is a well developed foundation of basic skills, thinking skills, and personal skills. The second component is competencies in the areas of resources, interpersonal skills, information, systems, and technology.

Since workplace know-how essentially defines effective job performance ("What work requires," 1991), the implication is that these skills and competencies must be developed within the context of some specialized technical domain for which students are being prepared, such as drafting and design technology, manufacturing technology, automation electronics, aircraft power mechanics, and similar occupational titles. In other words, being work-ready must entail not only the general SCANS skills and competencies, but domain-specific skills and competencies as well.

Chapter 2 lists and describes the SCANS basic skills, thinking skills, and personal skills; and describes the SCANS competencies. Taken together, these constitute the indispensable general "workplace know-how" (p. xv) needed by all employees, as defined in the SCANS report ("What work requires," 1991).

However, before new curricula can be developed, or existing curricula altered to produce manufacturing employees with the required process-oriented skills, it was necessary to determine what domain-specific knowledge and skills those employees need for a given occupation. That is, the question, "what should be taught for effective functioning in a given occupation?" had to be answered.

In general, the problem in this study was to determine what should be taught in two year technical curricula in Mechanical Drafting and Design Technology in order to adequately prepare students for the modern high-performance manufacturing workplace. More specifically, this study addressed the following problems:

1. Based on a review of the literature, should the SCANS basic skills and competencies be included in two-year technical curricula in Mechanical Drafting and Design Technology?

2. Are there any differences between the perceptions of Iowa Merged Area VII manufacturers and Iowa technical educators regarding the specific courses that ought to be included a two-year technical curriculum in Mechanical Drafting and Design Technology?

3. Are there any differences between the perceptions of Iowa Merged Area VII manufacturers and Iowa technical educators regarding the relationship between manual and CADD drafting techniques in two year technical curricula in Mechanical Drafting and Design Technology?

4. Are there any differences between the perceptions of Iowa Merged Area VII manufacturers and Iowa technical educators regarding the value of nationally recognized skill certification for entry-level graduates of two-year technical curricula in Mechanical Drafting and Design Technology?

## Statement of Purpose

This study was conducted at Hawkeye Community College in Waterloo, Iowa, in the Department of Engineering and Technology. The study specifically applied to the two-year Associate in Applied Science Degree program in Mechanical Drafting and Design Technology, which is presently undergoing extensive revision. The curriculum is being revised in order to ensure that program content more accurately reflects the needs of Iowa Merged Area VII manufacturers, since 62% of Hawkeye Community College Graduates are employed in industries and businesses located within Merged Area VII after graduation ("Bet you didn't know," 1994).

Most comprehensive community colleges have a well defined service area within the state in which they are located. In the case of Hawkeye Community College, the service area is denoted as Merged Area VII. Iowa Merged Area VII consists of all or portions of 10 counties in the state of Iowa, and includes the Waterloo-Cedar Falls Metropolitan Area.

As is the case in most community colleges, Hawkeye Community College strives to meet the specific educational needs of business and industries located within, and sometimes adjacent to, its service area. In particular, technical programs at community colleges are specifically designed in order to provide individuals with the knowledge, skills, and competencies that service area manufacturers need in order to be competitive in the high-performance manufacturing workplace.

According to the American Society for Training and Development ("ASTD study shows," 1991), this future workplace will be one in which "learning is the rationing hand that distributes earnings . . . " (p. 2), and "people with the most education and access to learning on the job do best . . . " (p. 3). However, it is imperative that the right kind of learning be provided if employees are to be properly prepared for the modern workplace immediately upon graduation ("What work requires," 1991).

In order to provide work-ready employees that meet the needs of Merged Area VII manufacturers, it was necessary to know those needs in considerable detail. Therefore, the purposes of this study were:

1. To assess and compare the perceived educational needs of Iowa Merged Area VII manufacturers and Iowa technical educators regarding the content of the Mechanical Drafting and Design Technology curriculum at Hawkeye Community College.

2. To increase the relevance of the Mechanical Drafting and Design Technology program at Hawkeye Community College to the needs of Iowa Merged Area VII manufacturers.

3. To establish a sound basis for the development and implementation of a new curriculum in Mechanical Drafting

and Design Technology at Hawkeye Community College that more closely approximates the expressed educational needs of Iowa Merged Area VII manufacturers.

## Statement of Need

There has been a significant and growing concern that the process of education in America at all levels lacks relevance to the modern high-performance manufacturing workplace. Furthermore, many critics in business, industry, government, and education have decried the ability of the American educational system to "turn out people capable of handling the growing complexity of knowledge-intensive manufacturing" ("Making things better," 1990, p. 3).

Sinn (cited in "Will the workforce work?," 1992) states that " . . . much technical education is isolated, disjointed, out of date, and irrelevant to the needs of a technological culture" (p. 49). And, a 1992 study commissioned by the American Production and Inventory Control Society entitled Learning to learn: Survival for U.S. manufacturers (cited in "Calls for," 1993), indicates that, "academic institutions should begin or expand efforts to reevaluate curricula in order to provide post-secondary education with a greater focus on the work force" (p. 1).

Today, the American educational system is being asked to produce entry-level employees at all levels that are flexible, adaptable to new modes of management, able to function in new forms of work organization, capable of exploiting new technologies, proficient in the acquisition of new skills, and able to enhance the productivity and competitiveness of a manufacturing firm ("Making things better," 1990). By most accounts, the responsibility for the development of these skills and competencies in the workforce rests with the American educational system (Jacobs, 1993; Owen & Sprow, 1994a).

According to some (Koska & Romano, 1988; "Making things better," 1990; "U.S. workers need," 1990), significant and sweeping changes in the American educational system is the only viable means of providing an appropriately educated workforce However, Eisen (1993) notes that "education reform is a long-term goal" (p. 19). Thus, short term solutions must be sought within the context of the current educational establishment.

Eisen (1993) states that the chief executive officers (CEOs) of many companies believe that community colleges are the component of the present educational establishment that are most responsive to "customer [that is, industry] needs" (p. 19). And, the Office of Technology Assessment (OTA) indicates that community colleges are an important source of support for the training needs of industry ("U.S. workers need," 1990).

Lorenzo and LeCroy (1994) state that " . . . community colleges are already way ahead of the other segments of education in their responsiveness, flexibility, and community-based stratagems" (p. 19). And, Jacobs (1993) notes that "community colleges throughout the nation have responded [to the need to retrain the present workforce] by providing training and education customized to meet the specific needs of local employers" (p. 1).

Clearly, the nation's community colleges are in a position to effectively meet the immediate educational needs of industry. Hence, this study will be conducted at Hawkeye Community College in order to develop a fuller understanding of the perceived educational needs of manufacturing industries located in Iowa Merged Area VII. Within this broad context, the specific needs that were fulfilled by this study were:

1. The need to expand existing knowledge, and add new knowledge regarding the general problem of workplace relevance in vocational-technical education.

2. The need for an in-depth understanding of the perceived educational needs of Iowa Merged Area VII manufacturers, particularly the needs of smaller manufacturing industries whose interests may be poorly represented, or not represented at all, on Program Advisory Committees (PACs).

3. The need to determine the relevance of the SCANS basic skills and competencies to existing and anticipated

employment needs of manufacturers located within Iowa Merged Area VII.

4. The need to determine the relevance of the Mechanical Drafting and Design Technology curriculum at Hawkeye Community College to the existing and anticipated employment needs of Iowa Merged Area VII manufacturers.

5. The need to assess the importance of, and relationship between, traditional drafting techniques and computer-based drafting techniques in preparing students for employment by Iowa Merged Area VII manufacturers.

6. The need to determine the perceived value of nationally recognized occupational skill certification to Iowa Merged Area VII manufacturers.

7. The need to enable and facilitate the revision of the Mechanical Drafting and Design Technology curriculum at Hawkeye Community College to more closely reflect the needs Iowa Merged Area VII manufacturers.

## Research Questions

This study was a survey of selected manufacturers located in Iowa Merged Area VII. The main thrust of the study was to ascertain the perceived educational needs of manufacturers located within the geographic limits of Iowa Merged Area VII.

A secondary thrust of the study was to gain a better understanding of the manufacturing industries themselves in terms of size, utilization of drafting and design personnel; use of computers, networks, CADD, and related technologies; and the application of advanced manufacturing technologies and management techniques. This understanding was developed through the responses to a number of demographic-type research questions that were included in Section 1 ("Your Company") of the survey instrument. The research questions associated with this study were:

1. How many people in Iowa Merged Area VII manufacturing firms perform drafting and design duties?

2. How many people that are performing drafting and design duties are graduates of two-year Associate Degree programs in Mechanical Drafting and Design Technology?

3. To what extent is CADD technology used in Iowa Merged Area VII manufacturing industries?

4. To what extent are manual drafting techniques used in Iowa Merged Area VII manufacturing industries?

5. What type of CADD and associated computer technologies are in use in manufacturing industries in Iowa Merged Area VII?

6. To what extent are advanced manufacturing technologies such as computer numerical control (CNC) machining centers, robots, lasers, and rapid prototyping used in Iowa Merged Area VII manufacturing industries?

7. To what extent are advanced manufacturing management techniques, including the management of quality under the terms of ISO 9000, in use in manufacturing industries located in Iowa Merged Area VII?

8. Based on a review of the literature, should the SCANS skills and competencies be developed within the courses in the revised Mechanical Drafting and Design Technology curriculum at Hawkeye Community College?

9. Do Iowa Merged Area VII manufacturers have any preference regarding the various occupational skill certification programs available through professional organizations?

## Research Hypotheses

The research hypotheses for this study were based on supporting data elicited from the review of the literature. Research hypotheses were not be formulated for Items 1.1 through 1.23 of Section 1 ("Your Company") of the manufacturer version of the survey instrument. This is because these items were addressed by the research questions that were stated in the foregoing discussion.

A single research hypothesis was developed for each individual item in Section 2, Section 3, and Section 4 of both versions of the survey instrument. The specific titles of each of these sections on both versions of the survey instrument were:

1. Section 2--Associate Degree Curriculum Components
2. Section 3--Drafting Practices
3. Section 4--Occupational Skill Certification

Based on the review of the literature, it was hypothesized that there was no significant difference between the means of the responses of Iowa Merged Area VII manufacturers and Iowa State technical educators over each item in Section 2, 3, and 4 of the survey instrument. Thus:

1. For each item in Section 2, Associate Degree Curriculum Components, there was no significant difference between the means of the responses of Iowa Merged Area VII manufacturers and Iowa State technical educators:

$H_1$: $\mu_1 \neq \mu_2$ and

$H_0$: $\mu_1 = \mu_2$.

2. For each item in Section 3, Drafting Practices, there was no significant difference between the means of the responses of Iowa Merged Area VII manufacturers and Iowa State technical educators:

$H_1$: $\mu_1 \neq \mu_2$ and

$H_0$: $\mu_1 = \mu_2$.

3. For each item in Section 4, Occupational Skill Certification (except item 4.9), there was no significant difference between the means of the responses of Iowa Merged Area VII manufacturers and Iowa State technical educators:

$H_1$: $\mu_1 \neq \mu_2$ and

$H_0$: $\mu_1 = \mu_2$.

## Assumptions

The following assumptions were made in the conduct of this research:

1. It was assumed that both versions of the survey instrument could be adequately evaluated for effectiveness by experts selected from among appropriate individuals on the graduate faculty at the University of Northern Iowa. These individuals were Dr. Mohammed F. Fahmy, Professor and Head of the Department of Industrial Technology, and Dr. John W. Somervill, Dean of the Graduate College, both of the University of Northern Iowa, Cedar Falls Iowa. In addition, both versions of the survey instrument were reviewed by members of the candidate's Faculty Advisory Committee and by cognate administrators and instructors at Hawkeye Community College.

2. It was assumed that the manufacturers listed in the most recent version of the Iowa Manufacturers Register constituted a complete and valid listing of manufacturing industries located within Merged Area VII, in the state of Iowa.

3. It was assumed that Department Chairs (or an equivalent entity) at other Iowa community colleges routed the educator version of the survey instrument to the individuals in their departments that were most qualified to execute the survey instrument.

4. It was assumed that the manufacturer version of the survey instrument was executed by one or more individuals in the firm that were most qualified to do so.

5. It was assumed that all individuals executing either version the survey instrument were familiar with the manufacturing-related and technical terminology used in either version of the survey instrument.

6. It was assumed that all individuals executing either version of the survey instrument were, by experience, education, or both, generally familiar with the content of the courses listed in Section 2 of both versions of the survey instrument, based on the stated name of the course.

7. It was assumed that the enumeration of courses in Section 2 (Associate Degree Curriculum Components) of both versions of the survey instrument represented a reasonably complete listing of the courses that would normally be included in an Associate Degree program in Mechanical Drafting and Design Technology.

8. It was assumed that all individuals executing either version of the survey instrument were familiar with the voluntary occupational skill certification programs offered by the professional societies that were listed in Question 4.9.

## Delimitations

A number of factors delimited this research. These factors were:

1. This research was delimited to manufacturers located within Iowa Merged Area VII.

2. This research was delimited to manufacturers that were listed in the Iowa Manufacturers Register.

3. This research was delimited to those selected firms that met the following specific requirements:

a. The firm must have had a square footage listed under the entry entitled "Mfg. Plant" in the Iowa Manufacturers Register. That is, the firm must have had a specific space within its physical plant that is devoted to manufacturing operations.

b. The description of the product(s) in the Iowa Manufacturers Register must have indicated that raw materials, components, parts, or complete products were produced, manufactured, fabricated, assembled, or otherwise processed by the performance of value-added manufacturing operations upon the materials, components, parts or products.

c. The information listed under the entries for "SIC" (Standard Industrial Classification), "Sales," "Employs," and "Distribution" in the Iowa Manufacturers Register was such that it could reasonably be judged by the researcher that the firm employed at least one person that performed the functions normally associated with machine drafting and design.

3. This research was delimited to technical educators at two-year community colleges and technical institutes located within the state of Iowa, who were currently teaching in Mechanical Drafting and Design Technology or closely related programs.

4. The selection of courses listed in Section 2 of both versions of the survey instrument was delimited to those courses that could be taught by the faculty that are currently employed in the Department of Engineering and Technology at Hawkeye Community College.

5. The selection of skill certification programs listed in Section 4 of both versions of the survey instrument was delimited to those programs that are most closely related to manufacturing, engineering technology, and drafting and design technology.

## Definitions of Terms

The following terms are defined to clarify their specific use in the context of this research, and in the conduct of this study.

Advanced manufacturing technology--manufacturing, production, or fabrication technologies characterized by extensive computer integration and automation of the productive process (Goetsch, 1990).

Agile manufacturing firm--a manufacturing firm that exhibits the ability to adapt to, manage, and profit from continuous change; that is capable of quickly responding to rapidly changing markets, and that implements high standards of quality in product and process (McCarty, 1993).

Associate degree--a two-year college degree granted by a community college or technical institute upon completion of a program of study in some occupational area generally regarded as an applied science.

Basic skill--a foundation or supporting skill denoting the achievement of competency in reading, writing, listening, speaking, arithmetic, and mathematics ("What work requires," 1991).

CAD--acronym for computer-aided drafting; an automated method for producing engineering drawings; the representation of an object as an electronic image within a computer system (Freedman, 1991); the final result of the CAD process is a depiction of the object as a digital image stored on magnetic or optical media.

CNC--acronym for Computer Numerical Control; usually used with reference to a machine tool.

Computer numerical control--a form of tooling using an on-board computer to control the motion and actions of a machine through the use of numerical values stored on a suitable medium such as magnetic tape, punched paper tape, or diskette (Seames, 1990).

Competency--a learned performance which can be accurately measured according to a specific predetermined standard, and that is used as an instructional objective in the educational process.

Comprehensive community college--state approved and regionally accredited post-secondary educational institution authorized to grant the Associate Degree in both technical and academic areas.

Culture of quality--the working environment including values, beliefs, and behaviors created within an organization that embraces the principles of total quality at all levels (Goetsch & Davis, 1994).

Custom manufacturing--the manufacture of a relatively broad range of products or components, or groups of similar products or components, in small lots, according to specifications provided by the customer, and usually with relatively long manufacturing cycle time (long lead time) (Goetsch, 1990).

Data literacy--term used by Drucker (1992) to indicate the ability to interact with an information system; includes such factors as knowing what information is required, what the information can be used for, how to use the information, and how to access the information.

Domain-specific--knowledge, skills, and/or competencies that are applicable to a specific occupation, vocation, area, or career.

Employment security--the assurance or guarantee by a company that an individual was employed by the company, but not necessarily in the same job or position.

Factory discipline--the regimen of work imposed upon humans employed in a traditional industrial or manufacturing environment, particularly on a moving assembly line specialized to produce mass quantities of identical parts.

Fixed automation--automated production machinery that is permanently installed, highly specialized to produce mass quantities of a limited range of components, and has high initial cost (Custer, 1993); also called dedicated or hard automation.

Flexible automation--automated production machinery that can produce a moderate volume and variety of parts, and that can rapidly be reconfigured and reprogrammed to produce a new group of parts, usually in small lots, according to design changes and market demands; also called soft automation (Black, 1993; Custer, 1993; Goetsch, 1991).

In-process quality control--quality control procedures applied throughout the manufacturing cycle emphasizing defect prevention rather than defect detection.

Integration--the linking of all parts of the manufacturing operation using computer control, computer communications and networking; and the sharing of various types of databases, including CADD drawings and similar documents that are electronically generated and maintained.

Iowa Merged Area VII--a geographic area consisting of all or portions of ten counties in the state of Iowa whose educational needs are served by Hawkeye Community College.

ISO 9000--international quality certification program developed and administered by the International Organization for Standardization that deals with the management and documentation of quality assurance programs (Lamprecht, 1991).

Job security--the assurance or guarantee by a company that an employee will have the same job or position as long as he or she is employed with that company.

Know-how--the ability to use knowledge, techniques, and tools in the effective and efficient performance of a task (DeVore, 1987).

Knowledge-intensive manufacturing--general term denoting a manufacturing environment in which the productive process is dependent upon the generation, use, and communication of data and information.

Manual drafting--representation of an object on paper plastic film, or other media using traditional pencil-and-paper techniques; the final result of the manual drafting process is a depiction of the object on a physical medium such as paper, mylar film, or other non-electronic media.

Manufacturing cycle--the complete sequence of operations involved in the production of a product, from design inception to delivery of the finished product to the customer; sometimes called design-to-delivery cycle.

Occupational skill certification--(v) the process of determining, usually by written and/or performance examination, whether an individual possesses the knowledge, skills, and competencies necessary to function effectively in a specific occupation; (n) a credential indicating that an individual has been examined, and found to possesses the knowledge, skills, and competencies necessary to function effectively in a specific occupation.

Outsourcing--contracting the manufacture of one or more component parts required in the production of a product to a secondary source outside the primary manufacturing firm. The secondary source is usually independent of the primary manufacturing firm, but may be a subsidiary. True outsourcing occurs when the secondary source is independent of the primary manufacturing firm, and results in a reduction in vertical integration (Cubberly & Bakerjian, 1989).

PAC--acronym for Program Advisory Committee.

Program Advisory Committee--a group composed of representatives from business and industry located within the service area of a community college that advises the college regarding a specific program of study.

Programmable automation--automated production machinery and processes that can be rapidly adapted to produce a wide range of parts, usually in relatively small volumes, and that operates under real-time, digital computer, stored program control in a fully integrated environment (Groover, 1980).

Process-oriented education--an educational process in which creative thinking, problem-solving, visualization, analysis, synthesis, logical reasoning and similar thinking skills are developed within the courses that comprise a technical program or technical curriculum ("What work requires," 1991).

Professional society--an organization of individuals, businesses, and/or industries engaged in the same profession, or related professions, in order to advance the interests of the profession as a whole, and the interests of the individual members of the society.

Program--a group of related courses, consisting of between 64 and 76 semester hours credit, that constitute a curriculum in some occupational area; the successful completion of a program leads to the granting of an Associate in Applied Science Degree in that occupational area.

Rapid response--the ability to reconfigure manufacturing systems to produce products that are in current demand in the marketplace; a manufacturing firm that is capable of bringing a product from design inception to finished product in a short time.

Robotics--the theory and practice of automating tasks that were previously performed by humans (Waldman, 1985); robotics are implemented by using " . . . reprogrammable, multi-functional manipulators designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks" (Asfahl, 1992, p. 132).

SCANS--acronym for Secretary's Commission on Achieving Necessary Skills of the U.S. Department of Labor ("What work requires," 1991).

Self-directed work team--a relatively autonomous, multi-disciplinary group formed to address a specific manufacturing problem, and disbanded after the problem has been addressed.

Service area--a specified geographic area, usually defined by a state entity, whose educational needs are served by a designated community college or technical institute located within that geographic area.

Short cycle manufacturing--the manufacture of a product with greatly reduced manufacturing cycle time.

Technical education--an educational process that emphasizes the applied aspects of traditionally academic subjects, that qualifies an individual for entry-level employment in a specific occupational area, and that leads to the Associate in Applied Science degree in the same occupational area. Also termed vocational-technical education, and more generally known as occupational or career education.

Technical educator--an individual who teaches in a community college or technical institute, and that is licensed by an appropriate state entity to teach in the post-secondary setting, and whose teaching license is endorsed for some technical occupation such as drafting and design technology.

Terminal quality control--quality control procedures based on the inspection of the completed product, and implemented at the end of the production or manufacturing cycle; emphasizes the detection of defects.

Total quality systems--a philosophy of manufacturing management emphasizing continuous improvement or kaizen; high levels of both employee and customer involvement and participation; long-term success through customer satisfaction, and quality at all levels of the organization (Goetsch & Davis, 1994).

Trade association--an organization of industries and related business supporting those industries that is formed for the general purpose of the economic betterment of all concerned.

Traditional manufacturing model--the older mass manufacturing model characterized by dedicated automation, assembly lines, terminal quality control procedures, extreme specialization of labor, and the production of mass quantities of products for mass consumption markets ("What work requires," 1991)

Value-added manufacturing operation--a manufacturing operation that adds to the utility, quality, and marketability, and hence, the price of a product.

Work cell--an automated manufacturing unit composed of at least two workstations that are served by automated loading and unloading equipment and automated material transport devices; and that may incorporate robots for materials handling functions, actual production operations, or both (Waldman, 1985); also called a manufacturing cell.

Workforce--general term denoting all individuals that are directly employed in production, manufacturing, or manufacturing-related activities.

Workplace--general term meaning the actual location where production, manufacturing, or manufacturing-related activities take place; the term is synonymous with, but not limited to, the terms factory, plant, shop, works, or production floor.

Workplace relevance--correspondence between the technical and academic content of a technical program and the needs of the industries employing program graduates.

World-class--general term indicating a high standard of excellence (Bemowski, 1992), craftsmanship, or workmanship; possessing characteristics that enable or facilitate successful competition in the global marketplace.

# CHAPTER II

# REVIEW OF THE LITERATURE

The last quarter century has seen the slow but steady decline of the traditional, centrally controlled, mass manufacturing firm. These businesses are, of necessity evolving into, or being replaced by high-performance, world-class manufacturing firms capable of competing in a global economy ("What work requires," 1991). High-performance firms are those that rely heavily on workers to solve problems, place heavy emphasis on continuous training and life-long learning, promote cooperation between labor and management, and integrate technology into all levels of the productive process (Eisen, 1993).

## Global Socio-economic Change

High-performance world-class manufacturing firms have developed in response to fundamental and sweeping changes in what has become a global business and manufacturing environment (Obi, 1991). Some of the more salient characteristics of the international global business environment are:

1. An increasingly complex manufacturing environment (Eisen, 1993; "What work requires," 1991).

2. Profound social and economic change and restructuring (Banach & Lorenzo, 1993; Barcus, 1992; Cetron, et al., 1988; Koska & Romano, 1988).

3. An atmosphere of constant uncertainty and continuous change in all facets of the business environment (Drucker, cited in Banach & Lorenzo, 1993; Eisen, 1993; "Manufacturing management in crisis," 1992; McCarty, 1993; Saffo, 1989; Wishard, 1987).

4. A high rate of technological change and rapid technological obsolescence (Cetron et al., 1988; "Manufacturing management in crisis," 1992; "Tomorrow's manufacturing technologies," 1992).

5. Relentless competition for a share of international markets (Cetron et al., 1988; "Making things better," 1990; Obi, 1991).

6. A global network of interdependent national economies that are a part of a larger international or global economy (Cetron et al., 1988; Koska & Romano, 1988).

7. Increased demand for more technically sophisticated products (Koska & Romano, 1988).

8. Product quality that is defined by the customer ("ASTD study shows," 1991; Banach & Lorenzo, 1993; Koska & Romano, 1988).

9. A wider range of products for global markets (Banach & Lorenzo, 1993; "ASTD study shows," 1991; Koska & Romano, 1988).

10. More, and more sophisticated, features and options for individual products (Banach & Lorenzo, 1993; Koska & Romano, 1988).

11. Reduced design-to-delivery (or short cycle) manufacturing cycles ("Will the workforce work?," 1992).

12. A shift from mass manufacturing practices to small-lot, custom order, agile manufacturing, utilizing flexible manufacturing management techniques and flexible automation ("Automating solid model," 1994; Oliva, 1991; "Will the workforce work?," 1992).

13. Information exchange and utilization facilitated by the emergence of global computer-mediated communications and networks (Banach & Lorenzo, 1993; Cetron et al., 1988; "Europe's enterprises," 1994; Koska & Romano, 1988; Myers, Wilson, & Lienhard, 1992; Wishard, 1987).

14. Increased emphasis on data literacy and the strategic importance of information ("Automating solid model," 1994; Charp, 1994; Drucker, 1992; Myers et al., 1992; Saffo, 1989).

15. Manufacturing as a significant source of national prosperity and economic well-being, and international competitiveness (Barcus, 1991b; Barcus, 1992; Chowdhury, 1992; Naisbitt & Aburdene, 1990; Ritter, 1992; Wishard, 1987).

## Concomitant Changes in Manufacturing

The effects of these broad or primary changes have diffused throughout the manufacturing sector, producing accompanying secondary changes. The most typical and obvious of these changes are:

1. The continued loss of high-pay, low-skill manufacturing jobs characteristic of traditional manufacturing operations (Cetron et al., 1988; Krugman & Lawrence, 1994; Noaker, 1994; Owen & Sprow, 1994a).

2. Corporate downsizing and massive layoffs of low-skill, high-wage, manufacturing employees, that is, elimination of traditional assembly-line employees (Eisen, 1993).

3. Elimination of middle management jobs (Cetron et al., 1988; Koska & Romano, 1988).

4. A shift away from traditional factory discipline toward more participative roles for workers (Owen & Sprow, 1994a; "What work requires," 1991).

5. A move from employee job security to employment security ("ASTD study shows," 1991).

6. The decline of large manufacturing firms (Cetron et al., 1988; Gray, 1993).

7. The proliferation of small, agile, custom manufacturing firms ("Automating solid," 1994; Cetron et al., 1988; Gray, 1993; Oliva, 1991).

8. A shift away from regarding the human resource as an expense, and toward to regarding it as a competitive asset in manufacturing (Owen & Sprow, 1994c; "What work requires," 1991).

9. The emergence and proliferation of computer-integrated businesses through the union of total quality systems and computer-integrated manufacturing (Brown, Harhen, & Shivnan, 1988).

10. A need for well educated, highly skilled people who constantly upgrade their skills (Eisen, 1993; Findlen, 1994; "Making things better," 1990; Sprow, 1994), and that are " . . . in tune with current trends in industry" (Obi, 1991).

As these changes have evolved, a common and recurring theme has emerged. In today's manufacturing environment the most important, and at the same time the most neglected, element of the productive process is the human asset, that is, the manufacturing worker (Booth, 1992; Chowdhury, 1991/1992; Owen & Sprow, 1994a).

The modern high-performance manufacturing paradigm requires a very different caliber of worker than did industries of just 10 to 20 years ago ("Will the workforce work?," 1992). Progressive companies have come to realize that the key to competitiveness in today's radically changed manufacturing environment is the manufacturing worker ("U.S. workers need," 1990).

Traditional Manufacturing Model

As recently as 10 years ago, the skills required of workers in traditional manufacturing businesses were substantially the same as those required of their predecessors at the beginning of the Industrial Revolution ("What work requires," 1991). Those skills can be summed up in the concept of factory discipline (Kranzberg, 1967).

Under the traditional manufacturing paradigm, factory discipline required that workers have a strong back, a willingness to work, and the education necessary to follow simple verbal or written instructions without thinking ("What work requires," 1991). Individuals with these qualifications were typically employed on assembly lines. The essence of their labor was the production of mass quantities of functionally identical components or products.

This environment, as described in the SCANS report ("What work requires," 1991), was characterized by fixed or dedicated automation, terminal quality control, and extreme specialization of labor. Tasks were highly fragmented (that is, there was an extreme division of labor), and as a result, individual workers had little knowledge of, or concern for, the ultimate quality of the product. On the traditional assembly line, quality was inspected into the product at the end of the production process rather than being built into the product during the production process.

Both the responsibility and the authority for production rested with line supervisors and middle managers. Advancement among the ranks of production employees was essentially a closed system based on seniority. Overall, the manufacturing or production employee was regarded as overhead, that is, as a cost to be added to the price of the final product.

In about the mid 1980s a very different form of manufacturing organization began to evolve in the United States. These businesses were called high-performance manufacturing organizations, and they developed primarily as a result of competition with, and market share loss to Japan and to a lesser extent, Germany ("Making things better," 1990; "U.S. workers need," 1990).

Much of the success of America's competitor nations was due in part to the adoption, particularly by Japan, of the principles of quality espoused by Deming as early as 1950 (Aguayo, 1990). And, it was Deming's quality principles that provided the groundwork for the development of modern manufacturing organizations.

In these organizations, the application of the principles of total quality systems result in the evolution of an entire organizational culture of quality (Goetsch & Davis, 1994; Ritter, 1992) that is dedicated to the continuous improvement of both product and process. This concept of continuous and incremental improvement is termed kaizen (Bemowski, 1992).

In the modern manufacturing organization, quality is not product-focused, rather it is customer-focused. Thus, customer needs, expectations, and satisfaction (Cavallaro, 1991; Kendrick, 1991) define quality, drive the productive process, and are ultimately expressed in the final manufactured product that is delivered to the customer for acceptance.

High-Performance Manufacturing Model

The characteristics of the work environment in high-performance manufacturing organizations are very different from those of the traditional manufacturing organization. This environment requires the effective utilization of people, quality, and technology; a continuous and concentrated focus on the needs of the customer, and includes:

1. Management structures that embrace total quality systems, and form a quality culture within the organization (Ritter, 1992; "Will the workforce work?," 1992).

2. A shift from terminal quality control procedures (inspecting quality into a product at the end of the productive process), to process-based quality control (manufacturing quality into the product during the productive process) ("What work requires," 1991; "Will the workforce work?," 1992).

3. A commitment to customer-centeredness, customer involvement, customer service, and customer satisfaction (Kendrick, 1991; "What work requires," 1991; "Will the workforce work?, 1992).

4. Decentralization of production decision-making with operational decisions being made by self-directed work teams close to the productive process rather than individual supervisors or mid-level managers (Oliva, 1991; "What work requires," 1991; "Will the workforce work?," 1992).

5. A move away from the traditional fixed automation assembly line to flexible automation, robotics, and work cells (Black, 1993; "What work requires," 1991; "Will the workforce work?," 1992), and ultimately to a fully integrated manufacturing environment based entirely on programmable automation and computer communication and control (Custer, 1993; Thacker, 1989).

6. The complete integration of all parts of the manufacturing enterprise; that is, the evolution of a computer-integrated business; full integration is accomplished through the application of computers, computer communications networks, and shared information and databases (Brown et al., 1988; "Europe's enterprises," 1994; "A game of," 1992; Koska & Romano, 1988; Myers et al., 1992).

7. The proliferation of multi-disciplinary and interfunctional work teams on the manufacturing floor, rather than insular individual workers and independent isolated organizational elements (Cetron et al., 1988; "Future factories," 1991; Koska & Romano, 1988; Oliva, 1991).

8. An increasing disparity between the educational needs of the new manufacturing workplace and the educational qualifications of the workforce (Aronson, 1994; Banach & Lorenzo, 1993; Owen & Sprow, 1994a; Tornatzky & Hochgreve, 1993; "U.S. workers need," 1990).

9. Heavy reliance on the intelligence, ingenuity, skills, and work ethic of every employee within the manufacturing organization (Sprow, 1994; "What work requires," 1991).

10. The emergence of both corporate and individual learning, and learning to learn (sometimes called lifelong learning), as a competitive advantage and a survival strategy (Barcus, 1991a; Barrow, 1993; "Calls for," 1993; Findlen, 1994; Gray, 1993; Koska & Romano, 1988, "Lifelong learning is critical," 1993; "Will the workforce work?," 1992).

11. The evolution of small, rapid-response, agile manufacturing firms as the paradigm for current and future high-performance manufacturing organizations ("Automating solid", 1994; Maloney, 1992; "Manufacturing management in crisis," 1992; McCarty, 1993; Norton, 1993).

12. A critical need for the development of knowledge and skills in the foundational areas of communications, group participation strategies, and problem-solving strategies (D. T. Pine, personal communication, March 25, 1994).

## Problems in the Educational System

Today, educators, government, industry, and the general public are faced with an apparent failure of the American educational system (Feldman, 1994). According to some, this failure amounts to nothing less than a national crisis in education (Nelan, 1992). Cetron and Davies (cited in Nelan, 1992) have noted that "in a world whose workers require ever more basic education, technological savvy, and specialized skill, America's schools are the least successful in the Western world" (p. 38).

From scores on national standardized tests to basic entry level academic skills to actual performance in the workplace, American students have demonstrated consistently mediocre performance in areas that most authorities regard as essential for success in the new workplace (Feldman, 1994; Schargel, 1993; "U.S. workers need," 1990). The United States Office of Technology Assessment (cited in "Making things better," 1990) summarized the problem by stating:

> Another problem ripe for action is the poor quality of American education. Industry needs well-educated people, from the shop floor to the design laboratory to the executive suite. As matters stand, the American educational system fails to turn out people capable of handling the growing complexity of knowledge-intensive manufacturing. (p. 3)

Some critics maintain that the failure of the American educational system extends into college level education as well, both in terms of student learning, and in terms of teacher preparation. Bradshaw (1993) states, "the acceptance of mediocrity is rampant in our country and extends from manufacturing to industrial education. Yet, where do we find our educators? Buried deep in thought, like tenured witch doctors, reading the entrails of dead birds" (p. 32).

According to Sinn (cited in "Will the workforce work?," 1992), there is, " . . . little or no coordination among primary and secondary schools, two and four-year colleges and universities, and graduate schools . . . " (p. 49). And Schargel (1993) flatly states that, " . . . there are serious problems in our schools including . . . many high school--and even college--graduates that have inadequate basic skills" (p. 67). However, these problems may in part, stem from an incipient redefinition of the meaning of education in our society.

To some critics, the problem is not that American schools and colleges fail to provide appropriate learning. Rather it is that the traditional process of schooling has come to mean something different than learning, and because of this, the entire educational system must be overhauled. Perelman (cited in Fisher, 1994) maintains that:

> . . . learning and schooling are on a collision course. Report cards, grades, SATs, diplomas, degrees are all phony claptrap . . . the classroom and the teacher have as much place in tomorrow's learning as the horse and buggy in modern transportation . . . for the 20th century and beyond, learning is in, and school is out. (p. 68)

Seymour Papert, Professor of Learning Research at the Massachusetts Institute of Technology Media Laboratory (cited in Fisher, 1994), also advocates overhaul of the educational system. He describes the American educational system as:

> . . . a sleepwalking dinosaur of an institution that lumbers along a set path, more and more out of alignment with the society it thinks it serves and less and less able to channel the energy and vision of teachers who try to work in it. (p. 68)

Papert (cited in Fisher, 1994) further states that "strong dissatisfaction with today's schools is making it impossible to tinker around the edges" (p. 68). Similarly, Koska and Romano (1988) state that it is necessary to "revamp the educational system" (p. 17), and that "massive surgery [on the educational system] is required" (p. 17) to bring about the necessary changes. And, O'Banion (1994) states that, "the quality reformation has called for nothing less than the complete overhaul of education" (p. 25).

Experts and critics of the educational system disagree on both the extent and severity of the problem. Likewise, there is little agreement on how best to address the problem. However, the number of training dollars spent by business and industry clearly indicates that a problem does exist.

By some estimates, the amount of money spent on training in business and industry ranges between 30 Billion dollars and 50 Billion dollars annually (Schargel, 1993;

"Will the workforce work?," 1992). However, these training dollars are not being spent on qualifying American workers to use the high-tech cutting-edge technologies that would provide American industry with a competitive edge in the global marketplace.

In American industry and business, most training dollars are being spent to provide workers with the basic knowledge and skills needed to function in the modern manufacturing environment (Sprow, 1994; "Will the workforce work?," 1992). These are the basic skills and knowledge that should have been, but were not, acquired during the educational process.

Thus, most training dollars spent by industry go toward the remediation of workers. This has been called "closing the skills gap" ("Will the workforce work?," 1992, p. 46).

Not all authorities are certain of the degree of correlation between the level of education and training possessed by workers, their productivity, and the economic performance of employers. However, most authorities do agree that such a correlation exists.

In a recent study (cited in Lewis, 1994a) conducted by the Institute on Education and Training of the RAND Corporation, it was found that education and training do affect economic performance, but that the mode and extent of the effect was indeterminate. Further, the study suggested that economic data do not support the sweeping reform of the nation's educational system that has been espoused by many authorities.

Sturm (1994) states that further research is needed to ascertain the relationship between education and training and productivity. Despite this, most writers still maintain that increased education and training, and education with increased relevance to the modern workplace, are essential prerequisites to increased productivity and economic performance. For example, Sprow (1994) maintains that "skill requirements for those [employed in manufacturing] continue escalating to levels hard to believe" (p. 6).

## Lack of Unified National Policy

Apparently, the issue is not as simple as schools not teaching the necessary knowledge and skills. The situation is exacerbated by the absence of an articulated unified national policy on manufacturing and industrial matters to guide educational efforts ("Who needs government?," 1992).

In competitor nations such as Germany, national policies are in place that link schools and industries. These policies guide the educational establishment toward meeting the needs of industry and business (Mann, 1994; Owen & Sprow, 1994c).

Moreover, America is one of the few progressive countries that has no cabinet-level position in the Federal government to represent the interests of industry, manufacturing, and production (Barcus, 1992). Koska and Romano (1988) regard the creation of such a post as an essential first step in making manufacturing and technology a national priority.

This situation has been addressed to some extent through the formation of alliances such as the National Coalition for Advanced Manufacturing (NACFAM), Skills for Industrial Modernization (SIM), Jobs for the Future (JFF), and the Cooperative Network for Dual-Use Information Technologies (CoNDUIT) among industry, education, and trade associations (Owen & Sprow, 1994b). These coalitions were formed to forge closer relationships between education and industry, and to positively influence public policies regarding international technological and economic competition (Bamford, 1993b).

American industry is in daily global competition with countries such as Japan and Germany, and other nations of the European Community and Pacific Rim. In these competitor nations, the development and maintenance of a strong productive capacity is regarded as a strategic national resource, and is supported by national policy ("Making things better," 1990).

A similar situation exists for education in America's competitor nations. For example, in Japan and Germany education is a nationalized resource in which the education of a world-class manufacturing workforce is a matter of national concern that is expressed in terms of national policies ("Will the workforce work?", 1992).

In contrast, education in America is highly fragmented, locally controlled (Owen & Sprow, 1994b) and lacks both a national focus, and adequate economic support from the Federal government. Sinn (cited in "Will the workforce work?," 1992) has stated that:

1. "[There is] little connection between education and business, though business is education's customer" (p. 49).

2. "[There is] no linkage of math, science, and technology in technical programs" (p. 49).

3. "[There are] obsolete equipment and obsolete instructors on campus" (p. 49).

4. "[There are] inflexible, bureaucratized, and politicized educational structures from state to local levels" (p. 49).

5. "[There are] overlapping and conflicting technical and professional groups, all busy with turf battles rather than useful agendas" (p. 49).

In simplest terms, education has become a competitive resource ("Calls for," 1993) that is essential to the survival and prosperity of both the individual, and the firm employing that individual (Owen & Sprow, 1994a). Thus, there is an explicit need to couple what is taught in schools with the educational requirements of a changing workplace (Bamford, 1993b). That is, vocational-technical educators must strive to develop and maintain a correspondence between the content of their curricula and the requirements of local business and industry (Buzzell, 1994b; Jacobs, 1993).

## Coupling Education and Industry

Historically, there has been a long-standing and mutually beneficial relationship between industry and vocational-technical education. For this reason, vocational-technical education may be uniquely poised to provide a significant part of the educational leadership (Bradshaw, 1993; Buzzell, 1994a; Feldman, 1994) necessary to more effectively couple the educational process to the needs of American industry and business.

Bartels (1994) notes that "a huge gap exists between the needs of employers (especially in manufacturing) and the training received by most high school students" (p. 14), and that "employers and schools must work together to change the way we educate most of our students today" (p. 14). Goldstein (1994) maintains that it is the coupling of the educational process to the needs of industry that will produce a workforce ". . . capable of meeting the demands of the 21st century" (p. 7). Owen and Sprow (1994c) go even further by stating that " . . . teachers and manufacturers must be close partners, not philosophically separated like church and state" (p. 37).

However, the coupling of the educational process to the needs of industry is not a new idea. The modern beginnings of the mutually beneficial relationship between industry and vocational-technical education can be found in Felix Adler's Workingman's School (Herschbach, 1979), and in the early kindergartens that aimed to " . . . foster in the youngest child a spirit of interest and empathy for all industry" (Brooks, cited in Herschbach, 1979, p. 12). This is why that, since the late 1800s, vocational-technical education programs have been one of the mainstays in providing American industry with workers who possess the requisite knowledge and skills for technical work.

Equally important, vocational-technical education programs have provided individuals who have learned to work (Barlow, 1976; Newell, cited in Herschbach, 1992). That is, in vocational-technical programs, students have been taught both specific or occupational skills and life or work skills as well (Hudson, 1994b).

Learning to work means that individuals have been taught the attitudes and ethics necessary for effective industrial work. Both these ideals, learning the skills of work and learning how to work, are crucial components of every present day vocational-technical education program. Moreover, these same ideals are also major components of the modern SCANS model ("What work requires," 1991).

When taught within the context of the knowledge and skills of an appropriate technical domain (Gray, 1993), the SCANS basic, thinking, and personal skills are analogous to the skills of work. Similarly, the five SCANS competencies (resources, interpersonal, information, systems, and technology) are analogous to learning how to work.

The context of, the knowledge and skills required for, and the technology involved in industrial work have all changed dramatically, and will continue to change rapidly for the foreseeable future. However, the fundamental need to teach present and future manufacturing employees both the technical and general skills of work, and how to work, has remained essentially unchanged since the beginning of the Industrial Revolution.

Most institutions delivering vocational-technical education programs already have the advantage of close ties with the consumers of their product, that is, business and industry, through the medium of the Program Advisory Committee appointed for each program. These ties can be used by technical educators to incorporate workplace relevance into technical curricula (Buzzell, 1994b). Bamford (1993a) indicates that the advice and assistance of area industries should be sought in program decisions, industrial laboratory equipment, and similar matters, including curriculum. However, the viability of the Program Advisory Committee as a barometer for technical curriculum content has been questioned (Welsh, 1991). This is, in part, due to the emergence of an international economy, the accelerating progress of profound global socio-economic changes, and the resulting evolution of the high-performance manufacturing workplace as previously discussed.

Traditionally, post-secondary technical institutions have tailored their programs to meet the needs of the firms that hire their graduates (Welsh, 1991). Since large corporate firms tend to be well represented on Program Advisory Committees, Welsh (1991) contends that this may give educational institutions a biased picture of the educational needs of all service area companies. That is, the educational needs of smaller manufacturing companies may be going unmet because these companies are often poorly represented, or not represented at all, on local Program Advisory Committees.

However, most new jobs for graduates of technical programs are not being created by large corporations. Most new technical jobs are being created by small industrial or manufacturing firms (Cetron et al., 1988; Gray, 1993; Welsh, 1991). These smaller manufacturing firms typically employ less than 100 people (Maloney, 1992), and in many cases, as few as 10 people. This is due, in part, to an increase in outsourcing, and in the use of computer-based technologies.

Hence, in the new industrial workplace, Program Advisory Committees can be regarded as only one source of information about the knowledge and skills required of students. In order to ensure that technical curricula are relevant to the workplace, educational institutions need to develop more effective methods of assessing the needs of a broader spectrum of manufacturing employers in their service areas (Gourley, 1990).

Educators must strive to ensure that programs meet the needs of industry, and to ensure that technical curricula are relevant to the rapidly changing needs of the modern manufacturing workplace (Bamford, 1993b; Buzzell, 1994b). This can only be accomplished through the expanded involvement of business and industry in the educational process (Bamford, 1993a; Bamford, 1993b; Buzzell, 1994b; Eisen, 1993; Kennedy, 1993; Welsh, 1991; "What work requires," 1991).

## National Skill Standards

The debate regarding the quality of education in America, and the relevance of that education to the requirements of the modern industrial workplace has given both prominence and impetus to the notion of validation of the educational process through the implementation of national skill standards. According to Hudelson (1993), the purpose of the verification or validation of occupational knowledge and skills, that is, occupational competency, is

" . . . to impose quality control on a field" (p. 32). But, quality control can be accomplished only when established skill standards are used to couple instructional content to workplace needs. Hence, it is this linking of school and work that is the ultimate purpose of occupational skill certification (Lewis, 1994c).

In well developed systems, the possession of recognized occupational skills confers much more than the ability to earn a living. Hudson (1994a) notes that "Recorded history confirms that all civilizations place a high value on occupational skills and believed them to enhance a person's social standing" (p.7). The embedding of social status within occupational skills, usually via the medium of an apprenticeship system, is most notable in the German Meister system (Mann, 1994).

The certification of occupational knowledge and skill is not a new idea, and dates back to the craft guilds of medieval Europe (Mann, 1994). Certification programs in one form or another have been established by industry, government, and professional societies for a number of occupations (Hudelson, 1993). However, in America, the nationwide linking of both basic and domain-specific occupational skill certification as a measurable consequence of the educational process is a fundamental departure from previous practice.

The stimulus for the development of national occupational skill standards is both economic and competitive. Most of America's competitor nations already have national competency-based skill standards in place (Hudelson, 1993; Lewis, 1994b; "Professional Qualifikation [sic]," 1994).

To become and remain competitive in a global economy requires an appropriately educated and skilled workforce (Obi, 1991). The current national initiative to develop and emplace occupational skill standards is intended to facilitate the development of such a workforce (Hudson, 1994b).

There are several advantages that accrue to individual employees in the development and implementation of a national program for the certification or verification of occupational skills. These advantages include ("National skill standards," 1994):

1. Portability of employment credentials.
2. Increased employability.
3. Enhanced job or employment security.
4. More effective recruitment and placement.
5. An easier transition from school to work.
6. A sound base for retraining and life-long learning.
7. A more relevant paradigm for developing curricula.

Piper, Smith, and Wilbin (1994) maintain that occupational skill standards can also provide a number of benefits for technical education institutions and programs. These benefits include (p. 39):

1. Improved program quality.
2. Improved facilities and equipment.
3. Improved student entry-level abilities.
4. Improved instructor technical skills.
5. Provision of worksite mentors.
6. Improved linkages with business and industry.
7. Enhancement of the vocational-technical curriculum.
8. Improved image of vocational-technical education.

The development of occupational skill standards, national or otherwise, requires that government, industry, educational agencies, labor unions, professional societies, and schools work together to determine what skills are required (Hoachlander & Rahn, 1994), and develop technical curricula to meet those needs. Aronson (1994) states that a new spirit of cooperation between industry, academia, and government now exists. However, current efforts in the development of a national skills standards program are only in the formative stage. A commitment to " . . . a national system of occupational and performance standards" (Hudelson, 1993, p. 33) was made by the Executive Branch of the Federal government in December of 1991. That commitment has been renewed in principle by the present (Clinton) administration.

Some Federal legislation to facilitate the development of national occupational skill standards is presently awaiting action ("Goals 2000 bill passes," 1994). One such example is the Goals 2000: Educate America Act ("National skill standards," 1994), now approved by both the U.S. House of Representatives, and the U.S. Senate ("Senate passes," 1994).

This legislation created a National Skills Standards Board to develop occupational skills standards in several industries. However, participation in the program in voluntary rather than mandatory.

Another example is the School to Work Opportunities Act. This legislation includes language to implement national voluntary standards for education (Piper et al., 1994). In addition, a considerable number of Federal grants to study skill certification in a range of occupations have been made to 49 states (Lewis, 1994d), with Federal monies being supplemented by state funds in 34 states. But, by far, the greatest emphasis thus far in occupational skill certification is occurring within the sphere of vocational-technical education.

Lewis (1994d) reports that local school districts are developing occupational skill requirements that are coordinated with the performance standards of vocational-technical programs. These arrangements are generally referred to as articulation agreements, and are made between participating high schools and community colleges.

However, a serious problem in skill standards development for vocational-technical programs is that of faculty ignorance regarding actual conditions in industry. Lewis (1994d) states that "the most severe [problem] is lack of knowledge in both academic and vocational instructional staff of industry needs" (p. 5).

To more effectively prepare for the future, industry, business, trade associations, and professional societies have not waited for the government or the educational system to address the issue. Many manufacturing-oriented trade and industry associations have conducted studies related to predicting future personnel needs.

For example, the Midwest Manufacturing Technology Center of the Industrial Technology Institute at Ann Arbor, MI conducted a study of member companies of the Precision Metalforming Association in the Fall of 1991. One of the results of that study was the recommendation for the development of (Tornatzky & Hochgreve, 1993) " . . . a system of standardized job descriptions and certification standards for all technical jobs nationwide with a centralized data base" (p. 34).

Clearly, American manufacturers have perceived a need for national occupational skill certification in order to remain competitive in the global marketplace. As a result, a number of initiatives are underway in several segments of the private sector to define and implement occupational skill standards programs.

National study panels or alliances have been formed among leaders in professional societies, business, industry, labor unions, and the educational establishment to determine the chief skills required by industrial workers in occupations that demand the use of advanced technologies (Owen & Sprow, 1994b). For example, the Foundation for Industrial Modernization (FIM) has just completed the early phases of a project to develop national voluntary occupational standards for computer-aided drafting and design (CADD) ("CAD standards," 1994); and the Norton Manufacturing Company of Fostoria, OH has been selected as the first national project for the development of skills standards in metalworking (Dobbins, 1995). And, Lewis (1994d) states that, " . . . many trade associations in this country are leading the way globally on setting standards" (p. 4). In addition to national and regional efforts, many smaller, local alliances between industries and educators have been formed to ascertain local industry-specific skill requirements and develop appropriate curricula (Owen & Sprow, 1994a; Sprow, 1994; Templeton, 1994a).

Thus, considerable effort is being expended at the national, state, and local levels, and in the private sector to develop an integrated skills standards program. However, these efforts are largely insular and uncoordinated. Therefore, a concerted and viable program of national occupational skills standards remains to be developed and implemented, and is some years away.

In the short-term, the skill certification programs offered on a voluntary basis by various professional organizations are the most viable path to skill certification for technical students. These organizations include the National Occupational Competency Testing Institute, the Society of Manufacturing Engineers, the American Society for Quality Control, the American Design Drafting Association, the National Association of Industrial Technology, the National Institute for the Certification of Engineering Technicians, and others. However, the value of these programs to individual employees is equivocal.

For example, the Society of Manufacturing Engineers conducted a study of 752 individuals who had attained certification in manufacturing through nationally administered certification examinations. These examinations were developed and administered twice each year by the Society of Manufacturing Engineers (Society of Manufacturing Engineers, 1989).

In this study, individuals who had already attained certified status were asked their opinion regarding the benefits of certification for individuals, the value of certification to the manufacturing community, and their reasons for seeking certified status. With regard to the perceived benefits of certification for individuals, the following results were reported:

| | | |
|---|---|---|
| 1. | Career aid | 73% |
| 2. | Professional development | 80% |
| 3. | Skill documentation | 92% |
| 4. | Commitment to manufacturing profession | 88% |
| 5. | Increased self-confidence | 83% |
| 6. | Peer recognition | 67% |

With regard to the perceived value of certification to the manufacturing community, the following was reported:

| | | |
|---|---|---|
| 1. | Improve public image of manufacturing | 78% |
| 2. | Enhance image of manufacturing | 91% |
| 3. | Enhance manufacturing profession | 93% |
| 4. | Promote individual professionalism | 93% |
| 5. | Provides individual with competitive edge | 75% |
| 6. | Leads to increased productivity | 68% |

With regard to the individual's reasons for seeking certification, the following results were reported:

| | | |
|---|---|---|
| 1. | Personal achievement | 35% |
| 2. | Professional recognition | 32% |
| 3. | Skill validation | 19% |
| 4. | Job promotion | 05% |
| 5. | Obtain employment | 04% |
| 6. | Other | 05% |

Clearly, the perceived personal or individual benefits of certification for the individual employee are significant. However, this study provided no quantitative data regarding the effect of skill certification on acquiring initial employment, aiding individual advancement on the job, obtaining a good initial salary, or securing raises in salary and advancement in position or rank once employed.

A past president of the Society of Manufacturing Engineers has stated (Templeton, 1994b) "the truth is that though many employers do hold it [Society of Manufacturing Engineers Certification] in high regard, many others pay little or no attention to a job applicant's certification" (p. 6). And, the current president of the Society of Manufacturing Engineers (Olling, 1995) recently wrote that, "certification, for example, is a clear form of peer recognition and is becoming more and more the benchmark of manufacturing knowledge and expertise. We must truly accelerate the pace to make that the benchmark in the United States" (p. 8).

Hence, voluntary occupational skill certification appears to be highly valuable to individuals in terms of peer recognition and in the individual's own sense of achievement or accomplishment in his or her occupation ("Why certification is key," 1995). However, the literature is silent regarding the value of voluntary occupational skill certification in terms of hiring preference, promotional preference, or additional financial reward for those individuals possessing or gaining voluntary occupational skill certification.

Thus, despite the considerable and vocal lip service paid to the desirability and importance of skill certification by manufacturing employers, it appears that American industry at large is unwilling to appropriately reward those individuals who have voluntarily attained occupational skill certification offered through a professional organization such as the Society of Manufacturing Engineers.

## SCANS Workplace Skills

The area of educational preparation most discussed and most often cited as deficient is that of the basic skills. White (cited in "Comments on the C-Word," 1993) asserts that "the U.S. will remain industrially competitive only to the extent that it has a workforce trained and educated for the new technological world" (p. 192). The SCANS Report states that the basic skills " . . . lie at the heart of job performance" (p. xv). In a 1993 position paper (cited in Bamford, 1993b), the National Coalition for Advanced Manufacturing stated that basic skills mastery and entry-level qualifications must be documented through an appropriate certification process. And, Booth (1992) maintains that, "the face of competition is infrastructure vs. infrastructure, as opposed to company vs. company, and that requires new skills, training, and learning" (p. 4).

Jacobs (1993) maintains that the technological base of American industry requires " . . . workers who possess a higher level of basic skills" (p. 1). And, a 1990 OTA report ("Making things better," 1990) states that "in the long run a better basic education . . . and early and effective training in math and science . . . " (p. 4) are essential for success in the new workplace. Another OTA report ("U.S. workers need," 1990) maintains that presently employed workers ought to be encouraged to develop basic skills on their own.

Busse (1992) asserts that employees still need basic skills, but that these basic skills alone are no longer adequate for the new workplace. Along with the basic skills must go the new skills such as teamwork, problem-solving, effective communication, and creative thinking; and technical knowledge. Gebo notes that these new skills are based in " . . . brains, not brawn . . . " (p. 47), and that workers will need to " . . . use skills once used by supervisors and managers . . . to think, to negotiate, to communicate, and to lead" (p. 47).

Thurow (cited in Bamford, 1992) maintains that "while technology creates competitive advantage, seizing that advantage requires a workforce skilled from top to bottom"

(p. 4). Hence, employees at every level in a manufacturing organization must possess the new basic skills. Thurow (1993) also speaks to the competitive advantages that accrue from a skilled workforce by saying, "if anyone can buy raw materials, borrow capital, and copy technology, however, what's left as a source of long-run competitive advantage? Skills of your workforce" (p. 176).

Westra (cited in "How to be," 1993) indicates that high-performance manufacturing firms are essentially learning organizations that have developed an educational plan for their workforce. A part of that educational plan must include basic skills and core competencies. However, these skills and competencies are not an end in themselves, but are a prerequisite to mastery of advanced technologies.

According to Friedman (1991), there needs to be a renewed emphasis on traditional skills, that is, reading, writing, and mathematics. However, these older skills must be supplemented by the new basic skills that employers want such as oral communication, statistics, teamwork, listening, negotiating, critical thinking, and problem solving.

Smaller manufacturing firms that are unable to afford a large training budget especially need individuals that are work-ready in terms of the new basic skills (Eisen, 1993). These firms, represented by the National Association of Manufacturers, believe that the level of basic skills in entry-level job applicants is deficient (Eisen, 1993).

Schargel (1993) echoes the importance of basic skills saying, " . . . many high school-and even college-graduates have inadequate basic skills" (p. 67). Gray (1993) notes that the expectations of employers run high, and include both " . . . basic employability skills . . . [and] core literacy skills . . . " (p. 36), and that " . . . basic employability skills and academic skills are the floor requirement for most occupations . . . " (p. 36).

Clearly, basic or core skills are a critical prerequisite to both employment and continued effective functioning in today's workplace. More importantly, these skills form the foundation for the development of the more advanced domain-specific technical skills (Gray, 1993) that are necessary in all technical occupations. Perhaps most important, the presence of well developed basic skills enables employees to rapidly adapt to, and more effectively exploit, the rapid technological change that is inherent in the existing and emerging high-performance manufacturing workplace ("Comments on," 1993; "U.S. workers need," 1990).

The basic skills needed by industrial workers in a variety of manufacturing industries are remarkably similar. According to the 1991 SCANS (Secretary's Commission on Achieving Necessary Skills) study, there are three types of foundation skills that are essential for all workers at all levels in today's high-performance manufacturing environment. These foundation skills are basic literacy skills, thinking skills, and personal skills ("What work requires," 1991).

As described in "What work requires" (1991), the SCANS basic skills, and the definitions of these skills are:

1. Reading--the ability to locate, understand, and interpret written information in text and graphic form.

2. Writing--the ability to communicate thoughts, ideas, messages, and information in textual form, and to create documents such as memos, reports, and graphs.

3. Arithmetic and Mathematics--the ability to perform basic computational tasks, and apply appropriate mathematical techniques to practical problems.

4. Listening--receives, attends to, interprets, and responds appropriately to verbal messages and instructions, and to non-verbal communication as well.

5. Speaking--organizes concepts, thoughts and ideas, and effectively communicates them using the spoken word.

As described in "What work requires," (1991), the SCANS thinking skills, and their definitions are:

1. Creative thinking--generating new ideas.

2. Decision-making--the ability to set goals, recognize constraints, develop options, assess risks, and select the best option.

3. Problem-solving--the ability to recognize the existence of a problem, devise an appropriate plan of action, and implement that plan.

4. Seeing things in the mind's eye--the ability to mentally organize and process objects, graphs, symbols, text, and other information.

5. Knowing how to learn--the ability to use efficient learning strategies and techniques in order to acquire and apply new knowledge and skills.

6. Reasoning--the ability to discover a general rule or principle underlying the relationship between two objects, and to apply the rule or principle in solving problems.

As described in "What work requires," (1991), the SCANS personal skills, and their definitions are:

1. Responsibility--the ability to apply a high level of effort, and persevere toward the realization of established goals.

2. Self-esteem--the quality of believing in the value of self, and maintaining a positive view of self.

3. Sociability--the overt demonstration of the qualities of understanding, friendliness, adaptability, empathy, and politeness in group settings.

4. Self-management--the ability to accurately assess self, set personal goals, and monitor progress; and to exhibit self-control.

5. Integrity/Honesty--the ability to recognize and select the ethical course of action.

The SCANS basic skills in turn form the foundation for the development of several competencies that are essential to success and effectiveness in the new manufacturing workplace. As described in the SCANS document ("What work requires," 1991), the SCANS competencies, and their definitions are:

1. Resources--the ability to identify, organize, plan for, and allocate resources, including time, money, material facilities, and personnel.

2. Interpersonal--the ability to participate effectively as a member of a team, teach others new skills, serve clients and customers, exercise leadership, negotiate, and work with diversity.

3. Information--the ability to acquire, evaluate, organize, maintain, interpret, communicate, and use information; and to process information in a variety of forms using computers.

4. Systems--the ability to understand how complex social, organizational, and technological systems work; to function effectively within those systems, and to monitor and improve system performance.

5. Technology--the ability to work with a variety of technologies, including selection of an appropriate technology, effective application of the selected technology, and the ability to maintain and troubleshoot equipment.

Each of these competencies may be developed in several levels of proficiency ranging from preparatory to specialist.

The foregoing skills and competencies are generally regarded as common-denominator skills and competencies that are desirable in all employees, regardless of occupational title (Owen & Sprow, 1994c). However, it must be remembered that these are general skills and competencies.

Thus, while these general skills may contribute to an individual's work-readiness and on-the-job effectiveness, they cannot by themselves qualify an individual for employment in a technical occupation. Cyert and Mowery (1989) assert that historical evidence shows that technological change increases the value of the basic skills. Hence, as technological change proceeds, the value of the basic skills will continue to increase as well, but only in the context of domain-specific occupational skills. The basic requirement for meaningful employment (Banach & Lorenzo, 1993) in modern manufacturing remains what it was since the time of the Industrial Revolution: technical skills that match the requirements of industry.

Qualification for employment in an occupation is attained only through the mastery of appropriate domain-specific knowledge and skills. As Gray notes, " . . . more technical work does require relevant occupational skills" (p. 36). Hence, the SCANS basic skills and competencies must be " . . . taught and understood in an integrated fashion that reflects the workplace contexts in which they are applied ("What work requires," 1991, p. xv). Moreover, learning the basic skills within the context of a specific occupational domain also contributes to the relevance of the educational process in the eyes of the student (Lerman, 1994), thereby increasing the student's motivation to learn.

## Associate Degree Curriculum Components

The literature search for specific curriculum recommendations for Associate Degree programs in Mechanical Drafting and Design Technology produced scant results. Consultation with Dr. Michael D. Waggoner (personal communication, August 07, 1994), a community college curriculum expert at the University of Northern Iowa, Cedar Falls, IA, both confirmed the general lack of curriculum guidance in the literature, and suggested several alternative sources of curriculum guidance. These were:

1. The specific educational needs of business and industry in the community college's service area.

2. Requirements of State Departments of Education.

3. Requirements of professional societies that accredit vocational-technical programs.

4. Curricula in Mechanical Drafting and Design Technology and closely related programs currently in place in other community colleges in Iowa.

However, both Waggoner (personal communication, August 07, 1994) and Callahan (personal communication, August 02, 1994) indicated that a review of curricula currently in place in other community colleges in Iowa could not be construed as recommended or approved curricular practices. Rather, these programs must be viewed and reported as simply current curricula in place, and used only for purposes of comparison and guidance.

Curriculum Guidance in the Literature

There are few studies that provide specific curriculum recommendations for Associate Degree programs in Mechanical Drafting and Design Technology. However, one of the most current and most useful studies was conducted by Gourley in 1990. Gourley's (1990) study gathered opinion data regarding essential curriculum elements and levels of proficiency in two-year engineering technology programs, one of which was Mechanical Drafting and Design Technology. Respondents to the survey included North Carolina employers, program graduates, and instructors; and out-of-state instructors. 395 questionnaires were mailed and 178 usable responses received, giving an overall response rate of 45%. Gourley (1990) found that survey respondents regarded the following topical areas as essential in an Associate Degree program in Mechanical Drafting and Design Technology:

1. Computer usage
   a. Computer basics
   b. Microcomputer usage
   c. Computer workstation usage
   d. Computer-aided design
   e. Engineering computer applications
2. Mathematics
   a. Metric units
   b. Arithmetic
   c. Algebra
   d. Geometry
   e. Trigonometry
   f. Analytic Geometry
3. Communications
4. Drafting, including computer-aided drafting

Gourley (1990) summarized the results of the study by stating that "from the overall response by all groups, the traditional '3 R's' have, for engineering technicians, become the '3 C's'--computers, computation, and communications" (p. 430).

Needs of Business and Industry

Because of the long-standing and close ties previously described, most vocational-technical curricula are strongly and properly influenced by the industries and businesses that hire the graduates of those programs. Obi (1991) maintains that " . . . whatever is out there in the business world determines what students should know which, in itself, has a direct bearing to the curriculum. The curricular offerings are very much associated with trends in industry" (p. 19).

Most community colleges are careful to align their curricula with the needs of business and industry. This alignment is a strong selling point in attracting high-quality students, as well as in placing graduates.

As an example of the community college's sensitivity and commitment to the needs of business, industry, and other prospective employers, the Hawkeye Community College Catalog (1992-1994) states that "all career preparatory programs offered by the college are committed to being responsive to the employment needs of business, industry, public agencies, and entrepreneurship" (p. 28). Clearly, the current and projected needs of business, industry, and other prospective employers of graduates are a significant source of curriculum guidance for community colleges.

Huer (1990) underscores the influence that industry's needs have upon curriculum by stating, "What do employers want? What do students need? What should educators teach?" (p. 17). As previously pointed out, this influence is most often felt through the medium of the Program Advisory

Committee. However, as documented in foregoing paragraphs, the current trend is one of the expansion of the involvement of business and industry in curriculum decisions at community colleges.

Requirements of State Departments of Education

All vocational-technical programs at community colleges located within the state of Iowa are administered by the State Department of Education. That Department imposes certain minimum educational requirements upon all Associate Degree Programs.

The minimum State Department of Education requirements for Associate Degree vocational-technical programs at Iowa community colleges are (Hawkeye Community College Catalog, 1992-1994):

1. A minimum of 60 semester hours of credit in four semester programs.

2. A minimum of 12 semester hours of credit in general education distributed as follows:

a. 6 semester hours in communications, both oral and written.

b. 3 semester hours in human relations, psychology, or sociology.

c. 3 semester hours in mathematics and science.

Requirements of Accrediting Professional Societies

Professional societies are another important source of curriculum guidance for community colleges. Even if the institution elects not to seek program certification, the curriculum requirements may still be used in whole or in part for curriculum guidance.

Two of the most prominent professional societies that accredit vocational-technical programs in the technologies are the Accreditation Board for Engineering and Technology, Inc. (ABET), and the National Association of Industrial Technology (NAIT). These bodies are typically, but not always, independent affiliates of the parent organization.

The accrediting bodies of professional societies publish standards and requirements that community college programs must meet in order to be recognized as an accredited institution by that body. Accreditation requirements vary considerably with the accrediting body. However, most contain standards for program administration, faculty qualifications, program curricula, course content, and similar matters. The ABET and NAIT accreditation requirements for programs in Mechanical Drafting and Design Technology are discussed below.

ABET accreditation requirements. The ABET curriculum requirements (called curriculum elements) are general in nature. They address curricular areas, course content, and educational outcomes rather than specific course names or minimum semester hours of credit. According to ABET accreditation standards, the curriculum requirements (that is, curriculum elements) for the accreditation of Associate Degree programs in Mechanical Drafting and Design Technology ABET, 1993) must include:

1. Technical sciences--the core of technological knowledge needed to function effectively in a given technical specialty. The recommended basic sciences are physics and chemistry.

2. Technical skills and techniques--knowledge of the skills, methods, and techniques appropriate to a given technical specialty.

3. Technical design courses--well established or standardized practice-oriented design procedures in a specialty area.

4. Technical electives--any related technical courses that support the student's career interests.

5. Mathematics--the mathematics sequence must begin with college algebra, include trigonometry, and culminate with at least an introduction to calculus.

6. Communications--coursework in oral and written English Composition, literature, and especially technical writing.

7. Social Sciences/Humanities--courses which lead to an enhanced appreciation of our rich cultural heritage, the

complexities interpersonal relationships, the relationship between technology and society, and the development of a system of values.

8. Computer literacy--courses which impart a working knowledge of computer usage in the student's specialty area, and that include instruction in one or more of the languages used in engineering technology.

9. Topics in materials or applied mechanics.

10. Sufficient instruction in applied drafting practices, with instruction emphasizing mechanical components and systems.

11. An introduction to computer-aided graphics and design.

12. A course in manufacturing methods.

13. Use of ASME Codes and Standards, or other relevant codes and standards that are appropriate to the student's occupational area.

14. Use of current industrial practices in the student's specialty area.

15. A familiarity with the International System of Units (SI).

NAIT accreditation requirements. The accreditation requirements of the National Association of Industrial Technology (NAIT) are considerably more specific than those of ABET. However, rather than prescribing specific course names, course descriptions, course content, or topical areas of study, the NAIT requirements simply specify a definite number of semester hours of work that must be completed in several traditional and well defined subject areas.

The NAIT accreditation requirements for Associate Degree programs (National Association of Industrial Technology, 1994) are:

1. Communications; 6-8 semester hours.
2. Mathematics; 4-12 semester hours.
3. Physical Sciences; 4-12 semester hours.
4. Technical Subjects; 36-42 semester hours.
5. General electives; 0-10 semester hours.

Current Iowa Community College Curricula

The curricula in Mechanical Drafting and Design Technology and closely related programs currently in place in other community colleges in Iowa can be used as a source for curriculum guidance. However, the limitations of this information must be understood.

Both Waggoner (personal communication, August 07, 1994) and Callahan (personal communication, August 02, 1994) emphasized that curricula currently in place in other community colleges in Iowa cannot be regarded as recommended practices, or as reflecting required practices. However, they may be viewed as contemporary practices, and used for purposes of discussion, comparison, and general guidance.

Catalogs were requested from all 15 of Iowa's community colleges, and were unavailable from three of these institutions at the time this paper was written. Programs leading to the Associate Degree in Mechanical Drafting and Design Technology or closely related programs were available at nine of the community colleges from which general catalogs were received.

The purpose of the catalog review was to discern curriculum content in Associate Degree programs in Mechanical Drafting and Design Technology at Iowa community colleges. Programs leading to certificates or diplomas in closely related areas were also reviewed. The institutions and associated curricula reviewed were:

1. Clinton Community College, Clinton, IA; Technical Drafting and Computer-Aided Design.

2. Hawkeye Community College, Waterloo, IA; Drafting and Design Technology.

3. Iowa Lakes Community College, Esterville, IA; Computer-Aided Drafting and Design.

4. Kirkwood Community College, Cedar Rapids, IA; Mechanical Engineering Design Technology.

5. Marshalltown Community College, Marshalltown, IA; Drafting and Design Technology.

6. Northeast Iowa Community College, Peosta, IA; Mechanical Engineering Technology.

7. Northwest Iowa Community College, Sheldon, IA; Mechanical Engineering Technology.

8. Southeastern Community College, West Burlington, IA; Drafting Technology.

9. Western Iowa Technical Community College, Sioux City, IA: Mechanical Engineering Technology.

The results of the community college catalog review were assembled into a matrix of semester hours of credit required in the various topical areas versus institution as shown below and detailed in Appendix A:

1. Mathematics
2. Sciences
3. General Education
4. Technical Sciences
5. Drafting and Design
6. CAD and Computer Topics
7. Other Cognate Required Topics

A summary of the range of semester hours required in each topical area is presented below.

1. Mathematics--5 to 12 semester hours
2. Sciences--0 to 12 semester hours
3. General Education--6 to 15 semester hours
4. Technical Sciences--0 to 26 semester hours
5. Drafting and Design--9 to 31 semester hours
6. CAD and Computer Topics--3 to 27 semester hours
7. Other Required Topics--0 to 15 semester hours

## Drafting Practices

The most significant portion of the Mechanical Drafting and Design curriculum is that of drafting and design, for this is after all the occupational area in which the student is being educated to work. The area of drafting is also the one that has undergone, and is still undergoing, the most rapid and volatile change (Madsen, Shumaker, Turpin, & Stark, 1991). This change is directly attributable to the introduction and proliferation of computer-based technologies, especially computer-aided drafting (CAD), into high-performance manufacturing operations, and will ultimately lead to the emergence of computer-integrated businesses (Brown et al., 1988).

The importance of CAD to the implementation of computer-integrated manufacturing (CIM), and ultimately the development of computer-integrated businesses cannot be overemphasized. CAD is the single essential stepping stone into many new technologies that are now in use, or just coming into use, in industry (Kashef, 1993). Lamit (1994) calls CAD " . . . the primary CIM integrator for computer-based applications in manufacturing" (p. 58). Thus CAD may be regarded as the common denominator of computer applications in engineering and manufacturing. Hence, CAD enables rather than facilitates the realization of computer integrated manufacturing.

Most new and emerging technologies that impart a significant competitive edge in global markets are CAD-based. For example, rapid prototyping systems, just now coming into wide use in concurrent engineering (CE) in firms seeking manufacturing agility, drastically reduce the time-to-market for a product by reducing the lead time between product conception and prototype development (Sprow, 1992).

These systems require a CAD-generated drawing of the component for every phase of manufacture. Indeed, in these systems there are no alternatives to a CAD-generated drawing because the associated rapid prototyping equipment, usually computer mediated and controlled lasers, requires binary computer files rather than actual paper drawings for their operation (Andrews, 1992; Crump, 1992; Sprow, 1992; Warner, 1993). Because computer-generated and stored information is required for all rapid prototyping and computer integrated manufacturing technologies, a lucrative market now exists for service companies that convert existing traditional paper-and-pencil drawings to CAD-compatible computer files (Mueller & Bex, 1991).

Most cutting-edge manufacturing and manufacturing management technologies are also dependent upon CAD for their operation, and for the efficiencies they impart to the manufacturing process. For example, such technologies as Flow Management Technology (FMT), Total Quality Management

(TQM), Just-In-Time (JIT) inventory management systems, Group Technology (GT), Computer-Integrated Manufacturing (CIM), Statistical Process Control (SPC), Cellular Manufacturing (CM), and Flexible Manufacturing Systems (FMS) all require product specifications in the form of CAD computer files as the initial input into the automated manufacturing system (Eade, 1992; "FMS and the future," 1994).

Clearly, computer technology in general, and CAD in particular, are fundamental and significant forces that are reshaping the way American manufacturers operate in the global business environment. As a result, the sale of CAD software and associated computer systems, equipment, and supplies have "at least doubled or tripled in the last two years" in Merged Area VII (W. Lattimer, personal communication, August 25, 1994).

The steadily increasing use of CAD in industry has trickled down to education as well. For example, a review of the general catalogs of nine of Iowa's community colleges that offer Associate Degree programs in Mechanical Drafting and Design Technology revealed that, in addition to computer basics and computer software applications courses, at least one course in Computer-Aided Drafting is required, and that most institutions required more than one such course.

Moreover, CAD is also being integrated into traditional drafting courses offered at these institutions. However, the adoption of CAD technology by schools and colleges and in educational materials, is occurring more slowly than is the same transition in industry.

Most current textbooks used in traditional manual drafting courses also contain chapters on the principles of automated drafting and the use of CAD software, and extol the benefits of computer technology in drafting. At the same time, these texts also stress the necessity of teaching traditional manual drafting techniques.

For example, Giesecke et al., (1991) assert in their drafting text that "the use of electronic computers today in nearly every phase of engineering . . . is well known. The computer has become an indispensable and effective tool for design and practical problem-solving" (p. 59). However, earlier in the same textbook, Giesecke et al. (1991) state that ". . . the ability to work with computer-controlled drawing techniques requires a thorough knowledge of the graphic language. The engineer or designer who uses a computer for drawing and design work must be proficient in drafting, designing, and conceptualizing" (p. 1).

Similarly, Madsen et al. (1991) emphasize the importance of CAD by stating that "the world of computer graphics is a dynamic, and at times, volatile field. The developments in technique and equipment have advanced rapidly, and the areas of application continue to spread. The drafting applications of CADD are unlimited" (p. 49).

This statement is followed by:

> The drafter must also interpret, visualize, and achieve aesthetic layouts by using mental skills. The use of these two types of skills [mental and manual] has not changed with the advent of computer graphics, but the tools and techniques associated with them has. (p. 50).

This dichotomy is echoed in other standard reference texts on drafting, including Lamit (1994), Spence (1988), and Jensen and Helsel (1992).

The dichotomy between the necessity for CAD to increase productivity and competitiveness, and the desirability of using manual drafting techniques to teach visualization, thinking skills, and drafting discipline has been reflected in the educational establishment. Some educators (Loft, 1993; Schwendau, 1994) maintain that it is important to teach the skill and discipline of drafting first, and the tools of drafting, manual or electronic, second. Others (Kashef, 1994) maintain that the concepts and principles of drafting can be effectively taught using CAD methods rather than traditional manual drafting techniques. Still another approach is to teach both techniques simultaneously (sometimes called concurrent drafting), as it is presented in most modern standard drafting texts as previously cited.

Even in industry, long a bastion of any technology that aids productivity, the dichotomy between the use of CAD versus manual drafting techniques persists. Graber (1992) reports that 80% of all technical drawings are done using manual drafting techniques rather than CAD, even though sales of graphic computer workstations are measured in billions of dollars annually. Further, Graber also states that "most designers involved in conceptualizing new products indicated they prefer pencil and paper over a computer by a ratio of four to one" (p. 30).

Like Giesecke et al. (1991) and Madsen et al., (1991) Graber also maintains that " . . . the drawing board is just as much a mental tool as a tangibility tool" (p. 31). Hence, the issue may not be as simple as a effecting a direct increase in industrial productivity through the installation of automated drafting and design techniques. Rather, it may be that productivity is intimately linked to the individual designer's or draftsperson's most effective and efficient mode of analysis, synthesis, and expression in the mechanical design environment.

The issue of increasing industrial productivity through the automation of drafting and design functions is also being reevaluated and debated. Representative proponents in favor of the widespread adoption of CAD technology and other forms of industrial automation include Weiner (1989), who states "from tennis shoes to jet airlines, there are few industries in the United States not affected by the cost savings, design efficiency, and increased productivity generated by CAD/CAM technology" (p. 16). Similarly, Noller (1991) maintains that "the ability to use the computer to store, retrieve, and update engineering drawings allowed flexibility and cost savings compared to the equivalent paper-based systems" (p. 25). And, Boznak (1994) states:

> Since the industrial Revolution, management has targeted the processes of manufacturing and assembly as its means to extract greater business performance. This trend continued through the 1980s when manufacturers invested heavily in robotics and computer-aided design to improve productivity. (p. 74)

However, the anticipated gains in productivity with the adoption of CAD and other forms of automation have not always been realized. Terrill Woods (cited in Graber, 1992) of the John Deere & Company World Wide Engineering Center indicates that a productivity increase of from 30%-35% was expected with the conversion from manual drafting to CAD drafting systems at John Deere. However, Deere realized only a 10%-15% productivity increase with the adoption of CAD systems.

The maturation of CAD as an occupational endeavor may be indicative of the extent of its use in industry. The length of time that CADD has been available, and the extent to which it has been, and is continuing to be, adopted throughout industry has prompted the Foundation for Industrial Modernization (FIM) to develop voluntary academic and occupational skill standards ("CADD standards," 1994) for the field of computer-aided drafting and design.

# CHAPTER III

# RESEARCH METHODOLOGY

This research was a descriptive study that compared the perceptions of Merged Area VII manufacturers and Iowa technical educators regarding several areas of interest including curriculum, skill certification, and drafting practices. The necessary opinion data were obtained through the use of a survey instrument, and were subjected to appropriate statistical analyses.

## Populations

Two populations were identified for this study. The first population consisted of selected manufacturing industries listed in the Iowa Register of Manufacturers (hereafter called the Register) that also met the additional criteria stated below. The second population consisted of technical educators currently employed at public community colleges or post-secondary technical institutes in the state of Iowa, and who were currently teaching in Mechanical Drafting and Design Technology, or in closely related programs.

### Criteria for Selecting Industry Participants

Due to the construction of the Register, it was necessary to develop a selected population by sorting the entries listed in this publication. This was because the

Register listed all industries throughout the entire state of Iowa that responded to the publisher's request for information.

Thus, the Register was not limited to the manufacturing industries per se that were the intended subject of this study, but included such businesses as grain elevators, retail and wholesale suppliers, construction firms, food processing plants, and other types of non-manufacturing industrial firms. Therefore, it was necessary to sort the entries in order to develop a selected population of firms engaged in manufacturing as defined in this study.

In order to be included in the selected population of manufacturers, a firm had to have met the following criteria:

1. The firm had to be located within the geographic limits of Iowa Merged Area VII. This includes all or portions of Benton, Black Hawk, Bremer, Buchanan, Butler, Chickasaw, Fayette, Floyd, Grundy, and Tama counties.

2. The firm had to be listed in the Iowa Manufacturers Register.

3. The Register entry must have indicated that the firm had specifically designated a portion of its physical plant for the performance of value-added manufacturing operations. This was shown in the Register by the appearance of an entry for square footage under the category "Mfg. Plant" in the narrative description of the business.

4. The description of the product(s) as given in the Register must have indicated that raw industrial materials; or components, parts, or complete products were produced, manufactured, fabricated, assembled, or otherwise processed by the performance of value-added manufacturing operations upon the materials, components, parts or products.

5. The information listed under the entry for "SIC" (Standard Industrial Classification) in the Register must have been such that it could reasonably have been assumed that the firm would employ one or more persons that performed the duties normally associated with mechanical designers or mechanical draftspersons, either on a part-time or a full-time basis.

A total 178 firms located within the geographical boundaries of Merged Area VII were identified by sorting all entries in the Register according to the criteria stated above. Since this selected population was relatively small, it was decided to take a census of all 178 firms that met the selection criteria stated above.

In the case of manufacturers, the survey instrument was mailed directly to the President, Chief Executive Officer, or Chief Operating Officer of the firm, as listed in the Register. As previously stated, the assumption was made that when the instrument was received by the manufacturing concern, it was routed to the individual within the firm most qualified to execute it.

Criteria for Selecting Educator Participants

The specific area of interest in this study was Mechanical Drafting and Design Technology, and closely related programs. Therefore, in order to be included in this study, an educator had to meet the following criteria:

1. The individual had to have been currently employed at a two-year public community college or post-secondary technical institute located within the state of Iowa.

2. The individual had to have been currently teaching in mechanical drafting and design technology, or a closely related program.

Based on conditions at Hawkeye Community College, it was estimated that no more than five appropriately qualified individuals were teaching in Mechanical Drafting and Design Technology or closely related programs in Iowa community colleges and technical institutes. Since there are 15 such institutions, a minimum population of 75 educators was anticipated.

In addition, the appropriate Department Chair (or equivalent entity) at each community college or technical institute was included in the survey. This addition yielded a total estimated educator population of 90. Since this is a relatively small population, a census was taken of all 90 individuals included in the selected population of Iowa educators.

In the case of educators, six copies the survey instrument were mailed directly to the Department Chair (or equivalent entity) at each of the 15 community colleges within the state of Iowa. Instructions included with the survey instrument required the Department Chair (or equivalent entity) to execute one copy of the survey instrument. The other five copies of the survey instrument were routed to those individuals in the department that were judged by the Department Chair (or equivalent entity) to be most qualified to execute the instrument.

## Samples

Two independent samples were used for this research. These samples consisted of survey responses from the selected population of Merged Area VII manufacturing industries (sample name: "Industry", designated $n_1$), and survey responses from technical educators currently teaching at community colleges in the state of Iowa (sample name: "Educator" designated $n_2$).

### Sample Size

Two-tailed $t$ tests for significance were performed on the data derived from Sections 2, 3, and 4 of the survey instrument, except Item 4.9. Therefore, both sample size and disparity between sample sizes were very much a concern in this study.

Witte (1993) indicates that two assumptions are required for a meaningful _t_ test. These assumptions are that both populations are normally distributed about the mean, and that the variances in both populations are equal.

However, Witte (1993) also indicates that these assumptions hold only if sample sizes are approximately equal, and if sample sizes are sufficiently large (greater than 10). This is because equal sample sizes tend to minimize the effects of non-normality and inequality of variance in the parent populations. Therefore, equal sample sizes are preferred. Both sample sizes in this study are well over the minimum of 10, and so were considered to be sufficiently large samples.

Witte (1993) further states that researchers should " . . . beware of unequal variances when the sample sizes are small _and_ unequal [emphasis added]" (p. 412). Since the sample sizes in this study were approximately equal (after adjustment for incomplete responses), and both samples were sufficiently large, the assumptions of normality and equality of variances were presumed to pertain.

## Survey Instrument

In order to conduct this study, the survey instrument for gathering the necessary data was developed in two versions. One version was used for gathering data from Merged Area VII manufacturing industries, and the other version was used for gathering data from Iowa technical educators.

Both versions of the survey instrument differed only in the content of the cover letter, in the instructions for completing each section of the instrument, and in the presence or absence of Section 1 eliciting demographic data from manufacturers. Both versions of the survey instrument were identical in all other respects.

## Research Questions

Research Questions 1 through 7, inclusive, dealing with demographic data on manufacturing firms, were answered by responses to the questions in Section 1 of the survey instrument ("Your Company"). For industry respondents, the questions in Section 1 dealt with actual demographic data regarding company size, number of drafting and design employees, drafting practices, levels of technology in use, and managerial practices. There was no equivalent to Section 1 on the educator version of the survey instrument.

Research Question 8 was answered through a qualitative interpretation of the literature regarding the SCANS skills and competencies. This topic was not covered by the survey instrument in order to keep the length of the instrument to a manageable level, and because the subject was very well documented, both in the popular media and in the professional literature.

Research Question 9 was answered through the determination of simple counts and percentages for Item 4.9 on both versions of the survey instrument. The intent was simply to determine the respondent's preferences regarding specific types of voluntary occupational skill certification programs offered through professional societies. This question also assessed the respondents' degree of familiarity with such programs as well.

## Research Hypotheses

As previously stated, a research hypothesis was established for each of the individual items in Sections 2, 3, and 4 (excluding Item 4.9) of the survey instrument. The null hypothesis that corresponded to the research hypothesis for each item in Sections 2, 3, and 4 (excluding Item 4.9) of the survey instrument was tested by comparing the mean of all industry responses for each individual item with the mean of all educator responses for the same individual item using a two-tailed $t$ test for significance, at the .05 level of significance.

### Section 2--Associate degree curriculum components.

Section 2 of both versions of the survey instrument consisted of 45 identical 5-point Likert-scaled items. Each item named a course that has been traditionally included in the typical Mechanical Drafting and Design Technology curriculum. Respondents were asked to give their opinion regarding the importance of each course listed in order to determine the courses that ought to be included in a two-year Associate Degree program in Mechanical Drafting and Design Technology.

Section 3--Drafting practices. Section 3 of both versions of the survey instrument consisted of 13 identical 5-point Likert-scaled statements related to how drafting is actually being performed in industry, and how the respondents believe it ought to be taught in two-year Associate Degree Programs in Mechanical Drafting and Design Technology. Respondents were asked to indicate their degree of agreement or disagreement with each of the 13 statements in this section.

Section 4--Occupational skill certification. Section 4 of both versions of the survey instrument consisted of eight identical 5-point Likert-scaled statements (except Item 4.9) relating to the value that respondents placed upon occupational skill certification for entry-level technical employees. Respondents were asked to indicate their degree of agreement or disagreement with each of the eight statements in this Section of the instrument.

Item 4.9 on both versions of the survey instrument was a multiple choice question consisting of nine possible responses, with only one response allowed. Each of six possible responses listed specific occupational certification programs offered by a professional technical society. Other options addressed the necessity for certification, no preference in type of certification, and no familiarity with the occupational certification programs listed.

Survey Instrument Review

Both versions of the survey instrument were reviewed by two individuals that were selected from among the faculty of the Graduate College at the University of Northern Iowa, Cedar Falls, Iowa. The individuals agreed to review the survey instrument were:

1. Dr. Mohammed F. Fahmy, Professor and Head, Department of Industrial Technology.

2. Dr. John W. Somervill, Professor of Psychology and Dean of the Graduate College.

The reviewers recommended several minor changes in the format of the survey instruments, and also made recommendations regarding changes necessary to increase the effectiveness of the instrument. All changes recommended by the reviewers were incorporated into the appropriate version of the survey instrument.

In addition, both versions of the survey instrument were reviewed by the candidate's Faculty Advisory Committee and cognate administrators and instructors at Hawkeye Community College. This review included an evaluation of the listing of courses included in Section 2, a qualitative evaluation of all questions in Sections 3 and 4, and an overall evaluation of appearance, expression, and readability. No significant discrepancies were noted by these individuals.

## Conduct of the Survey

The survey was conducted by a combination of mail and telephone techniques. The initial mailing of the instrument occurred on December 01, 1994. Respondents were asked to return the completed instrument not later than December 23, 1994. Pre-addressed postage-paid return envelopes were provided for the convenience of all respondents and to increase the response rate.

Because non-responses tend to yield data closer to the true population mean than do initial responses (Futrell, 1994), a follow-up was conducted by telephone. This method optimized effectiveness in eliciting responses.

A single telephone follow-up of non-respondents was conducted ten days after the cut-off return mailing date of December 23, 1994, on January 4-6, 1995. Due to time constraints imposed by the curriculum development process at Hawkeye Community College, a second telephone follow-up of non-respondents could not be conducted.

## Survey Response

Of the 178 survey instruments mailed to Merged Area VII industries, a total of 87 responses were returned, yielding a response rate for industry participants of about 49%. However, only 65 of these were usable due to incomplete data. Hence, the effective industry response rate was 37%.

Of the 90 survey instruments mailed to Iowa State vocational-technical educators, a total of 64 were returned, giving a response rate for Iowa State vocational-technical educators of 71%.

### Incomplete Responses

No incomplete survey instruments were received from Iowa vocational-technical educators. However, of the 87 responses received from Iowa Merged Area VII manufacturers, 21 were significantly incomplete in one or more sections. Since incomplete data may skew the results of statistical analysis, all incomplete survey instruments were discarded (S. A. Smaldino, personal communication, March 17, 1995).

## Analysis Methods

Portions of the data acquired from the survey were subjected to qualitative descriptive analysis using counts and percentages. Other portions of the data were subjected to statistical analysis using means and/or medians, the *t* test, Pearson Product Moment Correlation Coefficient, standard deviation, and computed level of significance. The analysis of the data derived from the study, presented by section of the survey instrument, is described in the following text.

Section 1--Your Company

This section was completed only by Merged Area VII industry respondents. This was the only portion of the survey instrument that was not identical for both samples, since educators could not reasonably be expected to respond to the items in this Section that were intended to elicit demographic data for industry respondents. The data in this Section were analyzed by determining simple counts, percentages, and measures of central tendency.

Section 2--Associate Degree Curriculum Components

This section was entitled "Associate Degree Curriculum Components" on both versions of the survey instrument. The data in this Section were analyzed in part by determining simple counts, percentages and measures of central tendency for both industry respondents and educator respondents.

In addition, the Pearson Product Moment Correlation Coefficient was determined for each item in this Section. The mean of the responses of both samples, the standard error of the mean, and the pooled variance estimate for each item was also determined for both industry and educator respondents. The means were then compared at the .05 level of significance using a two-tailed t test to detect any significant difference between the responses of industry participants versus the responses of educator participants.

Section 3--Drafting Practices

This Section was entitled "Drafting Practices" on both versions of the survey instrument. The data in this Section were analyzed in part by determining simple counts, percentages, and measures of central tendency for both industry respondents and educator respondents.

In addition, the Pearson Product Moment Correlation Coefficient was determined for each item in this Section. The mean of the responses for each sample, the standard error of the mean, and the pooled variance estimate for each item was also determined for both industry and educator respondents.

The means were then compared at the .05 level of significance using a two-tailed t test to detect any significant difference between the responses of industry participants versus those of educator participants.

Section 4--Occupational Skill Certification

This Section was entitled "Occupational Skill Certification" on both versions of the survey instrument. The data in this Section were analyzed in part by determining simple counts, percentages, and measures of central tendency for both industry respondents and educator respondents.

In addition, the Pearson Product Moment Correlation Coefficient was determined for each item in this Section. The mean of the responses for each sample, the standard error of the mean, and the pooled variance estimate for each item was also determined for both industry and educator respondents.

The means were then compared at the .05 level of significance using a two-tailed $\underline{t}$ test to detect any significant difference between the responses of industry participants versus those of educator participants.

# CHAPTER IV

# RESULTS AND DISCUSSION

The results of the statistical analysis of the data are reported below. In addition, these implications of these for curricula in Mechanical Drafting and Design Technology are also covered.

## Results for Section 1--Merged Area VII Industry Demographics

Because the data derived from Section 1 was used to develop a general descriptive profile of manufacturing industries in Merged Area VII, it was not subjected to statistical analysis. Rather, these data were treated with simple counts, percentages, and measures of central tendency.

Section 1 of the industry version of the survey instrument was intended to provide educational planners with a descriptive characterization of the industries located in Iowa Merged Area VII. The results of the analysis are summarized and presented in Tables 1-11.

Items 1.1-1.9 and items 1.18-1.23 were characterized by measures of central tendency (means, and in some cases, medians). The results for these items are summarized in Tables 1, 2, and 11. Items 1.10-1.17 were characterized using counts and percentages, and are summarized and presented in Tables 3-10.

Table 1

Survey Items 1.1-1.9, Industry Demographic Data

| Item | Content | maximum | minimum | mean |
|---|---|---|---|---|
| 1.1 | Number of employees | 3,700 | 3 | 156 |
| 1.2 | Drafters/designers | 50 | 0 | 5 |
| 1.3 | Associate degree graduates | 20 | 0 | 2 |
| 1.4 | Work at drawing board | 7 | 0 | 1 |
| 1.5 | Work at CADD station | 20 | 0 | 4 |

Table 1 summarizes items 1.1-1.5 of the industry version of the survey instrument. These items were related to company size and employment in drafting and design. Clearly, larger companies employ more individuals as draftspersons and designers. Moreover, in the average Merged Area VII manufacturing industry, only seven individuals worked at a drawing board, while 20 performed their drafting or design work at a computer (CADD) workstation.

Table 2 covers items 1.6-1.9 of the industry version of the survey instrument. These data demonstrate that the average manufacturing firm in Merged Area VII employs flexible manufacturing technologies such as work cells, robots, and CNC machining centers. Hence, it would be appropriate to ensure that instruction includes at least an introduction to these topics.

Table 2

Survey Items 1.6-1.9, Manufacturing Technologies

| Item | Content | maximum | minimum | mean |
|---|---|---|---|---|
| 1.6 | CNC machine tools/centers | 40 | 0 | 5 |
| 1.7 | Lasers in use | 1 | 0 | 0 |
| 1.8 | Robots in use | 25 | 0 | 1 |
| 1.9 | Manufacturing cells in use | 25 | 0 | 3 |

Table 3 covers the type of CADD platform in use in Merged Area VII manufacturing Industries. When the 29% of Merged Area VII industries that do not use CADD technology for drafting were discounted, it was found that 97% of the manufacturing industries surveyed employed the personal computer for use as a CADD platform. Hence, the educational practices in use at community colleges and technical institutes would be in consonance with current Merged Area VII industry practices if CADD instruction was based on the personal computer platform rather than on mainframe computer, minicomputer, or engineering workstation computers.

Table 3

Survey Item 1.10, Type of CADD Platform

| Platform Type | number | % |
|---|---|---|
| None (CADD not in use) | 25 | 29 |
| Personal computer workstation | 60 | 69 |
| Mainframe computer | 2 | 2 |
| Engineering workstation | 0 | 0 |
| Minicomputer | 0 | 0 |

Table 4 lists data about the type of Personal Computer (PC) platform used for CADD applications in Merged Area VII

Table 4

Survey Item 1.11, Personal Computer (PC) CADD Platform Type

| PC Platform Type | number | % |
|---|---|---|
| Not applicable (CADD not in use) | 27 | 31 |
| IBM or compatible PC | 55 | 63 |
| Apple Macintosh | 0 | 0 |
| Mix of IBM/compatible and Macintosh | 5 | 6 |
| Other | 0 | 0 |

manufacturing industries. When the 27 industries reporting that CADD was not in use were discounted, it was found that 92% of Merged Area VII industries used IBM or compatible personal computers as their CADD platform. Clearly, community colleges and technical institutes would be well advised to base CADD instruction on the IBM (or IBM compatible) personal computer platform.

Table 5 shows the extent to which Merged Area VII manufacturing industries had their CADD facilities linked via a local area network. When the data in Table 5 were adjusted to reflect the 27 industries that did not use CADD, it was found that 57% of the Iowa Merged Area VII manufacturing industries surveyed did not have their CADD facilities linked by a local area network. The conclusion was drawn that these industries probably did not have a

Table 5

Survey Item 1.12, CADD Facilities Networked

| Networking extent | number | % |
|---|---|---|
| Not applicable (CADD not in use) | 27 | 31 |
| Not networked | 34 | 39 |
| Partially networked | 12 | 14 |
| Totally networked | 14 | 16 |

sufficient number of CADD workstations to justify the expense of installing a local area network.

The data in Table 6 indicate the extent to which CADD facilities were linked to computerized production equipment on the shop floor. When the 46% of industries reporting neither CADD nor CNC production equipment in use were

Table 6

Survey Item 1.13, Networking of CADD/CNC Facilities

| Networking extent | number | % |
|---|---|---|
| NA (CADD and/or CNC not in use) | 40 | 46 |
| Not networked | 19 | 22 |
| Partially networked | 20 | 23 |
| Totally networked | 8 | 9 |

discounted, it was found that 60% of Iowa Merged Area VII manufacturing industries had their CADD facilities partially or totally linked to computerized production equipment on the shop floor. The data implied that these industries probably had a sufficient number of both CADD workstations and CNC machining centers to justify the expense of installing a local area network.

Table 7 presents data concerning the type of CADD software in use in Iowa Merged Area VII manufacturing industries. When the 26% of industries that reported no CADD software in use were discounted, it was determined that

Table 7

Survey Item 1.14, CADD Software in Use

| Software | number | % |
|---|---|---|
| None (CADD not in use) | 23 | 26 |
| Auto CAD | 41 | 49 |
| Generic CAD | 4 | 5 |
| Pro/Engineer | 4 | 5 |
| Cadam | 3 | 3 |
| CAD Max | 3 | 3 |
| Shop CAM | 3 | 3 |
| All other | 6 | 6 |

64% of the industries reporting used AutoCAD software. Since AutoCAD software is generally regarded as an industry standard for CADD, drafting and design courses that are based on AutoCAD software would appear to best meet the needs of the majority of Iowa Merged Area VII manufacturing industries. Curricula in Mechanical Drafting and Design at

Iowa community colleges would, therefore, be in consonance with the needs of industry if CADD instruction were based on AutoCAD software.

Table 8

Survey Item 1.15, Rapid Prototyping Technology in Use

| RP Technology | number | % |
|---|---|---|
| None | 81 | 93 |
| Selective Laser Sintering (SLS) | 2 | 2 |
| Stereo-lithography (STL) | 4 | 5 |
| Fused Deposition Modeling (FDM) | 0 | 0 |
| Laminated Object Manufacture (LOM) | 0 | 0 |

The data in Table 8 shows the extent to which rapid prototyping technologies are in use in Iowa Merged Area VII manufacturing industries. These data indicate that 93% of the industries reporting did not use rapid prototyping technology. Of the six companies that reported using this advanced manufacturing technique (rapid prototyping), two used selective laser sintering (SLS), and four used stereo-lithography (STL).

The data reported in Table 8 appear to support the conclusion that the majority of manufacturing industries in

Iowa Merged Area VII are not presently using rapid prototyping technology to a significant extent. Moreover, it should be remembered that these are emerging technologies that will be perfected over time, and whose cost will be reduced as the technology is improved. Hence, curriculum decision makers in community colleges and technical institutes should consider incorporating instruction in rapid prototyping technology only as the technology moves more toward the mainstream of manufacturing processes.

Table 9

Survey Item 1.16, ISO 9000 Certification Status

| Certification Status | number | % |
|---|---|---|
| Not certified | 43 | 49 |
| Considering certification | 18 | 21 |
| Certification in progress | 14 | 16 |
| Certified | 12 | 14 |

Table 9 presents data regarding certification under the ISO 9000 quality standard. These data indicated that only 12% of the manufacturing industries in Iowa Merged Area VII are actually certified under ISO 9000. However, these data also showed that 37% of the industries reporting were either considering certification under ISO 9000 or that certification was in progress. Hence, curriculum decision makers at community colleges and technical institutes may wish to consider including instruction in the ISO 9000 quality standard in Mechanical Drafting and Design Technology programs. This is particularly true since certification under ISO 9000 is generally regarded as either highly desirable, or is a definite prerequisite for, manufacturing companies doing business in most parts of Europe, Asia, and the Pacific Rim.

Table 10

Survey Item 1.17, ISO 9000 Certification Standard

| Standard | number | % |
|---|---|---|
| Not applicable | 43 | 49 |
| ISO 9001 | 35 | 41 |
| ISO 9002 | 9 | 10 |
| ISO 9003 | 0 | 0 |

Table 10 presents data regarding the specific ISO 9000 standard under which some Merged Area VII industries were certified, seeking certification, or considering certification. None of the industries were certified under

ISO 9003, and 51% were certified under ISO 9001 or 9002. Hence, instruction in Mechanical Drafting and Design Technology programs at community colleges should be centered around ISO 9001 and ISO 9002.

Table 11 summarizes and presents the data gathered regarding the frequency of use of contemporary manufacturing management techniques that are characteristic of high-performance manufacturing firms. The median score was used to facilitate adjective description. For other than

Table 11

Survey Items 1.18-1.23, Manufacturing Management Practices

| Item | Practice | $\mu$ | M | Adjective |
|---|---|---|---|---|
| 1.18 | CADD used for mech draft/des | 3.72 | 4.00 | Usually |
| 1.19 | Concurrent engineering meth | 2.69 | 3.00 | Frequently |
| 1.20 | Just-in-Time inventory mgt | 3.93 | 3.00 | Frequently |
| 1.21 | Competitive benchmarking | 2.38 | 2.00 | Seldom |
| 1.22 | Self-directed work teams | 2.90 | 3.00 | Frequently |
| 1.23 | Flow management technology | 2.41 | 2.00 | Seldom |

1.18, CADD technology, 1.21, competitive benchmarking, and 1.23, flow management technology, these data indicate that most Merged Area VII manufacturing firms were frequent users of contemporary high-performance manufacturing management techniques such as concurrent engineering methods, just-in-time inventory management techniques, and self-directed multidisciplinary work teams. Merged Area VII manufacturers reported that competitive benchmarking and flow management technology were seldom used manufacturing management techniques.

Based on the results of this study, it would be appropriate to include instruction in concurrent engineering methods, just-in-time inventory management techniques, and team dynamics in two-year technical programs. Because competitive benchmarking and flow management are generally regarded as mainstream manufacturing management technologies, it would also be appropriate to include these topics as well, even though Merged Area VII manufacturers reported that they were seldom used.

## Results for Section 2--Associate Degree Curriculum Components

The mean of industry respondents was compared to the mean of educator respondents for each item in this section using a two-tailed $t$ test for independent samples at the .05 level of significance. If the results of the $t$ test demonstrated no statistically significant difference between the industry mean and the educator mean for a given item at the .05 level of significance, then the null hypothesis was retained.

Retention of the null hypothesis was interpreted as indicating significant agreement between industry and educator participants regarding the importance of the course in a Mechanical Drafting and Design Technology curriculum. In this case, the course was retained for possible inclusion in the Mechanical Drafting and Design Technology curriculum at Hawkeye Community College.

Conversely, rejection of the null hypothesis at the .05 level of significance was interpreted as indicating that the null hypothesis ought to be rejected, and the alternative hypothesis accepted. This outcome was taken to mean that there was statistically significant disagreement between industry and educator respondents regarding the importance of the course in a Mechanical Drafting and Design Technology curriculum. Therefore, the course was excluded from further consideration for inclusion in the curriculum.

This section of the survey instrument aided in determining the specific courses that ought to be included in curricula in Mechanical Drafting and Design Technology. All 45 items on both versions of the survey instrument were presented to participants in random order to minimize any bias in subject matter area. However, for convenience and coherence, these items are presented in tabular fashion, and in several broad categories as shown below.

| | | |
|---|---|---|
| (1) | General Technology | See Table 12 |
| (2) | Mathematics | See Table 13 |
| (3) | Computer and CADD | See Table 14 |
| (4) | Sciences | See Table 15 |
| (5) | English and Communication | See Table 16 |
| (6) | Social Science/Work Skills | See Table 17 |
| (7) | Technical Sciences | See Table 18 |
| (8) | Engineering Mechanics | See Table 19 |
| (9) | Drafting and Design | See Table 20 |
| (10) | Manufacturing Technology | See Table 21 |

Each area is reported in a separate table, Tables 12-21 inclusive, as shown below.

Category (1)--General Technology

This curricular area included general, introductory, or survey courses in technology. At the associate degree level, these courses are typically introductory in nature, and have few, if any, prerequisites.

In community colleges, the topics for these courses may include an introduction to the various fields in engineering technology, development of study skills, expansion of the student's technical vocabulary, development of desirable workplace skills, and a review of critical technical areas such as a review of pertinent topics from algebra, geometry, and trigonometry; vectors, units and dimensional analysis; and principles of physics.

Table 12

Category (1)--General Technology

| Survey Item | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_o$ |
|---|---|---|---|---|---|---|---|
| 2.1 Funds of Sci/Tech | 3.30 | 3.00 | 1.06 | -.072 | 1.73 | .085 | Ret |
| 2.2 Tech & Society | 3.05 | 2.31 | .916 | -.005 | 4.55 | .000 | Rej |

Note. $n_1 = 65$; $n_2 = 64$; $df = 127$; $t_{crit} = \pm 1.980$.

The data in Table 11 indicate that Item 2.1, Fundamentals of Science and Technology had the higher mean (3.30) of the two items in this section. Further, $H_o$ was retained for this item, meaning that there was no statistically significant difference between the means of industry and educator respondents. Hence, a course in the Fundamentals of Science and Technology ought to be included in two-year technical programs.

Conversely, $H_o$ for Item 2.2 was rejected (and $H_1$ accepted). Thus, there was a statistically significant difference between the means of industry and educator respondents. This was interpreted as meaning that a course in Technology and Society ought not to be included in a two-year program in Mechanical Drafting and Design Technology. However, such a course may provide an ideal integrating experience for students in technology programs in colleges and universities.

Category (2)--Mathematics

Table 13 summarizes the data regarding mathematics courses. $H_o$ was rejected (and $H_1$ accepted) for Item 2.3, College Algebra, indicating that there was a statistically significant difference between the means of industry and educator respondents regarding the importance of a course in college algebra. Therefore, these data imply that a course in college algebra ought not to be included in curricula in Mechanical Drafting and Design Technology.

Table 13

Category (2)--Mathematics

| Survey Item | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_o$ |
|---|---|---|---|---|---|---|---|
| 2.3 College Algebra | 3.68 | 4.16 | 1.05 | -.024 | -2.59 | 0.011 | Rej |
| 2.4 College Trig/Geom | 3.80 | 4.06 | 1.15 | -.230 | -1.30 | 0.200 | Ret |
| 2.5 Applied Math | 4.12 | 4.31 | .864 | .138 | -1.25 | 0.220 | Ret |

Note. $n_1$ = 65; $n_2$ = 64; df = 127; $t_{crit}$ = ±1.980.

$H_0$ was retained (and $H_1$ rejected) for Item 2.4, College Trigonometry and Analytic Geometry, and Item 2.5, Applied Mathematics. This indicates that there was no statistically significant difference between the means of industry and educator respondents for both these items. Hence, these data imply that these courses should be considered for possible inclusion in two-year Mechanical Drafting and Design Technology programs at community colleges.

These data also show that Item 2.5, Applied Mathematics had the highest mean for both industry and educator respondents. Clearly, both groups preferred fundamental applied mathematical courses over more theoretical courses. Moreover, a course in college algebra is usually the minimum prerequisite for a course in college trigonometry and analytic geometry.

Based on this, Item 2.4, College Trigonometry and Analytic Geometry was eliminated from further consideration for inclusion in two-year Associate Degree curricula in Mechanical Drafting and Design Technology at community colleges. Further, a single intensive course in applied mathematics may be more appropriate in four-semester technical programs considering the limited amount of time available in such programs. Therefore, based on the data in this study, a single course in Applied Mathematics ought to be included in two-year Associate Degree programs in Mechanical Drafting and Design Technology.

Category (3)--Computer and CADD

Table 14 summarizes the data for survey Items 2.6, Computer Software Applications, 2.7, Computer-Aided Drafting and Design, and 2.8, Computer-Integrated Manufacturing. $H_o$ was rejected (and $H_1$ accepted) for Items 2.6 and 2.7. This was interpreted as meaning that the difference between the means for industry respondents and educator respondents was statistically significant for these two survey items, even

Table 14

Category (3)--Computer and CADD

| Survey Item | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_o$ |
|---|---|---|---|---|---|---|---|
| 2.6 Computer Software Apps | 3.46 | 3.84 | .942 | -.046 | -2.31 | .023 | Rej |
| 2.7 CADD | 4.25 | 4.75 | .833 | -.034 | -3.44 | .0008 | Rej |
| 2.8 CIM | 3.49 | 3.84 | 1.07 | -.158 | -1.86 | .066 | Ret |

Note. $n_1$ = 65; $n_2$ = 64; df = 127; $t_{crit}$ = ±1.980.

though the means clearly indicated that both groups of respondents considered computer and computer-related topics to be important. Therefore, based on the data gathered in this study, courses in these topics should be excluded from two-year Mechanical Drafting and Design Technology programs.

$H_0$ was retained (and $H_1$ rejected) for Item 2.8, Computer Integrated Manufacturing, indicating that the difference between the means for industry respondents versus educator respondents was not statistically significant. Hence, these data imply that a course in Computer Integrated Manufacturing ought to be included in two-year Associate Degree programs in Mechanical Drafting and Design Technology.

The data gathered in this study regarding computer-aided drafting and design were anomalous, and were contradictory to mainstream thought regarding this curricular area. This is because as noted in Chapter 2, virtually all authorities agree that computer-aided drafting is a crucial topic for drafting and design students because these students will be expected to use CADD in their jobs. Moreover, CADD is also a gateway technology, leading to many other types of computer-intensive manufacturing technologies. CADD skills would prepare students to use these advanced technologies, and thus would also increase employability and promotability.

The data for Item 2.7, Computer-Aided Drafting and Design, seems to indicate that both industry and educator respondents agreed upon the importance of instruction in CADD. However, it appears that industry and educator respondents differed significantly regarding the degree of importance of a course in CADD when this was compared with the other courses listed in Section 2 of the survey. Further, these data may also be indicative of the need for a more integrated approach to computing technology in the educational experience. Such an integrated approach would parallel the integration of computing technology in the modern manufacturing workplace. Hence, this curricular area requires further study and evaluation, and should be explored in greater detail in future studies related to technical curriculum development for programs in Mechanical Drafting and Design Technology.

Category (4)--Sciences

Table 15 summarizes and presents the data gathered regarding courses in the sciences. $H_0$ was retained (and $H_1$

Table 15

Category (4)--Sciences

| Survey Item | | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_0$ |
|---|---|---|---|---|---|---|---|---|
| 2.9 | Survey of Phys Sci | 2.83 | 2.72 | .939 | -.088 | 0.68 | .500 | Ret |
| 2.10 | Tech Phys | 3.23 | 3.63 | .907 | .359 | -2.47 | .015 | Rej |
| 2.11 | Appl Sci: Phys/Chem | 3.06 | 3.28 | 1.03 | .043 | -1.21 | .230 | Ret |

Note. $n_1$ = 65; $n_2$ = 64; df = 127; $t_{crit}$ = ±1.980.

rejected) for Items 2.9, Survey of Physical Sciences and Item 2.11, Applied Science: Physics and Chemistry. This indicated that there was no statistical difference between the mean for industry respondents versus the mean for educator respondents. Hence, either or both of these courses would be suitable for inclusion in most two-year programs in Mechanical Drafting and Design Technology.

Item 2.11, Applied Science: Physics and Chemistry had the higher mean of the two for both industry and educator respondents. Therefore, this course would be the optimal choice for two-year technical curricula containing a single course in the applied sciences.

$H_0$ was rejected (and $H_1$ accepted) for Item 2.10, Technical Physics, meaning that there was a statistically significant difference between the mean of industry respondents versus the mean of educator respondents. Hence, this course was not recommended for inclusion in two-year Associate Degree programs in Mechanical Drafting and Design Technology at community colleges.

Category (5)--English and Communication

Table 16 summarizes and presents the data gathered relative to courses in English and Communication. $H_0$ was rejected (and ($H_1$ accepted) for Item 2.12, Technical Writing. This meant that there was a statistically significant difference between the mean of industry respondents and the mean of educator respondents. These data were interpreted as meaning that this course ought not to be included in technical Associate Degree programs.

Table 16

Category (5)--English and Communication

| Survey Item | | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_o$ |
|---|---|---|---|---|---|---|---|---|
| 2.12 | Tech Writing | 3.22 | 4.13 | 1.03 | -.090 | -5.03 | .000 | Rej |
| 2.13 | English Comp | 3.11 | 3.50 | 1.14 | .144 | -1.95 | .054 | Ret |
| 2.14 | Oral Comms | 3.77 | 3.94 | 1.03 | .165 | -0.93 | .36 | Ret |
| 2.31 | Engrg Report/ Present | 3.43 | 3.63 | .935 | -.002 | -1.18 | .24 | Ret |

Note. $n_1 = 65$; $n_2 = 64$; $df = 127$; $t_{crit} = \pm 1.980$.

As can be seen from the data in Table 16 above, $H_o$ was retained (and $H_1$ rejected) for survey Items 2.13, English Composition, 2.14, Oral Communication, and 2.31, Engineering Reporting and Presentation. This meant that there was no statistically significant difference between the mean for industry respondents and the mean for educator respondents. Hence, any or all of these courses would be suitable for inclusion in two-year technical programs.

$H_0$ was rejected (and $H_1$ accepted) for survey Item 2.12, Technical Writing. Thus, there was a statistically significant difference between the mean of industry respondents and the mean of educator respondents for this survey item. Therefore, a course in technical writing ought not to be included in two-year programs in Mechanical Drafting and Design Technology.

Category (6)--Social Science/Work Skills

Table 17 summarizes and presents the data gathered regarding courses in the social sciences. The means were relatively low for all items in this group, indicating that both industry and educator participants ranked courses in the social sciences as having only slight importance. This

Table 17

Category (6)--Social Science/Work Skills

| Survey Item | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_0$ |
|---|---|---|---|---|---|---|---|
| 2.15 Human Relations | 2.80 | 3.53 | 1.09 | .019 | -3.82 | .0002 | Rej |
| 2.16 General Psych | 2.58 | 2.10 | .953 | .223 | 2.93 | .0041 | Rej |
| 2.17 Intro to Sociology | 2.34 | 2.06 | 1.01 | .120 | 1.55 | .12 | Ret |

*Note*. $n_1$ = 65; $n_2$ = 64; *df* = 127; $t_{crit}$ = ±1.980.

outcome was unexpected considering the emphasis given to workplace social skills in the literature.

$H_0$ was rejected (and $H_1$ accepted) for Items 2.15, Human Relations in the Workplace, and 2.16, General Psychology. This indicated that there was a statistically significant difference between the means of the responses for the two groups. Therefore, these courses were eliminated from further consideration for inclusion in the curriculum in Mechanical Drafting and Design Technology.

$H_0$ was retained (and $H_1$ rejected) for survey Item 2.17, Introduction to Sociology. Thus, there was no statistically significant difference between the mean of educator respondents versus the mean of industry respondents. Hence, a course in Introduction to Sociology ought to be included in two-year technical degree programs. Moreover, a course in the social sciences is required by the Iowa Department of Education as detailed in the review of the literature. Thus, this course would fulfill that requirement.

Category (7)--Technical Sciences

The data obtained regarding courses in the technical sciences is summarized and presented in Table 18. $H_0$ was retained (and $H_1$ rejected) for survey Items 2.22, Applied Thermodynamics, 2.23, Applied Fluid Mechanics, and 2.26, Metallurgy. Thus, there was no statistically significant difference between the mean for industry respondents and

Table 18

Category (7)--Technical Sciences

| Survey Item | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_o$ |
|---|---|---|---|---|---|---|---|
| 2.22 Applied Thermo | 2.85 | 2.94 | 1.03 | -.072 | -0.50 | .61 | Ret |
| 2.23 Applied Fluid Mech | 2.89 | 3.22 | 1.02 | -.008 | -1.82 | .070 | Ret |
| 2.26 Metallurg | 3.35 | 3.41 | 1.08 | -.059 | -0.28 | .78 | Ret |
| 2.27 Engrg Matls | 3.52 | 4.06 | .964 | -.036 | -3.18 | .0019 | Rej |

Note. $n_1$ = 65; $n_2$ = 64; df = 127; $t_{crit}$ = ±1.980.

the mean for educator respondents for all three survey items. Therefore, courses in each of these topics ought to be included in two-year technical programs.

Although the mean for both groups of respondents was relatively high for this curriculum component, $H_o$ was rejected (and $H_1$ accepted) for survey Item 2.27, Engineering Materials. This indicated that there was a statistically significant difference between the mean for industry respondents versus the mean for educator respondents. Hence, while the course was ranked as important, the two groups differed on the degree of importance. Therefore, a course in engineering materials ought not to be included in two-year Associate Degree programs in Mechanical Drafting and Design Technology.

Category (8)--Engineering Mechanics

Table 19 summarizes and presents the data gathered regarding courses in engineering mechanics. $H_0$ was rejected (and $H_1$ accepted) for survey Items 2.20, Strength of Materials, 2.24, Mechanisms and Kinematics, and 2.25, Machine Design.

Table 19

Category (8)--Engineering Mechanics

| Survey Item | | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_0$ |
|---|---|---|---|---|---|---|---|---|
| 2.18 | Statics | 3.37 | 3.72 | 1.17 | .193 | -1.70 | .092 | Ret |
| 2.19 | Dynamics | 3.28 | 3.37 | 1.01 | .050 | -0.55 | .58 | Ret |
| 2.20 | Str of Matls | 3.89 | 4.25 | .871 | .094 | -2.33 | .021 | Rej |
| 2.21 | Integrat Engr Mech | 3.54 | 3.69 | 1.06 | .004 | -0.80 | .43 | Ret |
| 2.24 | Mech & Kinemats | 3.34 | 3.72 | 1.01 | .127 | -2.14 | .034 | Rej |
| 2.25 | Machine Design | 3.72 | 4.36 | .710 | .128 | -5.21 | .000 | Rej |

*Note*. $n_1$ = 65; $n_2$ = 64; *df* = 127; $t_{crit}$ = ±1.980.

The rejection of $H_0$ was interpreted as meaning that there was a statistically significant difference between the mean for industry respondents and the mean for educator respondents over these survey items. Therefore, courses in these areas ought not to be included in two-year Associate Degree programs in Mechanical Drafting and Design Technology.

$H_0$ was retained (and $H_1$ rejected) for Items 2.18, Statics, 2.19, Dynamics, and 2.21, Integrated Engineering Mechanics. This indicated that there was no statistically significant difference between the mean of industry respondents versus the mean of educator respondents for these survey items. Hence, courses in these areas ought to be included in two-year Associate Degree programs in Mechanical Drafting and Design Technology at community colleges.

Category (9)--Drafting and Design

Table 20 summarizes and presents the data regarding courses in drafting and design. $H_0$ was rejected (and $H_1$ accepted) for survey Items 2.28, Senior Team Design Projects, 2.36 Mechanical Drafting and Design, and 2.38, Geometric Dimensioning and Tolerancing. This indicated that there was a statistically significant difference between the means for industry and educator respondents, and a lack of agreement between industry and educator respondents

Table 20

Category (9)--Drafting and Design

| Survey Item | | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_o$ |
|---|---|---|---|---|---|---|---|---|
| 2.28 | Sr. Team Des Proj | 3.25 | 3.81 | 1.10 | -.068 | -2.92 | .0041 | Rej |
| 2.30 | Creative Engrg Des | 3.72 | 3.45 | .864 | -.050 | 1.77 | .079 | Ret |
| 2.34 | Engrg Dwg | 4.05 | 4.25 | .792 | .092 | -1.45 | .15 | Ret |
| 2.35 | Indust Drftg/Des | 4.06 | 4.06 | 1.02 | -.080 | -0.01 | 1.0 | Ret |
| 2.36 | Mech Drftg/Des | 4.08 | 4.66 | .779 | -.018 | -4.22 | .000 | Rej |
| 2.38 | GD & T | 4.08 | 4.47 | .835 | -.077 | -2.66 | .0087 | Rej |
| 2.39 | Descrip Geometry | 3.49 | 3.87 | 1.13 | -.101 | -1.92 | .057 | Ret |
| 2.40 | Tool Des & Drftg | 3.88 | 3.81 | .855 | -.059 | 0.43 | .67 | Ret |

Note. $n_1 = 65$; $n_2 = 64$; $df = 127$; $t_{crit} = \pm 1.980$.

regarding the importance of the courses. Hence, these data demonstrated that courses in these subject areas ought not to be included in two-year Associate Degree programs in Mechanical Drafting and Design Technology at community colleges.

Conversely, $H_o$ was retained (and $H_1$ rejected) for survey Items 2.30, Creative Engineering Design, 2.34, Engineering Drawing, 2.35, Industrial Drafting and Design, 2.39, Descriptive Geometry, and 2.40, Tool Drafting and Design. These data indicated that there was no statistically significant difference between the mean for industry respondents and the mean for educator respondents for each of these survey items. Therefore, courses in these subject areas ought to be included in two-year programs in Mechanical Drafting and Design Technology.

Category (10)--Manufacturing Technology

Table 20 summarizes and presents the data gathered regarding courses in manufacturing technology. $H_0$ was retained (and $H_1$ rejected) for survey Items 2.29, Total Quality Concepts, 2.32, Engineering Economy, 2.37, Print Reading and Interpretation, 2.42, Manufacturing Tooling, 2.44, Hydraulics and Pneumatics, and 2.45, Industrial Electricity and Electronics. Therefore, the data gathered in this study support the contention that courses in these areas ought to be included in two-year Associate Degree programs in Mechanical Drafting and Design Technology at community colleges.

On the other hand, $H_0$ was rejected (and $H_1$ accepted) for survey Items 2.33, Statistical Process Control, 2.41, Manufacturing Processes, and 2.43, Machine Tool Operations. Thus, these data indicated that there was a statistically significant difference between the mean for industry

Table 21

Category (10)--Manufacturing Technology

| Survey Item | | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_o$ |
|---|---|---|---|---|---|---|---|---|
| 2.29 | Tot Qual Concepts | 3.78 | 3.84 | 1.02 | .013 | -0.33 | .74 | Ret |
| 2.32 | Engrg Econ | 3.23 | 2.94 | 1.01 | -.017 | 1.65 | .10 | Ret |
| 2.33 | SPC | 3.26 | 3.66 | 1.08 | .089 | -2.08 | .039 | Rej |
| 2.37 | Print Read & Interp | 4.43 | 4.16 | .889 | -.155 | 1.75 | .082 | Ret |
| 2.41 | Manuf Process | 4.09 | 3.78 | .796 | .054 | 2.22 | .028 | Rej |
| 2.42 | Manuf Tooling | 3.66 | 3.41 | .939 | -.142 | 1.54 | .13 | Ret |
| 2.43 | Mach Tool Oper | 3.65 | 3.28 | .987 | 1.00 | 2.10 | .038 | Rej |
| 2.44 | Hydraul & Pneum | 3.40 | 3.59 | .901 | .156 | -1.22 | .22 | Ret |
| 2.45 | Indust Elect & Electron | 3.36 | 3.38 | .853 | .213 | 0.06 | .95 | Ret |

Note. $n_1$ = 65; $n_2$ = 64; df = 127; $t_{crit}$ = ±1.980.

respondents and the mean for educator respondents over each of these survey items, indicating a lack of agreement regarding the importance of the course. Therefore, courses in these topics ought not to be included in two-year

Associate Degree programs in Mechanical Drafting and Design Technology.

## Results for Section 3--Drafting Practices

Respondents were asked to give their opinion regarding the importance of manual drafting versus CADD drafting, and how these subjects ought to be taught in the Mechanical Drafting and Design Technology program at Hawkeye Community College. If the results of the *t* test demonstrated no statistically significant difference between the industry mean and the educator mean for a given survey item at the .05 level of significance, then the null hypothesis was retained.

Retention of the null hypothesis was interpreted as indicating significant agreement between industry and educator participants regarding that item. Conversely, rejection of the null hypothesis at the .05 level of significance was interpreted as indicating that the null hypothesis ought to be rejected, and the alternative hypothesis accepted. This outcome was taken to mean that there was significant disagreement between industry and educator respondents for this item.

Table 22 summarizes and presents the data gathered regarding the opinion of industry and educator respondents on survey Items 3.1-3.13, which dealt with drafting practices in industry and instructional practices in

Table 22

Survey Items 3.1-3.13, Drafting Practices

| Survey Item | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_o$ |
|---|---|---|---|---|---|---|---|
| 3.1 | 3.57 | 4.14 | 1.30 | .006 | -2.49 | .014 | Rej |
| 3.2 | 3.11 | 3.52 | 1.42 | -.005 | -1.63 | .11 | Ret |
| 3.3 | 2.88 | 3.11 | 1.27 | .067 | -1.04 | .30 | Ret |
| 3.4 | 3.18 | 3.25 | 1.41 | -.012 | -.026 | .79 | Ret |
| 3.5 | 3.54 | 3.22 | 1.11 | -.109 | 1.64 | .10 | Ret |
| 3.6 | 2.14 | 1.84 | 1.16 | -.014 | 1.44 | .15 | Ret |
| 3.7 | 3.55 | 3.87 | 1.24 | .259 | -1.47 | .14 | Ret |
| 3.8 | 2.97 | 2.62 | 1.38 | .094 | 1.42 | .16 | Ret |
| 3.9 | 3.58 | 3.53 | 1.27 | .224 | 0.24 | .81 | Ret |
| 3.10 | 2.28 | 2.28 | 1.08 | .054 | -0.02 | .98 | Ret |
| 3.11 | 3.75 | 3.72 | 1.13 | -.023 | 0.18 | .86 | Ret |
| 3.12 | 2.85 | 3.34 | 1.23 | .116 | -2.30 | .023 | Rej |
| 3.13 | 1.83 | 1.97 | 1.04 | -.005 | -0.75 | .45 | Ret |

Note. $n_1$ = 65; $n_2$ = 64; df = 127; $t_{crit}$ = ±1.980.

teaching drafting in technical programs in community colleges. These items were evaluated on a five-point (1-5) Likert scale, with 1 being "strongly disagree," the mid-scale or 3 value being "neutral," and 5 being "strongly agree."

$H_0$ was rejected (and $H_1$ accepted) for survey Items 3.1 and 3.12. Rejection of the null hypothesis and acceptance of the alternative hypothesis for these two items meant that there was a statistically significant difference between the mean for industry respondents and the mean for educator respondents. This was interpreted as meaning that industry and educator respondents were in significant disagreement regarding truth of the statement, and so the statement was regarded as false.

Based on the data gathered regarding survey Item 3.1, it was concluded that in actual drafting practice in industry, it was not necessary that drafters and designers be skilled in both manual and CADD drafting techniques. Regarding the data gathered on survey Item 3.12, it can be said that the assertion that some topics in drafting can only be taught through the use of manual drafting techniques is false. This would tend to support Kashef's (1993) assertion that the principles of drafting and design can be taught and learned using CADD technology rather than traditional manual drafting techniques.

$H_0$ was retained (and $H_1$ rejected) for survey Items 3.2-3.11 and 3.13. Acceptance of the null hypothesis and rejection of the alternative hypothesis for each of these items meant that any difference between the mean for industry respondents and the mean for educator respondents was not statistically significant. Hence, the statement was accepted as true.

It should be noted that the means for most of these survey items were in the 2.5-3.5 range, indicating that survey participants were, for the most part, neutral to most of the statements in this section of the survey instrument. This argues that survey respondents were uncertain of the relationship between manual and CADD drafting, and were thus very cautious regarding the place of manual and CADD drafting techniques in both the educational setting and in industry proper.

The ambiguity of these data further suggests that both groups of respondents recognize the importance of CADD in industry, but were unwilling to abandon instruction in traditional manual drafting techniques entirely because of the value of manual drafting techniques in teaching the academic discipline of drafting. Thus, a degree of caution was exercised in the interpretation of these data.

Based on these data, it can be said that industry and educator participants in the study agreed that:

1. Individuals cannot be good CADD operators without first being skilled in manual drafting tools and techniques. Thus, these data imply that drafting skills ought to be learned before CADD operation is learned; and that manual drafting skills should be a prerequisite to the development of skills in CADD operation. Hence, the idea that CADD is

regarded as only one of many drafting tools available, while drafting itself is regarded more as an actual academic discipline appears to have some merit.

2. In college curricula, manual drafting subjects ought to be introduced and mastered before CADD topics are introduced. Hence, these data suggest that students should be required to take and master courses in manual drafting before courses in CADD are scheduled.

3. In industry, manual drafting ought to be replaced entirely by CADD, because CADD permits significant gains in industrial productivity, and hence, profitability. Thus, these data suggest that, while manual drafting must be learned as an academic discipline and as a prerequisite to CADD, CADD will be the preferred drafting technique in industry. Moreover, both industry and educator respondents indicated disagreement with the idea that design creativity would be lost when manual drafting techniques are replaced with CADD techniques in industrial drafting practice.

4. Educators should endeavor to teach generally applicable CADD concepts and skills rather than software specific CADD concepts and skills. These data suggest that educators ought to be concerned more with the development of conceptual knowledge about CADD, general CADD interface skills, and the relationship between CADD and other computer-based manufacturing technologies rather than

concentrating only upon the development of keyboard proficiency in a specific CADD software package.

5. In education, manual drafting techniques are the best medium for teaching the body of knowledge constituting the academic discipline of drafting. While the development of manual drafting skills must precede the introduction of CADD topics, colleges may also wish to teach manual drafting techniques concurrently with CADD techniques, with the manual techniques introduced first.

6. Colleges ought to devote the same amount of time to instruction in CADD drafting techniques as is devoted to manual drafting techniques. Again, these data suggest that both CADD and manual drafting techniques are important, and that neither can be ignored in the instructional process, even though both groups of respondents indicated that drafting in industry ought to be accomplished using CADD technology.

## Results for Section 4--Occupational Skill Certification

Respondents were asked to give their opinion regarding the importance of voluntary occupational skill certification offered by professional societies, and whether or not preparation for such certification ought to be included in the Mechanical Drafting and Design Technology program at Hawkeye Community College. If the results of the $t$ test demonstrated no statistically significant difference between the industry mean and the educator mean for a given item at the .05 level of significance, then the null hypothesis was retained.

Retention of the null hypothesis was interpreted as indicating significant agreement between industry and educator participants regarding this item. Conversely, rejection of the null hypothesis at the .05 level of significance was interpreted as indicating that the alternative hypothesis ought to be accepted. This outcome was taken to mean that there was significant disagreement between industry and educator respondents for this item.

Tables 23 and 24 summarize and present the data gathered regarding the opinion of industry and educator respondents for survey Items 4.1-4.9, Occupational Skill Certification. These items were evaluated on a five-point (1-5) Likert scale, with 1 being "strongly disagree," the mid-scale or 3 value being "neutral," and 5 being "strongly agree."

$H_0$ was rejected (and $H_1$ accepted) for survey Items 4.3, 4.4, 4.5, and 4.6. Rejection of the null hypothesis and acceptance of the alternative hypothesis for these four items meant that there was a statistically significant difference between the mean for industry respondents and the mean for educator respondents. This was interpreted as meaning that industry and educator respondents were in significant disagreement regarding the truth of the

Table 23

Survey Items 4.1-4.8, Occupational Skill Certification

| Survey Item | $\mu_1$ | $\mu_2$ | SD | r | t | p | $H_o$ |
|---|---|---|---|---|---|---|---|
| 4.1 | 3.18 | 3.06 | 1.22 | -.115 | 0.57 | .57 | Ret |
| 4.2 | 3.71 | 3.91 | .882 | .169 | -1.28 | .20 | Ret |
| 4.3 | 3.54 | 4.09 | .858 | .273 | -3.67 | .0004 | Rej |
| 4.4 | 3.40 | 4.16 | .879 | .146 | -4.89 | .0000 | Rej |
| 4.5 | 3.03 | 3.50 | 1.12 | -.101 | -2.37 | .019 | Rej |
| 4.6 | 2.78 | 3.25 | 1.15 | -.102 | -2.30 | .023 | Rej |
| 4.7 | 3.12 | 3.22 | .930 | .045 | -0.58 | .56 | Ret |
| 4.8 | 3.66 | 3.59 | .832 | -.044 | 0.46 | .64 | Ret |

Note. $n_1 = 65$; $n_2 = 64$; $df = 127$; $t_{crit} = \pm1.980$.

statement, and so the statement was regarded as false. The means for these items indicate that, in general, educator respondents believed occupational skill certification to be more important than did industry respondents in terms of hiring, promotional preference, and salary determination. Hence, the data for survey Items 4.3-4.6 suggests that industry:

1. Should not be responsible for encouraging currently employed individuals to attain occupational skill certification.

2. Should not help current employees defray the cost of attaining occupational skill certification.

3. Should not give promotional preference to individuals who have attained occupational skill certification.

4. Should not pay individuals that have attained occupational skill certification at a higher rate than individuals that have not attained such certification.

$H_0$ was retained (and $H_1$ rejected) for survey Items 4.1, 4.2, 4.7, and 4.8. Acceptance of the null hypothesis and rejection of the alternative hypothesis for these four items meant that there was no statistically significant difference between the mean for industry respondents and the mean for educator respondents. This was interpreted as meaning that industry and educator respondents were in significant agreement regarding the validity of the statement, and so the statement was accepted as true. Thus, the data gathered for survey Items 4.1, 4.2, 4.7, and 4.8 indicates that both industry and educator respondents were in significant agreement that:

1. Some form of standardized occupational skill certification, developed and administered at the national level, is necessary.

2. Occupational skill certification administered by various professional societies is an asset for the entry-level employee.

3. Individuals who have attained occupational skill certification through a professional society ought to be given preference in the hiring process.

4. Colleges should include preparation for occupational skill certification examinations offered by appropriate professional societies.

The data gathered for these survey items appears to be somewhat contradictory in nature. On the one hand, industry seems to recognize the importance of occupational skill certification offered through the various professional societies, and to support the certification process through hiring preference and wanting preparation for certification in college curricula.

On the other hand, industry is unwilling to reward individuals who have attained certification in terms of promotional preference, salary differential, help with the costs of the certification process, or endorsement of the certification process. Moreover, these data also support the premise that, in general, educators placed more value on occupational skill certification than did industry.

Table 24 summarizes and presents the data gathered from responses to survey Item 4.9 regarding industry and educator preference as to the specific type of occupational skill certification most desirable. These data are presented as counts and percentages to facilitate description and characterization.

Table 24

Survey Item 4.9--Preferred Occupational Skill Certification

| Survey Response | Industry | | Educator | |
|---|---|---|---|---|
| | Number | % | Number | % |
| No Preference | 11 | 17 | 16 | 25 |
| Unnecessary | 5 | 8 | 4 | 6 |
| ADDA Certified Drafter | 0 | 0 | 2 | 3 |
| ADDA Certified Mech Drafter | 1 | 2 | 6 | 9 |
| NOCTI Certified Mach Drafter | 0 | 0 | 2 | 3 |
| SME Cert Manufact Technologist | 10 | 15 | 8 | 13 |
| ASCET Cert Mech Engr Technician | 8 | 12 | 2 | 3 |
| ASQC Certified Quality Technician | 0 | 0 | 0 | 0 |
| Not Familiar | 30 | 46 | 24 | 38 |
| Total | 65 | 100 | 64 | 100 |

Based on these data, both industry and educator respondents agreed that the most preferred type of occupational skill certification offered through a professional society was that of Certified Manufacturing Technologist, offered through the Society of Manufacturing Engineers of Dearborn, Michigan. However, only 15% of industry respondents and 13% of educators expressed this choice. However, it should be noted that 63% of industry respondents and 63% of educator respondents either expressed no preference regarding the options offered, or were unfamiliar with the certification programs listed in Item 4.9 of the survey instrument. Hence, these data do not support the endorsement of the Certified Manufacturing Technologist certification as the credential of choice.

These data do support the position that most industry and most educator participants in the study were unfamiliar with many or all of the occupational skill certification programs offered through several of the various professional societies. Hence, community colleges should not make the attainment of occupational skill certification offered through a professional society a requirement for graduation.

Further, the results of this study argue that the advantages of such occupational skill certification are questionable in terms of promotion and salary, but may be beneficial in terms of initial hiring advantage. Therefore, curriculum planners should not make preparation for these examinations a part of the required curriculum, but could offer such preparation as an elective course in the curriculum. Alternatively, short seminar or workshop type activities offered during non-classroom hours late in the fourth term of technical programs are another option in helping students attain voluntary occupational skill certification.

# CHAPTER V

## SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This research was a descriptive pilot study that compared the perceptions of Iowa Merged Area VII manufacturers and Iowa technical educators regarding several areas of interest. These areas included curriculum, occupational skill certification, and drafting practices as these related to two-year Associate Degree programs in Mechanical Drafting and Design Technology.

In general, the problem in this study was to determine what should be taught in two year technical curricula in Mechanical Drafting and Design Technology in order to adequately prepare students for the modern high-performance manufacturing workplace. The purposes of this study were to assess and compare:

1. The perceived educational needs of Iowa Merged Area VII manufacturers and Iowa technical educators regarding the content of Mechanical Drafting and Design Technology curricula.

2. The attitudes of industry and educator respondents with regard to the relationship between, and implementation of, manual and CADD drafting.

3. The attitudes of industry and educator respondents regarding voluntary occupational skill certification.

Additionally, the study also served as the empirical basis for an entirely new curriculum in Mechanical Drafting and

Design Technology at community colleges that more closely approximates the expressed educational needs of the Merged Area VII manufacturers that employ the graduates of this program.

Two populations were identified for this study. The first was selected manufacturing industries listed in the Iowa Register of Manufacturers that also met other additional criteria stated. The second population was technical educators currently employed at public community colleges or post-secondary technical institutes in the state of Iowa, and who were currently teaching in Mechanical Drafting and Design Technology, or in closely related programs.

Two independent samples were used for this research. These samples consisted of survey responses from the selected population of Merged Area VII manufacturing industries (sample name: "Industry" designated $\underline{n}_1$), and survey responses from technical educators currently teaching at community colleges in the state of Iowa (sample name: "Educator" designated $\underline{n}_2$).

In order to conduct this study, the survey instrument for gathering the necessary data was developed in two versions. One version was used for gathering data from Merged Area VII manufacturing industries, and the other version was used for gathering data from Iowa technical educators. Both versions of the survey instrument differed only in the content of the cover letter, in the instructions for completing each section of the instrument, and in the presence or absence of Section 1 eliciting demographic data from manufacturers. Both versions of the survey instrument were identical in all other respects.

A research hypothesis ($H_1$: $\mu_1 \neq \mu_2$) was established for each of the individual items in Section 2, Associate Degree Curriculum Components; Section 3, Drafting Practices; and Section 4, Occupational Skill Certification (excluding Item 4.9) of the survey instrument. The null hypothesis that corresponded to the research hypothesis ($H_o$: $\mu_1 = \mu_2$) for each item in Sections 2, 3, and 4 (excluding 4.9) of the survey instrument was tested by comparing the mean of all industry responses for each individual item with the mean of all educator responses for the same individual item using a two-tailed $t$ test for significance, at the .05 level of significance. The results of statistical testing, the conclusions drawn therefrom, and resulting recommendations are detailed below.

## Merged Area VII Industry Profile

The data gathered in this study revealed that Iowa Merged Area VII contained a wide range of manufacturing concerns. This diversity was explored in terms of number and assignment of employees, technologies in use, management practices, and computer usage.

Employment

Based on these data, it can be concluded that, as delimited in this study, the typical Iowa Merged Area VII manufacturing business employs 156 people. Of this total, five persons (or about 3%) were employed as mechanical drafters or designers. Of the five individuals employed as mechanical drafters or designers, two were graduates of Associate Degree programs. Of the five persons employed as mechanical drafters/designers, four worked at a CADD workstation, and one at a drawing board. Thus, it was concluded that, aside from its value as a teaching tool, instruction in manual drafting ought to be retained since graduates of technical programs may be expected to work at the drawing board 25% of the time.

Technology

Based on these data, it can be concluded that, as delimited in this study, the typical Iowa Merged Area VII manufacturing business has five CNC machine tools or machining centers installed, no lasers in use, one robot installed, and three manufacturing cells in use. Thus, these data support the conclusion that the average Merged Area VII manufacturing business is relatively high-tech, and uses technologies at the high-end of mainstream manufacturing. However, only 7% of Iowa Merged area VII manufacturers used such cutting edge technology as rapid prototyping. This argues that the cost of cutting-edge technologies is probably prohibitive for the typical Iowa manufacturing firm. Another explanation may be that, since the cost of cutting-edge technology is so prohibitive, manufacturers may be resorting to outsourcing in order to take advantage of advanced manufacturing technologies.

## Management

Based on these data, it can be concluded that, as delimited in this study, the typical Iowa Merged Area VII manufacturing business is using manufacturing management practices that are well within the mainstream or mid-range of current manufacturing thought, but is failing to take advantage of ideas at the high-end or cutting-edge of current manufacturing thought. Iowa merged Area VII manufacturers reported that CADD is "usually" ($\mu$ = 3.72, $M$ = 4.00) used for drafting and design, thus enabling the use of other CADD-dependent advanced technologies.

These data demonstrated that concurrent engineering methods ($\mu$ = 2.69, $M$ = 3.00), just-in-time inventory management techniques ($\mu$ = 3.93, $M$ = 3.00), and self-directed, multi-disciplinary work teams ($\mu$ = 2.90, $M$ = 3.00) were "frequently" used. However, management techniques such as competitive benchmarking ($\mu$ = 2.38, $M$ = 2.00) and flow management technology ($\mu$ = 2.41, *M* = 2.00) that embodied more current manufacturing management thought and figure so prominently in the design and development process were reported as "seldom" used. Further, only 14% of Merged Area VII manufacturing businesses reported actual certification under ISO 9000. Therefore, these data support the conclusion that Iowa Merged Area VII manufacturing concerns are using the mid-range of mainstream manufacturing management techniques. However, they are failing to take advantage of the high-end of contemporary management practices that could lead to significant improvements in competitiveness and profitability, locally, nationally, and internationally. This failure is most likely due to simple ignorance on the part of manufacturers, and if this is the case, argues for the inclusion of these topics in two-year technical programs in Mechanical Drafting and Design Technology.

## Computing

Based on these data, it can be concluded that, as delimited in this study, the typical Iowa Merged Area VII manufacturing business is relatively computer intensive. These data demonstrated that the personal computer workstation was the most frequently used type of CADD platform, being used in 97% of companies (after correction for no CADD usage). Of those companies reporting the personal computer workstation as the most frequently used type of CADD platform, 92% (after correction for no CADD usage) reported that IBM or compatible personal computers were used.

These data demonstrated that CADD facilities were totally networked in only 16% of Iowa Merged Area VII manufacturing businesses, and partially networked in 14% of those businesses. When corrected for companies reporting no CADD usage, only 43% of Iowa Merged Area VII manufacturing industries had their CADD facilities either totally or partially networked.

The conclusion was drawn that the remaining 57% of Iowa Merged Area VII industries did not have a sufficient number of CADD workstations installed to justify the expense networking. However, this also argues for a conclusion of ignorance on the part of the manufacturers since the cost of the hardware and software for networking or workgrouping personal computers is quite reasonable, considering the gains in productivity and profitability that could be realized with the adoption of this technology.

These data demonstrated that 46% (after correction for no CADD usage and no CNC usage) of Iowa Merged Area VII manufacturing industries did not have CADD facilities networked to CNC/NC production equipment on the shop floor. It was concluded that these firms probably did not have a sufficient number of CADD workstations, CNC machining centers or machine tools, or both to justify the expense of networking these facilities. However, this also argues for a conclusion of ignorance on the part of the manufacturers since the cost of the hardware and software for networking or workgrouping personal computers is quite reasonable, considering the gains in productivity and profitability that could be realized with the adoption of this technology.

When these data were corrected for the manufacturing industries that reported no CADD usage, it was found that AutoCAD software was in use 64% of the manufacturers reporting. While this is not an overwhelming majority it is certainly is a significant number, and argues for the conclusion that CADD instruction in technical programs in community colleges based on AutoCAD software would best qualify students for employment with Iowa Merged Area VII manufacturers.

The demographic data developed from the study should be valuable to community college educators in terms of better understanding current conditions in Iowa Merged Area VII manufacturing industries. With this enhanced understanding, educators will be able to structure curricula and the instructional process itself to better meet the needs of local manufacturing industries, and to better qualify students for employment in those industries.

The industry demographic data supports the recommendation that community colleges should base CADD instruction in technical programs on the IBM or compatible

Table 25

Summary of Iowa Merged Area VII Selected Manufacturing Industry Demographic Data

| | |
|---|---|
| Mean Number of Employees | 156 |
| Mean Number Employed in Drafting/Design | 5 |
| Mean Number of Associate Degree Graduates | 2 |
| Mean Number Working at CADD Workstation | 4 |
| Mean Number Working at Drawing Board | 1 |
| Mean Number CNC/NC Machine Tools/Machining Centers | 5 |
| Mean Number of Lasers | 0 |
| Mean Number of Robots | 1 |
| Mean Number of Manufacturing Cells | 3 |
| Rapid Prototyping (SLS or STL) | 7% |
| CADD Used for Drafting/Design | USUALLY |
| Concurrent Engineering Methods | FREQUENTLY |
| Just-in-Time Inventory Management | FREQUENTLY |
| Self-Directed, Multi-Disciplinary Work Teams | FREQUENTLY |
| Competitive Benchmarking | SELDOM |
| Flow Management Technology | SELDOM |
| ISO 9000 Certified | 14% |
| PC Workstation for CADD (Corrected) | 97% |
| IBM/Compatible PC for CADD (Corrected) | 92% |
| CADD Facilities Networked--Total or Partial (Corrected) | 43% |
| CADD Networked to CNC/NC--Total or Partial | 60% |
| AutoCAD Software | 64% |

personal computer platform, running the current version of AutoCAD software. This would ensure that students receive instruction in computing and manufacturing computer applications that is in consonance with current conditions in Iowa Merged Area VII industries.

It is also recommended that the instructional computing environment be networked and that where possible, CADD facilities be networked to CNC/NC production equipment in the shops. Although this recommendation is not reflective of current conditions in Iowa Merged Area VII manufacturing industries, it must be recognized that new graduates that have had instruction in the appropriate topics are often sought by manufacturing companies seeking to implement change. Thus, this would tend to give new graduates a competitive edge in hiring.

Further, many companies are not aware of the need for internal change until an appropriately educated individual brings new knowledge and new methods from outside the company. Hence, a computing-intensive instructional environment would equip new graduates to be forward-looking agents of change, and to better handle the constant change and uncertainty that is an inherent part of the dynamic manufacturing environment. These attributes would also enhance initial employability, aid in the development of life-long learning habits, and contribute to employee retrainability and retainability. Table 25 summarizes the discussion above.

## Conclusions and Recommendations for Curricula in Drafting and Design Technology

The data derived from this section of the survey instrument was used to develop an ideal or optimal curriculum for two-year programs in Mechanical Drafting and Design Technology. The optimal or ideal curriculum, based only on the data derived in this study, contained only those courses that both industry and educator respondents agreed were important.

This agreement upon importance was established by conducting a two-tailed *t* test on the difference between the mean for industry respondents and the mean for educator respondents, at the .05 level of significance for each item in Section 2 of the survey instrument. Hence, if the null hypothesis was accepted (and the alternative hypothesis rejected), the difference between the means for industry and educator respondents was not considered to be statistically significant, and the course was retained for inclusion in the curriculum.

On the other hand, if the null hypothesis was rejected, the difference between the means of industry and educator respondents was considered to be statistically significant, and the course was not included in the curriculum. Table 26 shows those courses that were eliminated by statistical testing, the mean for each group, and the *t*-score obtained statistical testing.

Table 26

Associate Degree Curriculum Components Eliminated by Statistical Testing (Null Hypothesis Rejected)

| Survey Item | | $\mu_1$ | $\mu_2$ | $t$ |
|---|---|---|---|---|
| 2.2 | Technology and Society | 3.05 | 2.31 | 4.55 |
| 2.3 | College Algebra | 3.68 | 4.16 | -2.59 |
| 2.6 | Computer Software Applications | 3.46 | 3.84 | -2.31 |
| 2.7 | Computer Aided Draft/Design | 4.25 | 4.75 | -3.44 |
| 2.10 | Technical Physics | 3.23 | 3.63 | -2.47 |
| 2.12 | Technical Writing | 3.22 | 4.13 | -5.03 |
| 2.15 | Human Relations | 2.80 | 3.53 | -3.82 |
| 2.16 | General Psychology | 2.58 | 2.10 | 2.93 |
| 2.27 | Engineering Materials | 3.52 | 4.06 | -3.18 |
| 2.20 | Strength of Materials | 3.89 | 4.25 | -2.33 |
| 2.24 | Mechanisms and Kinematics | 3.34 | 3.72 | -2.14 |
| 2.25 | Machine Design | 3.72 | 4.36 | -5.21 |
| 2.28 | Senior Team Design Projects | 3.25 | 3.81 | -2.92 |
| 2.36 | Mechanical Drafting and Design | 4.08 | 4.66 | -4.22 |
| 2.38 | Geometric Dimension/Tolerance | 4.08 | 4.47 | -2.66 |
| 2.33 | Statistical Process Control | 3.26 | 3.66 | -2.08 |
| 2.41 | Manufacturing Processes | 4.09 | 3.78 | 2.22 |
| 2.43 | Machine Tool Operation | 3.65 | 3.28 | 2.10 |

Note. $n_1 = 65$; $n_2 = 64$; $df = 127$; $t_{crit} = \pm 1.980$.

It will be noted that several courses demonstrated a statistically significant difference between the means, even though the magnitude of the means themselves ranked the course as important. In these cases, it was concluded that while industry and educator respondents may have ranked a particular as course important, the two groups differed significantly on the degree of importance, and the course was excluded from the curriculum.

This ensured that the courses that were included in the curriculum represented the best thought of both industry and educator participants. Therefore, based on these data, it is recommended that the courses listed in Table 26 not be included in two-year Associate Degree Programs in Mechanical Drafting and Design Technology.

Table 27 shows those courses that were retained for inclusion in the curriculum. In addition, the mean for each group and the t-score obtained statistical testing are also shown. In general, the data gathered in this study supports the conclusions that:

1. Both industry and educator participants apparently believed that courses that have a practical or applied orientation ought to be included in the curriculum, while courses that are more theoretical or that have less immediate application in the manufacturing workplace ought to be excluded from two-year curricula in Mechanical Drafting and Design Technology.

Table 27

Associate Degree Curriculum Components Included by Statistical Testing (Null Hypothesis Accepted)

| Survey Item | | $\mu_1$ | $\mu_2$ | $t$ |
|---|---|---|---|---|
| 2.1 | Funds of Science and Technology | 3.30 | 3.00 | 1.73 |
| 2.4 | College Trig/Analytic Geometry | 3.80 | 4.06 | -1.30 |
| 2.5 | Applied Mathematics | 4.12 | 4.31 | -1.25 |
| 2.8 | Computer Integrated Manufacturing | 3.49 | 3.84 | -1.86 |
| 2.9 | Survey of Physical Science | 2.83 | 2.72 | 0.68 |
| 2.11 | Applied Science: Physics/Chem | 3.06 | 3.28 | -1.21 |
| 2.13 | English Composition | 3.11 | 3.50 | -1.95 |
| 2.14 | Oral Communications | 3.77 | 3.94 | -0.93 |
| 2.31 | Engrg Reporting and Presentation | 3.43 | 3.63 | -1.18 |
| 2.17 | Intro to Sociology | 2.34 | 2.06 | 1.55 |
| 2.22 | Applied Thermodynamics | 2.85 | 2.94 | -0.50 |
| 2.23 | Applied Fluid Mechanics | 2.89 | 3.22 | -1.82 |
| 2.26 | Metallurgy | 3.35 | 3.41 | -0.28 |
| 2.18 | Statics | 3.37 | 3.72 | -1.70 |
| 2.19 | Dynamics | 3.28 | 3.37 | -0.55 |
| 2.21 | Integrated Engineering Mechanics | 3.54 | 3.69 | -0.80 |
| 2.30 | Creative Engineering Design | 3.72 | 3.45 | 1.77 |
| 2.34 | Engineering Drawing | 4.05 | 4.25 | -1.45 |
| 2.35 | Industrial Drafting and Design | 4.06 | 4.06 | -0.01 |

(table continues)

| Survey Item | | $\mu_1$ | $\mu_2$ | t |
|---|---|---|---|---|
| 2.39 | Descriptive Geometry | 3.49 | 3.87 | -1.92 |
| 2.40 | Tool Design and Drafting | 3.88 | 3.81 | 0.43 |
| 2.29 | Total Quality Concepts | 3.78 | 3.84 | -0.33 |
| 2.32 | Engineering Economy | 3.23 | 2.94 | 1.65 |
| 2.37 | Print Reading and Interpretation | 4.43 | 4.16 | 1.75 |
| 2.42 | Manufacturing Tooling | 3.66 | 3.41 | 1.54 |
| 2.44 | Hydraulics and Pneumatics | 3.40 | 3.59 | -1.22 |
| 2.45 | Indust Electricity/Electronics | 3.36 | 3.38 | 0.06 |

Note. $n_1 = 65$; $n_2 = 64$; $df = 127$; $t_{crit} = \pm 1.980$.

2. Both groups apparently thought that courses with a broader and more integrated approach to the subject matter were more important than courses with a narrower focus or that resulted in the development of overly specific skills. This tends to support the broadly developed, technically adept "Renaissance man" idea of technical education espoused by Koska and Romano (1988).

3. Both groups seemed to adhere to the idea that a back-to-the-basics approach to technical education emphasizing applied mathematics, applied and technical sciences, integrating computer courses, oral and written communication, and drawing and design is most appropriate

for two-year Associate Degree curricula in Mechanical Drafting and Design Technology.

Of the two courses in mathematics retained for inclusion in the curriculum, survey Item 2.5, Applied Mathematics had the highest mean for both industry and educator participants. Therefore, these data support the recommendation that a single course in applied mathematics be included in curricula in Mechanical Drafting and Design Technology at community colleges.

A single course in applied mathematics may pose problems, however, since most technical programs consist of a definite sequence of courses to be completed over four semesters. This option implies that either students come to the program with the necessary prerequisites for a rigorous course in applied mathematics, or that community colleges be willing to engage in significant remediation in mathematics. Therefore, if this curriculum is adopted, it is strongly recommended that all students, without exception, have completed one course in high school algebra and one course in high school geometry before being admitted to programs in Mechanical Drafting and Design Technology.

Although the elimination of discrete courses in computer software applications and CADD was unexpected, this outcome does bolster the conclusion that courses in computing ought to be more integrating and comprehensive rather than so narrowly developed as is presently the case.

Hence, it is recommended that a course in Computer Integrated Manufacturing (CIM) be included in the curriculum for Mechanical Drafting and Design Technology at community colleges.

The data gathered regarding English and Communication support the conclusion that both industry and educator respondents considered this area to be important for students in two-year technical programs, since three of the courses listed in the survey instrument were retained for inclusion in the curriculum. Hence, it is recommended that curricula in Mechanical Drafting and Design Technology include three semesters of communication consisting of English Composition, Oral Communication, and Engineering Reporting and Presentation.

Only a single course, Introduction to Sociology, was retained for inclusion in the curriculum. The means for both industry and educator respondents for this item were quite low, as they were for all items in the social sciences group.

Considering the means, both industry and educator respondents apparently considered courses in the social sciences to be of marginal importance. However, State Department of Education requirements dictate the inclusion of 3 semester hours of coursework in this area. Hence, it is recommended that a course in Introductory Sociology be included in two-year Associate Degree programs in Mechanical Drafting and Design Technology.

Of the two courses retained for inclusion in the curriculum, the course in Applied Science: Physics and Chemistry had the highest mean for both groups of respondents. Thus, these data support the conclusion that both groups regarded an integrated approach to the principles of physics and chemistry as more important than a course covering only physics, or a course covering the entire range of the physical sciences. Hence, it is recommended that a single course in science covering the principles of both physics and chemistry, be included in curricula in Mechanical Drafting and Design Technology.

The data in this study support the conclusion that both industry and educator participants considered courses in the technical sciences to be important for Associate Degree students, since three courses in this group were retained for inclusion in technical programs. Therefore, it is recommended that curricula in Mechanical Drafting and Design Technology include courses in Applied Thermodynamics, Applied Fluid Mechanics, and Metallurgy.

Based on these data gathered in this study, it was concluded that both groups of respondents considered courses in engineering mechanics to be important. The more specific and narrowly focused courses such as kinematics and machine design were eliminated from consideration, while more basic and integrating courses such as statics, dynamics, and integrated engineering mechanics were retained for inclusion in the curriculum. Therefore, it is recommended that courses in statics, dynamics, and integrated engineering mechanics be included in Mechanical Drafting and Design programs. The course in integrated engineering mechanics should present an integrated treatment of the important principles from strength of materials, mechanisms, and machine element.

According to the means, both industry and educator respondents ranked courses in drafting and design as important. Based on these data, it was concluded that the more narrowly focused courses such as mechanical drafting and design ought to be eliminated in favor of more general principles-based courses that emphasize immediate application in industrial practice. Thus, it is recommended that courses in engineering drawing, descriptive geometry, industrial drafting and design, and tool design and drafting be included in Associate Degree programs in Mechanical Drafting and Design Technology.

These data support the conclusion that courses in manufacturing technology are important for technical students in drafting and design programs. However, as was the case in other areas, both industry and educator respondents opted for broad integrating courses that developed fundamental skills in key industrial areas such as print reading, total quality systems, tooling, hydraulics, pneumatics, and electricity. Based on these data, courses in total quality concepts, engineering economy, print reading, manufacturing tooling; hydraulics and pneumatics; and industrial electricity and electronics ought to be included in two-year programs in Mechanical Drafting and Design Technology.

In summary, the data derived from this study support the conclusion that technical curricula ought to emphasize broad integrating courses, adhere to a back-to-the-basics approach, and contain courses with a practical approach that are immediately applicable in industrial practice.

The specific courses that ought to be included are listed in Table 27. However, all the courses shown in Table 27 cannot be fitted into a 4 semester curriculum. Appendix B details the recommended curriculum for a two-year terminal Associate Degree program. Appendix C contains course descriptions for the recommended curriculum.

## Conclusions and Recommendations for Drafting Practices

Based on the data gathered in this study, it was concluded that, in general, survey respondents appeared to be uncertain of the relationship between manual and CADD drafting. Moreover, responses of both groups indicated that they were very cautious regarding the place of manual and

CADD drafting in both industry and in the educational setting. Specifically, it was concluded that:

1. CADD was regarded as a means of enhancing productivity and hence, profitability in industry.

2. The primary value of manual drafting is as a teaching tool in academic institutions.

3. Manual drafting skills ought to be developed either before, or concurrently with, CADD drafting skills.

4. Design creativity is not lost when CADD technology is introduced in the industrial setting.

5. Manual drafting is the best medium for teaching the body of knowledge associated with the academic discipline of drafting.

6. Colleges ought to give equal instructional time to CADD and manual drafting techniques.

7. In industry, most drafting will be done using CADD technology, however, there may be some instances in which manual drafting will be the primary drafting mode. Hence, students ought to be skilled in both technologies.

The conclusions above reflect a cautious approach due to the ambiguity of the data gathered in this study, but do represent a significant change in the way drafting is taught. Current practice in many community colleges is to teach manual drafting courses followed by CADD drafting courses, or to teach both topics simultaneously, but in discrete courses. Based on these data, the best practice would be to teach manual and CADD drafting techniques simultaneously, but in integrated courses rather than in discrete courses. Again, this is a conservative compromise position based on the inconclusive nature of these data.

Based on the conclusions above, it is recommended that:

1. CADD and manual drafting be taught in an integrated series of courses, as but two aspects of the same topic, rather than as discrete courses.

2. CADD also ought to be included in the Computer Integrated Manufacturing course as but one aspect of the total integration of the manufacturing environment.

3. That the use of both CADD and manual drafting techniques be required in all appropriate courses in the curriculum, and that equal use of each technology be made in those courses.

## Conclusions and Recommendations for Occupational Skill Certification

The data derived from this section of the survey instrument reinforced the findings from the literature review. These findings indicated that the primary value of occupational skill certification offered through a professional society is that of individual achievement, accomplished for personal satisfaction and peer recognition. Based on these data, it was concluded that:

1. Both groups of participants agreed that some form of nationally standardized and administered occupational skill certification program is necessary.

2. Both industry and educator respondents agreed that occupational skill certification offered through a professional society was a definite asset for entry level employees.

3. Industry and educator respondents could not agree upon the role industry should play in helping employees attain voluntary occupational skill certification offered through a professional society. In general, educators believed that industry should encourage such assistance. Conversely, industry participants indicated that certification should not be encouraged, that industry should not assist with the cost of certification, and that certified individuals ought not to receive a pay differential based on certified status.

4. Both groups of respondents did agree that hiring preference ought to be given to individuals that possess occupational skill certification offered through a professional society such as the Society of Manufacturing Engineers.

5. Both industry and educator respondents indicated that colleges ought to include preparation for occupational skill certification as a part of the regular technical curriculum.

6. Both groups of respondents demonstrated unfamiliarity with or indifference to, the occupational skill certification programs offered through the various professional societies.

In light of the data gathered in this study, and the conclusions drawn from these data, the following recommendations are made:

1. Preparation for occupational skill certification programs offered through a professional society ought not to be included in the regular curriculum for Mechanical Drafting and Design Programs.

2. Preparation for voluntary occupational skill certification examinations offered through a professional society ought to be offered on an extracurricular basis for those individuals seeking personal achievement or peer recognition. Further, students ought to be advised that successful completion of such an examination may offer an advantage in initial hiring after graduation.

## General Recommendations

This pilot study was successful in answering the basic research questions posed in Chapter I, and in providing a foundation for the development of a model curriculum in Mechanical Drafting and Design Technology at community colleges in general, and at Hawkeye Community College in particular. This curriculum represents both a good balance between the opinion of industry and educators respondents, and also more effectively meets the expressed needs of Iowa Merged Area VII manufacturing industries.

There were, however, certain areas of curriculum components and drafting practices that need further study and evaluation for their ultimate resolution. Hence, it is recommended that another more detailed survey, devoted only to CADD topics, the relationship between CADD and manual drafting, and their place in technical curricula be conducted to in order to clarify the ambiguity encountered in the data gathered for this study.

The review of the literature produced overwhelming evidence of the value and universal applicability of the SCANS skills and competencies as detailed in Chapter II. It is strongly recommended that instruction include the development of these skills in every course in the Mechanical Drafting and Design Technology curriculum.

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# APPENDIX A

## IOWA COMMUNITY COLLEGE CURRICULUM MATRIX

| COLLEGE | MATH | SCIENCES | TECH SCIN | DRAFT/DES | CAD/COMP | OTHER REQ | GEN ED |
|---|---|---|---|---|---|---|---|
| Clinton | 6 | 6 | 11 | 28 | 8 | 0 | 9 |
| Hawkeye | 8 | 10 | 19 | 29 | 3 | 0 | 9 |
| Iowa Lakes | 5 | 12 | 0 | 4 | 27 | 0 | 15 |
| Kirkwood | 8 | 7 | 21 | 23 | 10 | 3 | 12 |
| Marshal-ltown | 7 | 8 | 12 | 26 | 4 | 0 | 13 |
| Northeast Iowa | 8 | 4 | 26 | 23 | 10 | 12 | 6 |
| Northwest Iowa | 12 | 7 | 18 | 9 | 24 | 15 | 9 |
| South-eastern | 10 | 5 | 6 | 18 | 10 | 13 | 12 |
| Western Iowa Technical | 7 | 0 | 20 | 31 | 4 | 6 | 6 |

# APPENDIX B:
# RECOMMENDED MECHANICAL DRAFTING AND DESIGN TECHNOLOGY CURRICULUM

| | |
|---|---|
| **FIRST SEMESTER (FALL--19 SH)** | |
| Introduction to Science and Technology | 2 |
| Applied Mathematics | 5 |
| Applied Science: Physics and Chemistry | 5 |
| Engineering Drawing 1 | 4 |
| English Composition | 3 |
| **SECOND SEMESTER (SPRING--19 SH)** | |
| Engineering Drawing 2 | 4 |
| Integrated Engineering Mechanics 1 | 5 |
| Metallurgy | 3 |
| Print Reading and Interpretation | 3 |
| Introduction to Sociology | 3 |
| **THIRD SEMESTER (FALL--19 SH)** | |
| Industrial Drafting and Design 1 | 5 |
| Integrated Engineering Mechanics 2 | 5 |
| Hydraulics and Pneumatics | 3 |
| Total Quality Concepts | 3 |
| Oral Communications | 3 |

# APPENDIX B:

## RECOMMENDED MECHANICAL DRAFTING AND DESIGN TECHNOLOGY CURRICULUM (CONTINUED)

FOURTH SEMESTER (SPRING--19 SH)

| | |
|---|---|
| Industrial Drafting and Design 2 | 5 |
| Industrial Electricity and Electronics | 3 |
| Engineering Economy | 1 |
| Computer Integrated Manufacturing | 5 |
| Creative Engineering Design | 2 |
| Engineering Reporting and Presentation | 3 |

# APPENDIX C

## COURSE DESCRIPTIONS

INTRODUCTION TO SCIENCE AND TECHNOLOGY 2 SH

Introduces the new technical student to some of the important principles and concepts that underlie technical practice. Topics include the technical curriculum and course content; program writing, reporting, and computational requirements; professional organizations; academic and professional survival skills; computers and automation; use of hand-held scientific calculator; problem-solving technique and flow-charting; vectors and vector operations; principles of measurement; selected algebraic, geometric and trigonometric principles; systems of units; unit conversions; elements of descriptive statistics; and technical vocabulary. Prerequisites: None.

APPLIED MATHEMATICS 5 SH

An intensive course in applied mathematics for terminal technical students. Emphasis is placed upon the development of computational competence, reasoning and critical thinking skills, and the solution of practical problems from a number of technical areas. The course includes topics in arithmetic; measurement and error; units and conversions; basic and intermediate algebra; plane, solid, and analytic geometry; elementary trigonometric functions; right and oblique triangle trigonometry; and vectors. Prerequisites:

One semester each of high school algebra and geometry with a grade of "B" or better, or appropriate remedial courses.

APPLIED SCIENCE: PHYSICS AND CHEMISTRY 5 SH

An intensive study of the basic principles of physics and chemistry emphasizing industrial and engineering processes. Prepares technical students for subsequent coursework in engineering mechanics, metallurgy, hydraulics, and electricity. Emphasis is upon fundamental and unifying principles and the development of computational competence in a range of applied technical problems. Prerequisites: One year of high school algebra and geometry with a grade of "B" or better. Corequisites: Applied Mathematics.

ENGLISH COMPOSITION 3 SH

A first college course in the principles of standard written English as applied to various forms of written discourse. This course emphasizes the development of expository writing skills. Prerequisites: Four years of high school English or appropriate remedial course(s).

ORAL COMMUNICATION 3 SH

Introductory treatment of the principles and methods of oral discourse including group and one-on-one communication, and listening skills. Prerequisites: Introduction to Science and Technology and English Composition.

ENGINEERING REPORTING AND PRESENTATION 3 SH

This course integrates all the educational experiences in the program by requiring the student to plan, research, develop, document, and report upon a complete design project undertaken as a part of the corequisite course in Creative Engineering Design. Emphasis throughout is upon project organization and documentation, critical thinking and problem-solving, and oral and written reporting and presenting. Prerequisites: English Composition and Oral Communication with a grade of "B" or better. Corequisites: Creative Engineering Design.

INTRODUCTION TO SOCIOLOGY 3 SH

An introductory course in the principles of human social structure. The topics included are social behavior, the nature of culture; human culture and human social groups; social institutions; development and importance of the individual personality and self on social systems; and social control. Prerequisites: None.

ENGINEERING DRAWING 1 4 SH

A first course in applied engineering graphics including both manual and CADD drafting techniques. This course is suitable for students in all technical majors. Topics include drawing tools and techniques, ANSI drawing standards, scaling, construction and layout practices, geometric constructions, lettering, elements of descriptive geometry; orthographic and multiview projection; industrial drafting conventions, sectional views, and elementary dimensioning and tolerancing practices. Prerequisites: None. Corequisites: Introduction to Science and Technology.

ENGINEERING DRAWING 2 4 SH

The second course in the engineering drawing sequence emphasizing both manual and CADD drafting techniques. Subjects include advanced topics from descriptive geometry, various types of projection systems and theories of projection; primary and secondary auxiliary views; revolutions, intersections, developments, pictorial drawing techniques, thread systems and threaded fasteners; descriptive statistics and statistical tolerancing; and computation of area, volume, mass, density, and weight of geometric solids. Prerequisites: Applied Mathematics, Applied Science: Physics and Chemistry, and Engineering Drawing 1. Corequisites: Print Reading and Interpretation.

PRINT READING AND INTERPRETATION 3 SH

A basic course on the reading and interpretation of engineering drawings stressing manufacturing applications. This course is to be taken in conjunction with the engineering drawing sequence, and emphasizes the development of skill in the three-dimensional visualization of objects from orthographic views, and interpretation of dimensions, tolerances, notes, and other specifications on engineering drawings, including geometric tolerances. Prerequisites: None. Corequisites: Engineering Drawing 1. Corequisites: Engineering Drawing 2.

INDUSTRIAL DRAFTING AND DESIGN 1 5 SH

An intensive laboratory course in applied engineering drawing using both manual and CADD drafting techniques. This course emphasizes the layout and detailing of industrial quality working drawings according to ANSI standards. Topics covered include ANSI standard limits and fits, surface finish and specification; material selection and specification; sheet metal computations; weldments and weld symbology; gears and splines; keys, keyseats, and keyways; detail and assembly drawings; and an introduction to the use of standard handbooks and manufacturer catalogs. Prerequisites: Engineering Drawing 1 and 2 with grade of "B" or better and Print Reading and Interpretation. Corequisites: Engineering Mechanics 2.

INDUSTRIAL DRAFTING AND DESIGN 2 5 SH

An intensive laboratory course in applied engineering drawing using both manual and CADD drafting techniques. This course emphasizes manufacturing tooling and tool drawing and design. Topics include tool materials and heat treatment; the design of cutting tools; locating principles and devices; fasteners; jigs and fixtures; gaging and gage design; design of and detail and assembly drawings for blanking, piercing, bending, forming, and drawing dies; group technology; and organization and administration of the tool design department. Prerequisites: Integrated Engineering Mechanics 2, Print Reading and Interpretation, and Industrial Drafting and Design 1 with a grade of "B" or better; and Metallurgy.

METALLURGY 3 SH

An introductory course on ferrous and non-ferrous metals, alloys, and composites. Topics include ferrous and non-ferrous metal production; classification and measurement of metal properties; structure of metals; metal solutions and phases; heat treatment; alloy designation systems; standard steels; and metal manufacturing processes. Prerequisites: Applied Mathematics and Applied Science: Physics and Chemistry. Corequisites: Integrated Engineering Mechanics.

INTEGRATED ENGINEERING MECHANICS 1 5 SH

An integrated treatment of the principles of statics, dynamics, and strength of materials. Topics include forces, vectors, and resultants; moments and couples; equilibrium; structures and members; equilibrium in three dimensions;

friction; rectilinear motion; angular motion; plane motion; kinetics; work, energy, and power; impulse and momentum; centroid and center of gravity; moment of inertia, stress and deformation; mechanical properties of materials, welded and riveted joints; torsion in shafts and couplings; and beams and columns. The emphasis throughout is upon the development of computational competence in elementary applied problems using standard handbooks and other reference materials. Prerequisites: Applied Mathematics and Applied Science: Physics and Chemistry with a grade of "B" or better; and Engineering Drawing 1. Corequisites: Engineering Drawing 2 and Metallurgy.

INTEGRATED ENGINEERING MECHANICS 2 5 SH

An elementary treatment of selected topics from kinematics and machine elements. The course emphasizes the development of computational and drafting competence and the utilization of standard reference materials including manufacturer catalogs and reference data in the design and specification of tooling. Topics include the four-bar linkage and other types of linkages and components; cams types and cam displacement diagrams; spur and bevel gears; spur and bevel gear systems; belt and pulley components and systems; sprocket and chain components and systems; bearings; mechanical fasteners; "O" rings and seals; springs; clutches and brakes; and tribology and lubrication. Prerequisites:

Integrated Engineering Mechanics 1 with a grade of "B" or better. Corequisites: Industrial Drafting and Design 1.

HYDRAULICS AND PNEUMATICS 4 SH

A components-oriented approach to the behavior of fluids and in the design of fluid power systems. Topics include basic fluid mechanics, energy in fluid systems, fluid flow, frictional losses, hydraulic fluids; hydraulic and pneumatic system components; hydraulic and pneumatic circuits; sizing of system components; system monitoring and control; and system design and specification including engineering drawings and schematic diagrams. Prerequisites: Applied Mathematics and Applied Science: Physics and Chemistry with a grade of "B" or better, Engineering Drawing 1 and 2, and Integrated Engineering Mechanics 1 with a grade of "B" or better. Corequisites: Engineering Mechanics 2.

INDUSTRIAL ELECTRICITY AND ELECTRONICS 4 SH

A basic course in the principles of electricity and electronics with industrial applications. Topics include electrical units, DC circuits, conductors; energy and power; batteries, magnetism, induction, DC generators, alternating current; single and three phase circuits; transformers and regulators; semiconductor devices, DC motors and controls; polyphase motors and controls; synchronous motors, single phase motors, protective equipment, switchgear, electrical measurement and instrumentation; and industrial control circuits. Prerequisites: Applied Mathematics and Applied Science: Physics and Chemistry, both with a grade of "B" or better.

TOTAL QUALITY CONCEPTS 3 SH

An overview of quality technology with an emphasis on quality as the driving force in modern global manufacturing. Topics include definitions and the vocabulary of quality; ISO 9000 certification, the emergence of the global quality culture; essentials of descriptive statistics; precision measurement and dimensional metrology; statistical control charts for attributes and variables; process capability indices, and an introduction to experimental methods and hypothesis testing. Prerequisites: Applied Mathematics. Corequisites: Engineering Economy.

ENGINEERING ECONOMY 1 SH

An introduction to selected topics in engineering economics, statistics, production management, industrial management principles and methods; management ethics, and management strategy. Emphasis is upon an integrating approach to the economic and managerial aspects of the manufacturing organization. The use of computing technology is stressed throughout. Prerequisites: Introduction to Science and Technology and Applied Mathematics.

COMPUTER INTEGRATED MANUFACTURING 5 SH

A course on the integration of the manufacturing environment using computer communication and control. Topics include introduction to and the evolution of manufacturing systems; part design and specification; process engineering, fixed and flexible automation; programmable logic controllers, data communication and computer networks in manufacturing; file formats and data transmission protocols; numerical control, numerical control programming, industrial robotics, group technology, process planning, artificial intelligence and expert systems in manufacturing; CAPP systems, and planning manufacturing systems. Prerequisites: Applied Mathematics, Introduction to Science and Technology. Corequisites: Engineering Economy.

CREATIVE ENGINEERING DESIGN 2 SH

An overview of the creative design process as a learned skill rather than an innate ability. Topics include problem-solving paradigms and human information processing; qualitative problem description; computer aids in mechanical design; the human element in design; specific techniques for conceptual and product design activities; and written technical reporting and formal oral presentation. Prerequisites: Introduction to Science and Technology, Industrial Drafting and Design 1; Integrated Engineering Mechanics 1 and 2, and Total Quality Concepts.

# APPENDIX D:

## SURVEY INSTRUMENT CONTENTS

The substantive contents of both versions of the survey instrument are shown below. While the information provided in this Appendix is accurate, the appearance of the actual survey instrument differed considerably from that shown below.

### Section 1 of Manufacturer Version of Survey Instrument

This section asks for some basic information about your company in order to better understand the specific context of your educational needs. Please fill in the required information or mark the appropriate response in the space provided.

1.1 How many people are employed in your company (all locations)? __________

1.2 How many people are employed as mechanical drafters or designers in your company (all locations)? __________

1.3 How many mechanical drafters or designers hold an Associate Degree in Mechanical Drafting and Design Technology? __________

1.4 How many mechanical drafters or designers perform their work at a drawing board? __________

1.5 How many mechanical drafters or designers perform their work at a CADD terminal or workstation? __________

1.6 How many CNC machine tools and/or CNC machining centers are in use in your company? __________

1.7 How many lasers are in use in your company? __________

1.8 How many robots are in use in your company? __________

1.9 How many manufacturing or work cells are used in your company? __________

1.10 What type of CADD platform is most used in your company?

() None () Mainframe computer () Minicomputer () Engineering Workstation () PC Workstation

1.11 If your CADD hardware consists of Personal Computer workstations, are these:

() Not applicable () IBM or IBM compatible () Apple Macintosh

() A mix of IBM (or compatible) and Apple Macintosh

() Other ______________________________________________

1.12 Are the CADD facilities in your company linked by a Local Area Network?

() Not Applicable () No, not at all () Partially

() Yes, completely

1.13 Are the CADD facilities in your company linked to the CNC machine tools in the shop?

() Not Applicable () No, not at all () Partially

() Yes, completely

1.14 What is the primary type of CADD software used in your company?

() AutoCAD () CADKEY () CADDAM () CADMAX () EasyCAD

() DesignCAD () DrafixCAD () GenericCAD () IBM CAD

() MicrografxCAD () Pro/ENGINEER () RoboCAD () LaserCAD

() SonnetCAD () TurboCADD () VersaCADD () CADD is not in use

() Other ______________________________

1.15 Are any of the rapid prototyping technologies listed below used in your company?

() Selective Laser Sintering () Fused Deposition Modeling

() Stereo-lithography () Laminated Object Manufacture () No

1.16 What is the status of your company relative to certification under ISO 9000?

0 Not certified 0 Considering certification

0 Certification in progress 0 Certified

1.17 If considering or undergoing certification, or certified under ISO 9000, which standard?

0 Not applicable 0 ISO 9001 0 ISO 9002 0 ISO 9003

1.18 Is CADD technology used for mechanical drafting and design in your company?

| Never | | Frequently | | Always |
|---|---|---|---|---|
| 01 | 02 | 03 | 04 | 05 |

1.19 Are concurrent engineering methods used in your company?

| Never | | Frequently | | Always |
|---|---|---|---|---|
| 01 | 02 | 03 | 04 | 05 |

1.20 Are Just-In-Time inventory management methods used in your company?

| Never | | Frequently | | Always |
|---|---|---|---|---|
| 01 | 02 | 03 | 04 | 05 |

1.21 Are competitive benchmarking techniques used in your company?

| Never | | Frequently | | Always |
|---|---|---|---|---|
| O1 | O2 | O3 | O4 | O5 |

1.22 Are self-directed, multi-disciplinary work teams used in your company?

| Never | | Frequently | | Always |
|---|---|---|---|---|
| O1 | O2 | O3 | O4 | O5 |

1.23 Is flow-management technology used in your company?

| Never | | Frequently | | Always |
|---|---|---|---|---|
| O1 | O2 | O3 | O4 | O5 |

## Section 2: Associate Degree Curriculum Components

The information derived from this section will help determine what specific courses of study ought to be included in the two-year Associate Degree Mechanical Drafting and Design Technology program. A number of one-semester course titles that may typically be included in a Mechanical Drafting and Design Technology program are shown below. Please indicate your opinion of the importance of each course by marking the appropriate response on the numerical scale provided. [A sample 5-point Likert scale is shown below].

| Not Important | | Important | | Very Important |
|---|---|---|---|---|
| O1 | O2 | O3 | O4 | O5 |

2.1 Fundamentals of Science & Technology

2.1 Fundamentals of Science & Technology

2.2 Technology and Society

2.3 College Algebra

2.4 College Trigonometry & Analytic Geometry

2.5 Applied Mathematics

2.6 Computer Software Applications

2.7 Computer-Aided Drafting & Design

2.8 Computer Integrated Manufacturing

2.9 Survey of Physical Sciences

2.10 Technical Physics

2.11 Applied Science: Physics & Chemistry

2.12 Technical Writing

2.13 English Composition

2.14 Oral Communication

2.15 Human Relations in the Workplace

2.16 General Psychology

2.17 Introduction to Sociology

2.18 Statics

2.19 Dynamics

2.20 Strength of Materials

2.21 Integrated Engineering Mechanics

2.22 Applied Thermodynamics

2.23 Applied Fluid Mechanics

2.24 Mechanisms and Kinematics

2.25 Machine Design

2.26 Metallurgy

2.27 Engineering Materials

2.28 Senior Team Mechanical Design Projects

2.29 Total Quality Concepts

2.30 Creative Engineering Design

2.31 Engineering Reporting and Presentation

2.32 Engineering Economy

2.33 Statistical Process Control

2.34 Engineering Drawing

2.35 Industrial Drafting & Design

2.36 Mechanical Drafting and Design

2.37 Print Reading & Interpretation

2.38 Geometric Dimensioning and Tolerancing

2.39 Descriptive Geometry

2.40 Tool Drafting and Design

2.41 Manufacturing Processes

2.42 Manufacturing Tooling

2.43 Machine Tool Operations

2.44 Hydraulics and Pneumatics

2.45 Industrial Electricity & Electronics

2.46 Other ______________________________________

## Section 3: Drafting Practices

The information derived from this section will help determine how drafting is done in your firm, and how it should be taught in an Associate Degree Mechanical Drafting and Design Technology programs. Please indicate your opinion by marking the appropriate response on the numerical scale provided. [A sample 5-point Likert scale is shown below].

| Strongly Disagree | | Neutral | | Strongly Agree |
|---|---|---|---|---|
| O1 | O2 | O3 | O4 | O5 |

3.1 In industry, drafters and designers must be skilled in both manual and CADD drafting.

3.2 Before an individual can be a good CADD operator, she or he must first be a skilled manual drafter.

3.3 In colleges, manual drafting skills must be well developed before CADD is introduced.

3.4 In industry, manual drafting should be replaced entirely by CADD.

3.5 Colleges should teach generic CAD skills rather than a specific CADD software package.

3.6 In industry, design creativity is lost when manual drafting is replaced by CADD.

3.7 The primary value of manual drafting techniques is in teaching the principles of drafting.

3.8 Colleges should replace instruction in manual drafting techniques with CADD drafting techniques.

3.9 Colleges should teach manual drafting techniques concurrently with CADD drafting techniques.

3.10 In colleges, the amount of training in CADD drafting should be the same as that for manual drafting.

3.11 In industry, the primary advantage of CADD over manual drafting is a gain in productivity.

3.12 Some topics in drafting can only be taught through the use of manual drafting techniques.

3.13 The individual drafter should be allowed to use the drafting technique, either manual or CADD, with which he or she is most proficient.

## Section 4: Occupational Skill Certification

This section will help determine the importance of occupational skill certification for your drafting and design employees. In addition, this information will guide efforts in making occupational skill certification a part of the Associate Degree Mechanical Drafting and Design program. Please indicate your opinion by marking your response on the numerical scale provided. [A sample 5-point Likert scale is shown below].

| Strongly Disagree | | Neutral | | Strongly Agree |
|---|---|---|---|---|
| O1 | O2 | O3 | O4 | O5 |

4.1 Some form of nationally standardized and administered occupational skill certification is necessary for all entry-level employees.

4.2 Occupational skill certification administered by professional technical societies is a definite asset for an entry-level employee.

4.3 Current employees should be encouraged to seek occupational skill certification that is offered through professional societies.

4.4 Employers should help employees defray the cost of occupational skill certification offered through a professional society.

4.5 Employees who attain occupational skill certification offered through a professional society should be paid at a higher rate than employees who are not similarly certified.

4.6 Promotional preference should be given to employees who attain occupational skill certification through a professional society.

4.7 Hiring preference should be given to applicants who possess occupational skill certification through a professional society.

4.8 Colleges should include preparation for occupational skill certification examinations offered by a professional society.

4.9 I would prefer that a graduate of an Associate Degree program in Mechanical Drafting and Design Technology demonstrate occupational competence by being certified as a(n):

0 0 No preference; all are equally acceptable

0 1 None; occupational certification is unnecessary

0 2 ADDA Certified Drafter

0 3 ADDA Certified Mechanical Drafter

0 4 NOCTI Certified Machine Drafter

0 5 SME Certified Manufacturing Technologist

0 6 ASCET Certified Mechanical Engineering Technician

0 7 ASQC Certified Quality Technician

0 8 I am not familiar with any of these certification programs