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CAD associate degree programs in public post-secondary eduaction.

Xin-Ran Duan
Indiana State University

To My Parents

ZI-MEI DUAN and XUAN-ZHI YUAN

in loving memory

VITA

XIN-RAN DUAN

Education:

- May 2003, Ph. D. in Administration of Higher Education, Indiana State University. GPA 3.53.
- August 1992-May 1994, Ph. D. studies in Mechanical Engineering, University of Akron. GPA 3.68.
- May 1992, Master of Science in Mechanical Engineering, University of Oklahoma. GPA 3.78.
- July 1984, Diploma, Major: English. Xi'an Foreign Language Institute, China.
- December 1968, Bachelor of Science in Mechanical Engineering, Xi'an Jiaotong University, China. GPA 3.92.

Professional Experience:

- 1993-Present, Chair and Professor, Design Technology (Mechanical, CAD/CAM, Architecture, and Civil) Ivy Tech State College, Columbus, Indiana.
- 1993, Tutor of the Minority Engineering Program, University of Akron.
- 1992, Tool Engineer, B & C, Barberton, Ohio.
- 1990-1992, Instructor, School of AME, University of Oklahoma.
- 1987-1990, Assistant Professor, Lanzhou Railway University, China.
- 1986-1987, Research Associate, School of Engineering, Widener University.
- 1984-1986, Research Associate and Fellow, Drexel University.
- 1979-1984, Assistant Professor, Lanzhou Railway University.
- 1972-1979, Senior Engineer, Lanzhou Locomotive Factory, China.
- 1968-1972, Process Engineer, Xi'an Machine Tools Factory, China.

Honors and Scholarships:

- President's Award for Excellence in Instruction, Ivy Tech State College, June 2002.
- Award for Indiana State University Graduate School Research Fund, March 2001.
- Lexington Who's Who, 1999/2000, 2000/2001.
- Innovation Award, Ivy Tech State College, February 1999.
- Five Years' Service Award, Ivy Tech State College, 1998.
- Research Grant from Columbus Teacher's Network, 1998.
- Graduate Scholarship, University of Akron, 1992.
- Teaching Assistantship, University of Oklahoma, 1990-1992.
- "Excellence Research Paper" Award, Lanzhou Railway University, 1989.
- "Teaching for Excellence" Award, Lanzhou Railway University, 1988.
- Scholarship to study abroad by Chinese Railway Ministry, 1984.
- "Excellent Engineer and Technical Reformer" award, Lanzhou Locomotive Factory, 1978.
- "Excellent Employee" Awards, Xi'an Machine Tools Factory, 1970,1971.

XIN-RAN DUAN

Professional Memberships:

- American Society of Mechanical Engineers (ASME)
- American Design Drafting Association (ADDA)
- National Association of Industrial Technologies (NAIT)
- American Association of University Professors (AAUP)
- International Network for Engineering Education and Research (iNEER)

Selected Publications:

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CAD ASSOCIATE DEGREE PROGRAMS IN PUBLIC POST-SECONDARY EDUCATION

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by

Xin-Ran Duan

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APPROVAL SHEET

The Dissertation of Xin-Ran Duan, Contribution to the School of Graduate Studies, Indiana State University, Series III, Number 934, under the title *CAD Associate Degree Programs in Public Post-Secondary Education* is approved as partial fulfillment of the requirements for the Doctor of Philosophy Degree.

April 10, 2003
Date

Rebecca W. Liblers
Committee Chairperson

Anthony F. Gilbert
Committee Member

Joshua B. Powers
Committee Member

April 10, 2003
Date

Stephen S. Connelly
For the School of Graduate Studies

ABSTRACT

This study investigated what community colleges were teaching in CAD associate degree programs in manufacturing and construction fields, and what knowledge and skills were required to empower CAD students to become successful in the workplace. In order to better meet business and industry needs, a model curriculum for CAD associate degree programs was developed and presented. This model curriculum could more effectively prepare students with the required knowledge and skills for successful employment.

A three-round Delphi technique was used to collect data from CAD professors at community colleges and experts in industry. A total of 32 members in the Panel of Institution Experts, and a total of 30 members in the Panel of Industry Experts were selected from 29 states in four regions of the United States using a stratified random sampling method. The analysis of demographic data revealed geographic representation, professional background, and rich experience for the members of the two panels. The study found that AutoCAD was dominant in industry for CAD applications, and AutoCAD was the primary software used for CAD programs at community colleges. Also, the study found that all the surveyed colleges were accredited by six major regional accreditation agencies, and all the colleges were satisfied with program outcomes. In addition, a list of forty-seven items of required knowledge and skills were identified by the two panels, which should be included in the model curriculum as key elements.

As a result of the study, a model curriculum, containing a core curriculum with 24 courses in four categories plus suggested general education courses, was validated by the two panels. This ideal curriculum for CAD associate degree programs provided a combination of solid theoretical foundation, classroom studies, and laboratory practice. To make it deliverable at community colleges, adjustments may be necessary to accommodate general education courses and the core curriculum courses for an individual college.

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Chapter 1

INTRODUCTION

Computer aided drafting (CAD) is an example of technological innovation that has had a significant impact on the design and manufacturing industry and other fields. The rapid pace of technological change requires responses and innovative approaches from institutions of higher education. Therefore, "the development of high-technology programs has become a major concern for post-secondary colleges across the country" since the early 1980s (Abram, Ashley, Hofmann, & Thompson, 1983, p. vii).

Several studies addressed the impact of CAD technology on college programs. Jeswiet and Surgenor (1985) conducted a survey to determine how industry feels about the technological progress and to seek advice on how to update the educational programs. As a result of their study, they concluded that an educational program "must continually adapt and upgrade its courses to remain in tune with the changing technology" (p. 41). Richards (1985) described an appearance of adequate CAD educational programs and stated: "Most American colleges and universities are struggling to catch up with developments in computer aided design and manufacturing" (p. 19). They "have to adjust to the new realities of education and devise innovative ways to meet the demands of their expanding constituency" (p. 24).

Hill (1993) conducted a study about the impact of CAD on both the apparel industry and college apparel design program in Quebec, Canada. Hill sought to determine what knowledge and skills were needed to empower apparel designers to be successful in work environments with advanced technologies, and how corresponding college programs assisted students to understand and use the technologies. According to the result of the study, Hill noted that: "This study needs to be replicated both in other provinces and countries, and in other professional fields where college programs correspond to the world of work" (p. 249).

In addition, attention was paid to the issues related to community colleges in regard to the scarcity of the labor market for qualified CAD technicians. Abram et al. (1983) wrote that: "As two-year post-secondary colleges attempt to respond to the need for technicians, they may encounter a number of significant problems" (p. 2). One problem was obtaining the necessary public funding for program approval and implementation on the basis of occupational demands. Another problem was the burden that the development of new technology programs placed on educators. Full-time faculty members had limited time outside their teaching duties to develop and upgrade programs as well as to continue their own professional growth. More investigations were needed in order to aid educators in planning programs, gathering up-to-date information and advice, finding funding, receiving accreditation, and implementing high quality programs. Abram et al. noted: "Because of the speed and revolutionary nature of many new technical advances, access to up-to-date information needed to design core courses and programs is seriously limited" (p. 3).

Moreover, several studies have called for additional research that would bring consistency between community college preparation and the needs of business and industry in regard to the conceptual framework, required knowledge and skills, and cognitive outcomes of community college graduates. Wicklein and Rojewski (1999) conducted a study about developing a unified curriculum framework for technology education. A conceptual framework was needed for a college technology curriculum. There were a variety of curriculum strategies for technical education. Curriculum designs ranged from technical performance reflective of early 20th century manual arts such as woodworking, metal fabrication, and drafting to state-of-the-art learner-centered approaches in technology programs such as problem solving, critical thinking, engineering, and a multidisciplinary approach. Curriculum that emphasized technical content tended to be rather short lived and was constantly changing due to the rapid accumulation of knowledge and techniques used in business and industry. Their study "may contribute to a dialogue about the possibility and desirability of identifying a basic, unifying force for curriculum planning in technology programs" (Wicklein & Rojewski, 1999, p. 41).

A Delphi study (Wilhem, 1999) identified the required knowledge and skills for entry-level workers in Arizona. Wilhem noted: "The objectives of the identified skills and competencies are intended to afford entry-level workers personal and financial success in the workplace and become conscientious and contributing members of society" (p. 105). Based on the result of his study, Wilhem recommended educators "replicate similar studies in other geographical locations within the U.S." (p. 120).

Larson and Wissman (2000) conducted a Delphi study about critical academic skills. The purpose of the study was to define a finite list of critical academic skills for Kansas' community college graduates. This three-round Delphi technique used a panel of 23 members who were academic deans and faculty members in the State of Kansas. As a result of the study, a list of critical academic skills within 14 categories was provided. Larson and Wissman (2000) noted: "Critical academic skills are measures of student performance that specifically related to intended cognitive outcomes of college graduates" (p. 44). As a conclusion, they wrote: "the critical academic skills that should be the hallmark of associates' degree graduates of Kansas community colleges" (p. 45). Finally, Larson and Wissman suggested that: "Community college faculty should be encouraged and supported in their efforts to assess each of these critical academic skills within the context of individual courses and programs" (p. 52).

To respond to the needs of business and industry today, community colleges have developed CAD programs for students. However, there are a limited number of research studies that have sought to investigate how well students' preparation at community colleges aligns with the needs of business and industry. According to the review of related literature and research, it was found that no reliable, systematic study on CAD programs in manufacturing and construction fields at community colleges has been available.

In order to align community college outcomes with workplace demands, it would logically follow to conduct a nationwide investigation with two populations: industrial experts and community college CAD professors. Specifically, the researcher investigated what community colleges were teaching in CAD associate degree programs in

manufacturing and construction fields, and what knowledge and skills professional experts from industry believed were required to empower CAD students to become successful in the workplace.

This study was a qualitative study that relied on a Delphi technique for both the Panel of Industry Experts that consists of thirty members and the Panel of Institution Experts that consists of thirty-two members. These panel members were selected by a stratified random sampling method nationwide in the United States. Through three rounds in the Delphi process, a consensus of both panels was reached, and a model curriculum for CAD associate degree programs was validated by the two panels.

Statement of the Study

The purpose of this study was to determine what knowledge and skills were needed of CAD students to become successful at work, and how the corresponding community college programs could provide an ideal curriculum for CAD students. A Delphi technique was used to collect data from CAD professors at community colleges and industrial CAD experts. In order to better meet today's business and industry needs, a model curriculum for CAD associate degree programs was then proposed.

Little research has been done to inform curriculum and content decisions in CAD programs at community colleges. At the same time, the rapid technological development requires innovative educational approaches. This implies that what is currently taught may not match the needs of business and industry. Therefore, the problem of this study was to determine how CAD associate degree programs at community colleges in the

United States could more effectively prepare students with the required knowledge and skills for successful employment.

Research Questions

This study sought to address the following research questions:

1. What knowledge and skills do CAD Associate degree students need for successful employment?
2. What were the knowledge and skills taught to CAD associate degree students at community colleges?
3. What was the ideal curriculum for CAD associate degree programs?

Significance of the Study

The researcher of this study facilitated discussions between CAD professors at community colleges and experts in the drafting field to bring consistency between community college preparation and the needs of business and industry. As a result of this study, a model curriculum for CAD associate degree programs was developed and proposed. The results of this study could be beneficial to society at large, to prospective employers of industry, to professional organizations, to educators at both post-secondary and secondary education levels, and to CAD students.

Delimitations

1. This study was limited to CAD (Computer Aided Drafting) associate degree programs in public two-year institutions in the United States.

2. In this study, CAD programs were limited to the manufacturing and construction fields, including mechanical, architectural, and civil areas. It did not include art design, graphic design, advertisement design, and costume design.

3. The study was to be focused on associate degree CAD programs, but it did not include associate degree engineering programs.

4. A stratified random sampling method was used to select industry experts. The industry experts used in the Delphi process were randomly selected from four regions of the United States, using the Directory of the American Design Drafting Association (ADDA). The membership of the American Design Drafting Association was representative of designers, drafters, engineers, architects, managers, and supervisors in industry (*ADDA*, 2000).

5. A stratified random sampling method was also used to select institution experts. The institution experts used in the Delphi process were randomly selected within four regions of the United States from 323 two-year colleges that were identified from the directory of public vocational-technical institutions (Gabriel, 1998). All the subjects were from two-year community and technical colleges.

Limitations

1. The selection of industrial experts was restricted to the industrial members of the American Design Drafting Association (ADDA).

2. The selection of institution experts was restricted to CAD professors at community colleges.

3. The industrial experts and institutional experts subjects were selected within four regions of the United States. However, the subjects may not be selected from every state due to the limited number of selected subjects in the samples.

4. The survey instruments used for pre-survey and each round in the Delphi process of this study were developed and designed by the researcher.

Assumptions

1. The Delphi technique could be used to collect data to develop a model curriculum for CAD programs and to determine if consensus existed among the experts for the contents of this curriculum.

2. The selected industrial experts were in a position to identify the required knowledge and skills for CAD graduates and to evaluate the model curriculum.

3. The selected professors of CAD courses at public two-year colleges were in a position to identify the required knowledge and skills taught to CAD associate degree students and to evaluate the model curriculum.

Definition of Terms

1. CAD—This acronym denotes computer aided design and drafting. It is a widely used term and most typically associated with engineering and architectural applications for computer graphics. CAD means software applications that allow designers and architects to make precise drawings on the computer screen, then model them in three dimensions to see how the design would appear in an actual situation before it is manufactured (Collin, 1997; Dillon & Leonard, 1998).

2. CAD/CAM—This term is an acronym for computer-aided design and computer aided manufacturing. CAD/CAM denotes software applications used by engineers for the graphic design of components of products and manufacturing processes, including the CAD and CAM portions. Once components of a product were designed, they could be manipulated on a computer screen and evaluated. CAM applications extrapolate manufacturing specifications from the CAD designs and may further control manufacturing processes (Hansen, 1998; Spencer, 1993).

3. Technology—This term means "systematic knowledge and action, usually of industrial processes but applicable to any recurrent activity" (*McGraw-Hill Encyclopedia*, 1992, p. 151). Technology is a Greek word derived from the synthesis of two words: techne (meaning art) and logos (meaning logic or science). So loosely interpreted, technology means the art of logic or the art of scientific discipline. Formally, it has been defined as a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome (Rogers, 1995). Helms (2000) noted that "technology encompasses both tangible products, such as the computer, and knowledge about processes and methods, such as the technology of mass production introduced by Henry Ford and others" (p. 933).

4. Post-secondary education—This term denotes the level of instructional programs designed for students who have completed high school and graduation requirements. This level includes technical college, community college, and two-year university programs as well as regular college and university curricula (Good, 1973).

5. Community college—This term denotes a two-year institution of higher education, generally public, offering instruction adapted in content, level, and schedule to

the needs of the community in which it is located. Offerings usually include a transfer curriculum (credits transferable toward a bachelor's degree), occupational (or terminal) curricula, general education, and adult education (Baker III, 1994). Cohen and Brawer (1996) referred to the community college as any institution accredited to award the Associate in Arts or the Associate in Science as its highest degree. That definition included comprehensive two-year colleges as well as many technical institutes, both public and private. In the current study, community college specifically means the public two-year colleges.

6. Technical education—This is "a type of education that emphasizes the learning of a technique or technical procedures and skills and aims at preparing persons in the technical areas" (Good, 1973, p. 590). "Technical education includes general education, theoretical, scientific and technical studies and related skill training. The components of technical education may vary considerably depending on the type of personnel to be prepared and the education level" (*Terminology*, 1978, p. 17). Originally, technical education did not lead to a degree or carry college credits, but more commonly today involves transferable college credits and leads toward a degree in technology areas at a college or university.

7. Vocational education—The term refers to the education designed to prepare students for employment in careers, jobs or occupations requiring technical knowledge and skills. It is designed to impart necessary knowledge and develop essential skills in a chosen occupational field, but is preparatory in nature. Vocational education usually includes general education and practical training for the development of skills required by

the chosen occupation and related theory (*Terminology*, 1978). Currently, Career and Technical Education is often used for vocational education.

8. Delphi technique—This technique was developed by the Rand Corporation in the 1950s, named after the Delphic oracles in ancient Greece who prophesied the future. The Delphi technique is an interactive process designed to query an interested group of experts assembled around a specific topic for the purpose of reaching a consensus of opinions on issues related to that topic. The Delphi technique is a good approach intended to elicit and refine the opinions of a group of people. The process is repeated for several rounds until the investigator feels that positions are firm and agreement on a topic is reached (Brooks, 1979; Corsini, 1999; *Delphi technique*, 1994).

9. Likert scale—This term refers to a measure of attitudes where a participant responds to a series of statements on a continuum from strongly agree to strongly disagree. For example, the categories of strongly agree to strongly disagree form a five-point Likert scale. The scaling procedure has been used in research studies to evaluate a specific issue with numerical values since its introduction in the 1930s (Corsini, 1999).

10. Curriculum—This term denotes an organized program for specified educational goals corresponding to different levels of knowledge, skills, and qualification. As defied in this study, curriculum specifically means a list of the various courses for a two-year program.

Summary and Outline of Dissertation

The purpose of this study was to determine what knowledge and skills were needed of CAD students to be successful in the workplace, and how community college

CAD programs could provide students with an ideal curriculum to better achieve this goal. Chapter One provided a brief context for the study as well as articulated the problem and purpose statements, the significance of the study, its delimitations, and finally a definition of important terms. Chapter Two reviews the related literature while Chapter Three presents the methodology. Chapter Four presents the results while Chapter Five offers discussion, conclusions, implications, and recommendations of the study.

Chapter 2

REVIEW OF RELATED LITERATURE AND RESEARCH

This chapter provided a review of literature and research for this study. In this chapter, the researcher reviewed the history of CAD program development, and applications of the Delphi technique.

The literature reviewed for the study was drawn from various sources. A computerized search of several databases was conducted, including the Educational Resources Information Center (ERIC), Dissertation Abstracts International (DAI), Online Computer Library Center (OCLC), Proquest, and Wilson Web. In addition to the databases, a more comprehensive search of sources was also conducted, including library references, handbooks, directories of organizations, college catalogs, books, journals, magazines, research reports, and doctoral dissertations. Literature copies and doctoral dissertations were obtained through Inter-library loan.

A History of CAD Program Development

As a technological innovation, CAD technology has developed for the past five decades since the 1950s. Today, it has become very popular in business and industry. Several studies discussed CAD development and its significant milestones in history. In reviewing the literature, the following four phases were identified and addressed: 1)

Appearance of CAD technology, 2) The early CAD educational programs, 3) CAD update and maturity, and 4) The current CAD programs at community colleges.

Appearance of CAD Technology

Originally, the computer was a calculating tool for scientific research or military application purposes. After World War II and during the 1950s, research on interactive computer graphics progressed. Subsequently, in the 1960s the term CAD first appeared (Zeid, 1991).

The Massachusetts Institute of Technology played a significant role as a pioneer in the development of interactive computer graphics. One example was that MIT was able to produce simple pictures by interfacing a television-like CRT (cathode ray tube) with a Whirlwind computer in 1950 (Zeid, 1991). Another example was the creation of Sketchpad. A MIT graduate student, Ivan Sutherland, presented the Sketchpad system in 1962. Ibrahim Zeid, a professor at Northeastern University, noted: "The Sketchpad system was a dramatic event because it demonstrated that it was possible to create drawings and alterations of objects interactively on a CRT" (p. 9).

In the 1960s several large companies developed CAD systems for industrial applications. For example, in 1964 General Motors announced their DAC-1 (system design augmented by computers). In 1965, Lockheed Aircraft Company initiated the CADAM system, and Bell Telephone Laboratories launched their GRAPHIC 1 system (Zeid, 1991).

The number of CAD users rapidly increased after more CAD systems were provided. At the end of the 1960s, only 200 workstations were operating at large

aerospace and automotive companies and government labs. However, the number of users started to climb and was estimated to be more than twenty-five thousand in 1983. The rapid increase in the number of CAD users may be accounted for, in large part, by the declining costs of hardware and software and by the new development of CAD systems (Abram, et al., 1983).

The Early CAD Educational Programs

Most American colleges and universities were struggling to catch up with developments of CAD. They had to adjust to the new realities of education and devise innovative ways to meet the demands of their expanding constituency (Abram et al., 1983; Jeswiet & Surgenor, 1985; Richard, 1985). The early CAD educational programs appeared at the beginning of the 1980s.

Abram et al. (1983) wrote:

> As has happened with other technological innovations, the marketplace of potential CAD/CAM users is not well prepared to integrate such innovations into ongoing production systems. In the case of computer aided design, the availability of a trained work force to interact productively with CAD systems has lagged behind the development of hardware and software. Training programs to prepare skilled CAD and CAM technicians for jobs in business and industry have only recently began to appear in post-secondary colleges....
>
> . . . The rapid pace of technological change is a most significant condition, as exemplified by the fast-spreading adoption of complex, computer-directed technologies such as robots and computer-assisted engineering by major

> manufacturing industries. The pace of such change requires innovative approaches from schools in gathering up-to-date technological information for planning course content, in upgrading or recruiting needed teaching staff, and in gaining access to highly specific and expensive equipment. (p. 2)

Basically, the innovative approaches of educators were funneled into two phases related to the appearance of CAD. The two phases included: 1) Major research and development initiatives for engineering programs in four-year universities, 2) Introducing CAD into the traditional drafting programs in post-secondary colleges and secondary schools.

On the one hand (i.e. on the research phase in universities), several universities with strong engineering programs made great contributions to research and development initiatives. One good example was the College CAD/CAM Consortium in the early 1980s (Richards, 1985).

The College CAD/CAM Consortium, or 4C, was a cooperative approach to the development of instruction materials for CAD/CAM engineering programs. Faculty at member schools developed instructional modules to teach concepts, principles, or techniques related to CAD/CAM. The instructional materials were exchanged among the member schools. The consortium initially consisted of 12 schools: Carnegie-Mellon University, Cornell University, Dartmouth College, Duke University, Georgia Institute of Technology, Illinois Institute of Technology, North Carolina State University, Rensselaer Polytechnic Institute, John Hopkins University, University of Florida, University of Virginia, and Washington University in St. Louis. The consortium was funded by the

National Science Foundation, and later expanded to include other schools and industry sponsors.

On the other hand (i.e. on the drafting phase in post-secondary and secondary education), a significant trend for CAD programs was 'introducing CAD into the traditional drafting programs' at post-secondary colleges and secondary schools (Audi, 1987; Bertoline, 1988; Isabell et al., 1988; Lewis, 1990; Rintamaki, 1987). Several studies addressed the role of the computer in engineering graphics, in particular, the influence of microcomputers on drafting programs. Audi (1987) noted:

> The availability of microcomputers with their ever increasing capabilities at affordable prices has given educators an opportunity and a challenge. The opportunity lies in equipping our graduates with computer handling capacities that could make the difference between successful and mediocre professionals. The challenge lies in how to incorporate the use of these tools in the ever crowded curricula and in how to teach the application of these tools without harming the basic pedagogical principles. (p. 22)

"In most engineering and technology programs, engineering graphics is a basic component of the curriculum. Representing the world graphically is a fundamental communications skill used by designers, engineers, and drafters to change their conceptual design into sketches or engineering drawings" (Bertoline, 1988, p. 18). A good example was that: "In engineering, 92 percent of the design process is graphically based. The other 8 percent is divided between mathematics, and written and verbal communications. Why? Because graphics serves as the primary means of communication for the design process" (Bertoline, Wiebe, Miller, & Nasman, 1995, p. 6).

For this reason, the drafting program was one of the popular traditional technical programs in both post-secondary and secondary education.

Isabell and Lovedahl (1988) indicated: "The proliferation of micro-CAD has placed virtually every post-secondary drafting program into the position of being able to introduce students to CAD" (p. 13). They concluded in their study: "the large selection of hardware and software makes it possible to implement CAD into almost any size program" (p. 14).

In addition to post-secondary education, secondary education in the United States was also influenced by CAD technology development. A good example was a study on Montana high schools by Rintamaki (1987). Rintamaki (1987) conducted a survey of drafting programs for 153 public secondary schools for the State of Montana, and found that 19.2% of the schools owned CAD equipment at that time. Another example was that Lewis (1990) discussed CAD hardware and software applications for high school students. Lewis wrote: "Computer Aided Drafting offers you an opportunity to increase the level of creativity now existing in your program" (p. 21). Lewis also told his students: "You will discover that CAD truly is fun" (p. 21).

CAD Upgrade and Maturity

The integration of CAD with CAM for the new CAD/CAM technology and the solid modeling theory were the most important developments from 1980 to 1990 (Zeid, 1991):

> The management in various industries began to realize the impact of the then new CAD/CAM technology on improving productivity in the late 1970s. Engineers

> have been stretching the technology beyond drafting since then. They have demanded various design and manufacturing applications from CAD/CAM vendors who have been responding successfully within the existing limits of hardware, software, and the basic theories underlying the field. Consequently, the decade of the 1980s can be identified as the CAD/CAM heady years of research. New theories and algorithms have evolved. An essential goal for this decade is to integrate and/or automate the various elements of design and manufacturing to achieve the factory of the future. The major research focus is to expand CAD/CAM systems beyond three-dimensional geometrical design and provide more engineering applications....
>
> . . . Another significant achievement is the acceptance and growing credibility of the solid modeling theory. The fundamental potential of solid modeling lies in the fact that it provides unique and unambiguous geometric representations of solids, which, in turn, helped automate and/or support design and manufacturing applications. (pp. 9-10)

Several studies addressed the new development of CAD technology during the past decade, for example, the 'one-stop design and analysis' concept was introduced (Deitz, 1997). The new development of CAD technology showed that CAD technology had reached its maturity in integrating and automating design and manufacturing applications.

Daues and Meeker (1993) emphasized 'keeping ahead of the CAD/CAM curve' in the 1990s and wrote:

> Design engineering is the creative process by which ideas are converted into a format that both defines a product and enables it to be produced. When CAD/CAM tools first emerged over a decade ago, designers used them simply to automate time-consuming and tedious tasks such as layout and drafting. However, they soon realized that the technology would open a whole new range of possibilities. It would allow them to investigate many more scenarios or configurations and thus provide optimized design solutions. (p. 20)

The recent significant development was that: "The integration of finite-element preprocessing and analysis capabilities within CAD programs is enabling engineers to create and analyze design in a single process" (Deitz, 1997, p. 62). Deitz described the so-called one-stop design and analysis:

> Computer scientists and software developers have made substantial progress in enabling engineers to design, visualize, and simulate the performance of even the most complex mechanical structures and systems. Many engineers, however, agree that there's still a way to go before the new hardware and software can be used to their full potential as engineering tools that can identify opportunities to reduce product-development cycles, raise product quality, and cut costs. (p. 62)
>
> ... Now, a stream of new products is emerging that incorporate capabilities provided by different codes—CAD, finite-element preprocessing and analysis, and results interpretation—and make them available to design engineers via a unified CAD interface. Accordingly, the new integrated codes make the analysis, optimization, and verification of digital prototypes integral parts of the early design process. (p. 63)

CAD software producers have upgraded and created many new CAD software packages to support educational institutions and to meet the needs of business and industry. As a worldwide design resource and software producer, AUTODESK Company has helped over 4,000,000 professionals in over 160 countries using its products. Now AUTODESK has extended its branches in over 30 countries worldwide (*Autodesk Worldwide,* 2002).

AutoCAD software such as AutoCAD Release14, AutoCAD 2000 and AutoCAD 2002 with associated products is widely used in educational institutions. More recently, AUTODESK has released the 'iDesign' software package, which is a new industry-leading design software program to improve design processes by creating a more natural, intuitive design environment—both online and on the desktop (*Autodesk—iDesign*, 2002).

The Current CAD Programs at Community Colleges

By the end of the last century, CAD programs were available in American higher education, as well as in post-secondary education in many countries throughout the world. For example, the programs were available in Canada (Hill, 1993; Jeswiet et al., 1985), Britain (Fowler, 1997), and China (Zhu, 2000). However, only CAD associate degree programs in the United States were highlighted in this study.

In the United States, during the 1998-1999 academic year there were 332 public institutions of higher education (323 two-year colleges and 9 universities), offering CAD associate degree programs, according to *The Directory of Public Vocational Technical Schools, Colleges and Institutes in the U.S.A. 1998-1999* (Gabriel, 1998), which listed all

vocational-technical programs for over 1,600 public institutions. Among the 332 institutions, the programs were entitled: computer aided design technology (71 institutions, 21.4%), design technology (59 institutions, 17.8%), design and drafting technology (192 institutions, 57.8%), and CAD/CAM technology (10 institutions, 3.1%). However, a CAD technology program may include multiple specialties such as architectural, mechanical, or civil specialties. In addition, to associate degree programs, 137 of the total 323 two-year colleges also offered certificate programs. Within the four geographic regions of the United States, the distribution of public colleges offering CAD technology associate degree programs is shown in Appendixes A and B.

A preliminary research project to collect CAD associate degree curriculum was conducted by the researcher. Based on the results of a pre-survey project and preliminary project, it was found that many community colleges in the U.S. are updating their CAD programs. For example, AutoCAD, ProEngineer and other software are being used in industry and many community colleges. A list of collected CAD program catalogs is included in Appendix C.

The Delphi Technique

Introduction

The Delphi technique was developed by the Rand Corporation in the 1950s, and has been used extensively in education settings. This technique was an interactive process designed to query an interested group of experts assembled around a specific topic for the purpose of reaching a consensus of opinions on issues related to that topic. The Delphi technique was a good approach to elicit and refine the opinions of a group of

people. The process was repeated for several rounds until the investigator obtains positions that are firm and agreement on a topic is reached. The Delphi may be modified in many ways (Brooks, 1979; *Delphi technique,* 1994; Pullen, 1996; Smallwood, 1988).

A Delphi process usually includes the following steps:

1. The researcher identifies a panel of experts.
2. The researcher determines the willingness of individuals to participate.
3. The researcher mails the first forms to the panel and elicits initial responses and individual input on a given issue.
4. The researcher analyzes the data provided by the panel.
5. The researcher mails the assembled group-input to each panel member for assessment.
6. The researcher analyzes this new input from the members of the panel.
7. Each participant reviews the group data, reassesses his/her own position based on the group's responses, and provides a new response.
8. The researcher again analyzes and shares the input with the panel. Each participant reviews the new data and reassesses his/her own response.

In many projects, these steps may be modified; for example, Step 2 and 3 can be accomplished in a single mailing (Brooks, 1979).

The Delphi technique has many advantages, but also has some disadvantages. Michigan State University Extension Home Page (*Delphi technique,* 1994) illustrated the advantages as follows:

- Allows participants to remain anonymous
- Inexpensive

- Free of social pressure, personality influence and individual dominance
- A reliable judgment or forecast of results
- Allows sharing of information and reasoning among participants
- Conducive to independent thinking and gradual formulation
- A well-selected respondent panel

On the other hand, the Delphi technique has some disadvantages. Several studies addressed the concerns about the technique (Brooks, 1979; *Delphi technique,* 1994; Pullen, 1996). The two most common problems associated with the Delphi technique were the representation of the panel, and the timeframe required. The first problem was that a selected group of people might not be representative of the entire population. The second concern was that this process was more time-consuming than the regular group process methods. Usually, the process of mailing and receiving three or four queries consumed at least several months. In addition, this technique required participant commitment to complete the entire process. Brooks (1979) claimed that it simply could not be rushed into a few weeks under most conditions.

How many mailings are needed in a Delphi process? Brooks (1979) indicated that: "Normally, three mailings are sufficient to achieve the consensus desired; little or no change can usually be expected after four mailings" (p. 378). Though the number of experts in a group varies in the different cases, Brooks noted: "Delphi probes have involved numbers ranging from fewer than twenty to several hundred; however, it seems likely that little improvement in results is achieved with groups of more than twenty-five" (p. 377).

Delphi Technique Applications

"Originally designed as a method of forecasting, the Delphi technique has also been in a variety of situations" (Pullen, 1996, p. 35). Some doctoral dissertations focused on the Delphi technique as a major research tool. Also, many research projects utilized the Delphi technique for specific surveys.

Pullen (1996), of the University of Georgia, conducted a national survey utilizing a three-round Delphi technique for his dissertation. The purpose of this study was to develop a profile of the duties of the secondary vocational supervisor that are predicted to be necessary for the 21st century. Forty-nine experts were invited to participate in Pullen's study, "Twenty agreed to participate by returning their completed round one questionnaire" (p. 56). "The 20 expert panel members indicated their areas of expertise as being; four on secondary education, nine on college or university education, and seven on state departments of education" (p. 59). After Pullen completed the three-round Delphi study, a group consensus among vocational supervisory experts was reached and the duties of the secondary vocational supervisor were identified in the study.

Smallwood (1988), of Indiana State University, conducted a three-round Delphi study. The purpose of this study was to develop a list of components for curriculum in a technology education program by validating worker characteristics for industrial participative management. A total of 38 industrial personnel were selected from four regions of the United States to serve as a panel of experts. "They were chosen from a database of members in the Association for Quality and Participation (AQP), formerly the International Association of Quality Circles (IAQC)" (p. 54). "The opinions of the

group were solicited three times, through survey instruments, to arrive at a group consensus" (p. iii). As a result of the study, Smallwood noted:

> This study has ranked worker characteristics from essential to non-essential. Those characteristics which should be given priority in planning, organizing, and developing technology education programs to prepare students to be contributing members in work-group situations are: problem-solving, communication skills, team building, goal setting, group process, and coping with conflict. (p. 99)

Wilhelm (1999) conducted a study to determine the specific skills and competencies that employers required in entry-level employees. Wilhelm used a panel of 24 professionals in the Tempe/Phoenix, Arizona area for the three-round Delphi study. One of the results of this study included a ranking of skills and competencies. Wilhelm indicated that: "These identified skills and competencies serve as the target workplace skills and competencies criteria for the current Arizona Student Achievement Program (ASAP), which is intended to guide the curriculum throughout the state" (p. 105).

Larson and Wissman (2000) conducted a three-round Delphi study about critical academic skills. A panel of 23 members for the study included academic deans and faculty members in the State of Kansas. Larson and Wissman noted: "The research question that guided this study was as follows: What critical academic skills should be characteristic of Kansas community college graduates?" (p. 45). As a result of their study, a list of critical academic skills within 14 categories was defined.

Wicklein and Rojewski (1999) conducted a study about developing a "unified curriculum framework" for technology education using a three-round Delphi technique process. The Delphi panel was composed of 25 individuals including 19 professional

engineers, 3 educators, 2 scientists, and 1 inventor. Seventeen specific mental processes and their definitions were provided for the panelist's initial review. After three rounds, the study provided recommendations for future steps in the design procedure for a technology education curriculum.

The Delphi technique was also used in other fields. For example, Westbrook (1997) conducted a three-round Delphi study on Women's Studies Research. The panel consisted of 22 members in women studies, including stakeholders, experts, university faculty, and facilitators. Other examples included a three-round Delphi process in a study of the future of mathematics and mathematics education (Galbraith, Carss, & Grice, 1992), and a three-round Delphi study in nursing education planning (Mitchell, 1998).

In addition to the traditional Delphi technique, some Delphi studies were completed electronically. A typical example was "UM-C Delphi Study of Digital Libraries" (*The Delphi technique*, 2001). The brief description of this new system was:

> The Delphi Planning System, a Web-based software application was utilized initially. This particular software was developed by Planet Innovation (URL: http://planetrtec.org), an educational project group created by the University of Missouri-Columbia's College of Education as part of the South Central Regional Technology Consortium (SCRTC). The application falls within the group's development of Web-based decision making tools and is based upon the Delphi Technique created for scientific research. (p. 1)

In the UM-C Delphi study, letters and questionnaires were sent to the participants electronically; the responses from the participants were received electronically as well.

This three-round Delphi technique with 21 participants was conducted using the UM-C Web-based delivery method.

Based on the preliminary study of related literature, it was found that all of the Delphi studies only dealt with one panel of experts. The panel may comprise a specific group of people in an area with the same profession, such as industrial professionals (Smallwood 1988; Wilhelm, 1999), community college educators (Larson & Wissman, 2000); or comprise a mix of people of different professions (Pullen, 1996; Wicklein & Rojewski, 1999). In addition, it appeared that very little had been done to interact with both community college educators and industrial professionals, an issue of central importance to this study. As such, the researcher conducted a Delphi study with two panels composed of industrial professionals and community college professors.

Method of Reaching Consensus

Reaching consensus of the opinions from experts of a panel was the most important outcome for the Delphi process. Consensus "is meant to imply a gathering of individual evaluations around a median response, with minimal divergence" (Brooks, 1979, p. 378). "Determination of consensus has been one of the serious questions of the validity of the use of the Delphi technique" (Pullen, 1996, p. 42).

Pullen (1996) used a five-point Likert scale and described the criteria used in his research. Pullen noted: "In some Delphi studies, consensus has been assumed when a certain percentage of the responses fall within a prescribed range" (p. 43). "The selection of criteria for meeting consensus was based on the need to account for central tendency as well as to assure that the group either agreed or disagreed with the item" (p. 55). In

conclusion Pullen noted: "Consensus was reached on an item if sixty percent of the respondents were in agreement and the group answer fell within the agree or disagree range" (pp. I-II).

Smallwood (1988) also used the five-point Likert scale with a three-round Delphi technique to determine worker characteristics. Using 3.00 as criteria of consensus, Smallwood found 47 work characteristics "had mean values above 3.00 as perceived by the sample group" (p. 95). In addition, a five-point Likert scale was used "to determine the specific skills and competencies that employers require in entry-level employees and to identify specific student-produced performance products that applicants can use to signal proficiency in the respective skills and competencies" (Wilhelm, 1999, p. 105). In Wilhelm's three-round Delphi study, "a value of 3.0 was assigned to the mean scores as the degree of significance" (p. 113).

Summary

This chapter provided a review of related literature and research in two categories: A history of CAD program development and a discussion of the Delphi technique. Additionally, an overview of the related literature studies was summarized. First, as a technological innovation, CAD technology has developed significantly during the past five decades since the 1950s. The rapid pace of technological change required innovative approaches in educational programs. In the United States, CAD programs were available in public post-secondary education. By the end of the twentieth century, three hundred and twenty-three public two-year colleges were identified, offering CAD associate degree

programs. CAD programs in post-secondary education were also available in many countries throughout the world.

Second, the Delphi technique as a methodological approach was discussed. In summary, it is a research method to elicit and refine the opinions of a group of people. After review of this technique and related studies, the Delphi process was determined to be the appropriate research method for this study.

Chapter 3

METHODOLOGY

The purpose of this study was to determine what knowledge and skills were needed of CAD students to become successful at work, and how community college CAD programs could provide an ideal curriculum for students. Based on the data from industrial professionals and CAD professors at community colleges, a model curriculum for CAD associate degree programs was proposed. Chapter Three focused on the methodology used for the study, including the following sections:

- Research Process
- Steps of the Delphi Technique for This Study
- Standards of Analysis of Data
- Demographic Data

Research Process

This study proceeded in two steps. First, a preliminary survey of experts from industry and community college was conducted to obtain their perception of competencies of CAD associate degree students. The purpose of this pre-survey was to provide information in order to develop the questionnaire instruments for a Delphi study. The researcher invited four industrial professionals to participate in the study from the

Southern Indiana area: an architect from a small firm in Seymour, an engineer from a large manufacturing company in Columbus, a designer from a mid-sized manufacturing company in Columbus, and another designer from a mid-sized manufacturing company in North Vernon. Additionally, the researcher also invited four part-time adjunct faculty members of the Design technology department at Ivy Tech State College, Columbus, Indiana to participate in the survey. These four adjunct faculty members were also professionals in industry. They brought their expertise and experience to the college to teach. The pre-survey questionnaire is included in Appendix D.

Second, this study involved the use of a Delphi technique to collect and refine information provided by industrial experts and community college professors. According to the review of related literature and research in Chapter Two, it was found that: "The Delphi technique may be effectively used to determine consensus" among experts (Pullen, 1996, p. 90). In particular, it was used to determine a consensus for the required knowledge and skills needed to perform effectively at work (Larson & Wissman, 2000; Wilhelm, 1999). Therefore, the Delphi technique was used to obtain data and reach a consensus of opinions for both industrial professionals and CAD professors at public two-year colleges.

Steps of the Delphi Technique for This Study

The procedures of the special Delphi technique for this study consists of the following steps:

- Identifying the two panels of experts
- Round One

- Round Two
- Round Three

Identifying the Two Panels of Experts

Criteria for Selecting the Two Panels

Selecting qualified participants as members of the two panels was critical to this study. Each member of the Panel of Industry Experts had to be a professional from business and industry such as a designer, drafter, engineer, architect, manager, and supervisor in the related field with a minimum of three years of industrial experience. As it regarded the equally important Panel of Institution Experts, each member had to be a community college CAD professor such as a chairperson or faculty member at an accredited public two-year college and with a minimum of three years of teaching experience at the college level.

Choosing Potential Candidates for the Two Panels

Based on the review of related literature, a minimum of twenty experts with the required background in each panel seemed reasonable and appropriate for this study. The population of industrial professionals was limited to 450 industrial members from the Directory of the American Design Drafting Association (ADDA). These members were industrial professionals in the design and drafting field such as designers, drafters, engineers, architects, managers, and supervisors in the United States (*ADDA*, 2000). The population of community college professors was limited to 323 public two-year community colleges offering CAD associate degree programs. All 323 public two-year

colleges were identified from the *Directory of Pubic Vocational-Technical Schools, College and Institutes in the U.S.A.* (Gabriel, 1998).

To facilitate a national representation for the study, the following four regions were identified: Region I—Northeast; Region II—Southeast; Region III—Midwest; Region IV—West (Smallwood, 1988). A stratified random sampling method was used to select the potential candidates for both panels to ensure the geographic representation. To contact the potential industrial candidates, the first fifty industrial professionals were randomly selected in the four regions. To contact the potential institutional candidates, the first fifty public accredited community colleges were also randomly selected in the four regions.

Determining the Willingness of Individuals to Participate

To form a panel of industry experts, the fifty selected professionals were contacted via telephone, mail, fax, and e-mail by the researcher. If a selected professional was not willing to participate, another professional in the same region was randomly chosen, and this new person was contacted. If a selected professional was willing to participate and met the requirements of a minimum of three years of industrial experience, this candidate became an official panel member once he or she returned the completed initial questionnaire. In fact, the list of potential industrial candidates was much expanded. The process continued until the Panel of Industry Experts with thirty members was finalized.

To form a panel of institution experts, the fifty selected public and accredited community colleges were contacted via telephone in order to obtain the names and

telephone numbers of chairpersons of CAD department. The researcher then contacted with the chairpersons via telephone, mail, fax, and e-mail. If a chairperson, or an appropriate faculty member recommended by this chairperson accepted the invitation to participate and had at least three years of teaching experience, this candidate became an official panel member once he or she returned the completed initial questionnaire. If representatives of a college were not willing to participate, another college in the same region was randomly chosen and that chairperson was contacted. The list of potential institutional candidates was also much expanded. The process continued until the Panel of Institution Experts with thirty-two members was finally established.

Confirming the Two Panels

During the stage of identifying the two panels, a total of 149 official invitations were mailed to the potential industrial candidates, and a total of 133 official invitations were mailed to the potential institutional candidates. Meanwhile, much time was spent on telephone calls, faxes, and e-mails made by the researcher to invite the candidates to participate. The ratio of acceptance in participating in this Delphi study was not high, just 20.13% for the Panel of Industry Experts and 24.06% for the Panel of Institution Experts. The ratios of acceptance of invitations to participate in this study for the two panels are presented in Table 1.

A total of 62 participants from 29 states within four regions of the United States responded to the round one questionnaire. Thirty members of the Panel of Industry experts were from 15 states, thirty-two members of the Panel of Institution Experts were from 23 states. The distribution of panel members by geographic locations showed a

good balance within four regions: four industrial professors versus six college professors in the Northeast region; five versus eight in the Southern region; fourteen versus twelve in the Midwest region; and seven versus six in the West region (see the distribution in Appendix O).

Table 1

Ratio of Acceptance of Invitation to Participate in This Study

	Industry Experts Panel	Institution Experts Panel
Number of mailed invitations	149	133
Number of confirmed acceptance	30	32
Percent of acceptance	20.13%	24.06%

Note. In addition to the official mailed invitations, the researcher also conducted many invitations to candidates through the telephone, e-mail, and fax.

Round One

Round one was to solicit ideas of industrial experts about the required knowledge and skills for CAD associates degree graduates and to collect the relevant CAD

curriculum catalogs from two-year colleges. The data were then compiled to create a list of the required knowledge and skills that industrial experts believed to be needed of CAD students.

Inquiring of Opinions from Industrial Experts

The purpose of the first round with industrial experts was to obtain individual brainstorming responses on this issue: What would best prepare CAD associate degree students to be successful in the workplace? The researcher asked industrial experts to send a list of knowledge, skills, and dispositions that they believed to be necessary for CAD workers at the entry level in industry. This first mailing to industrial experts included a cover letter, the initial questionnaire form, and a postage-paid, return-addressed envelope. The cover letter delivered the official invitation to each member of the panel, explained the purpose, procedure and significance of the Delphi study, and also provided assurances of commitment and confidentiality (see Appendix E).

Asking CAD Professors to Provide Curriculum Catalogs

The purpose of the first round with community college experts was to collect CAD associate degree program curriculum catalogs that described course offerings and what was expected of students regarding the required knowledge, skills, and dispositions in the selected two-year institutions. This first mailing to CAD professors included a cover letter, the initial questionnaire form, and a postage-paid, return-addressed envelope (see Appendix F). The cover letter delivered the official invitation to each member of the panel, explained the purpose, procedures, and significance of the Delphi study, and also

provided assurances of commitment and confidentiality. At Round One, follow-up telephone calls were made and e-mail messages were sent to the members of the two panels to expedite the process (see Appendix G).

Round Two

Once the response envelopes from the two panels were received, an analysis of the feedback from industry experts and the necessary information from the collection of curriculum catalogs was conducted. First, the researcher compared and contrasted the responses of both panels. The data from both panels were then combined and merged, since the course offerings described college preparation and were linked with the required knowledge and skills. Finally, a list of the required knowledge and skills with 51 items was created for evaluation by the two panels of experts. The second mailing to the two panels included a cover letter, a postage-paid, return-addressed envelope and a questionnaire form seeking their evaluation to the list of required knowledge and skills (see Appendixes H and I). Follow-up calls were again made, and e-mail messages were sent to the members of the two panels to expedite the process (see Appendix J).

Round Three

Based on an analysis of data obtained from Round Two, the researcher assembled, combined, and merged the data into the Round Three instrument to form a proposed model curriculum that created courses linked with the required knowledge and skills. This proposed model curriculum for CAD associate degree programs was subsequently sent to the panels of experts for their evaluation. This third mailing to both panels

included a cover letter, a postage-paid, return-addressed envelope, and a questionnaire form seeking their reaction to the proposed model curriculum (see cover letters in Appendixes K and L, see model curriculum in Appendix M). Once again, follow-up calls were made and e-mail messages, faxes, as well as follow-up letters were sent to the members of the two panels to expedite the process (see follow-up in Appendix N).

An analysis of the data received from Round Three was then conducted. If a consensus of opinions on the model curriculum was reached, the inquiry would end at Round Three. However, if a consensus was not reached, the researcher would continue with another round until a consensus was obtained. In this study, a consensus was reached at Round Three. In other words, the proposed model curriculum was validated by the two panels. Hence, the Delphi process was ended. Finally, the researcher wrote a thank-you letter to all members of the two panels to express appreciation for their participation in this study (see the final thank-you letter in Appendix T).

In summary, the Panel of Industry Experts consisted of 30 members and the Panel of Institution Experts consisted of 32 members. The researcher facilitated discussions between the two panels to validate the model curriculum through three rounds in the Delphi study. All the members of the two panels completed the initial questionnaires and returned them to the researcher.

The Round two questionnaire forms were sent to all the 30 members of the panel of Industry Experts and 32 members of the Panel of Institution Experts. Members were contacted by telephone calls, faxes and e-mails to make sure that they received the Round Two questionnaire forms, and they were encouraged to respond on time. At Round Two,

for the Panel of Industry Experts, 29 were returned for a 96.67% return rate. For the panel of Institution Experts, 30 were returned for a 93.75% return rate.

The Round Three questionnaire was sent to all the members of the two panels. For the Panel of Industry Experts, Twenty-eight responses were returned for a 93.33% return rate. For the Panel of Institution Experts, twenty-nine responses were returned for a 90.63% return rate. The details about the return rates for the three rounds are shown in Table 2.

Table 2

Response Rates by Round for the Delphi Process

	Panel of Industry Expert		Panel of Institution Experts	
Round	No. of returned responses	Returning percentage	No. of returned responses	Returning percentage
1	30	100 %	32	100 %
2	29	96.67 %	30	93.75 %
3	28	93.33 %	29	90.63 %
Overall	87	96.67 %	91	94.79 %

Standards for Analysis of Data

Likert-type Scale Rating

A five-point Likert-type scale was employed to evaluate the list of required knowledge and skills at Round Two, and the model curriculum at Round Three in this study. The points on a five-point Likert-type scale were designed as numerical values as follows: 5—Strongly Agree (SA); 4—Agree (A); 3—Moderately Agree (MA); 2—Disagree (D); 1—Strongly Disagree (SD).

Criteria for Consensus

Based on the results of the prior Delphi studies, a mean value of 3.00, which indicated sixty percent of the panel members were in agreement, was assigned to be used as criteria for consensus in this study. If a mean value was higher than 3.00, it denoted that a consensus of opinions was reached. In this study, if both panels had a group mean higher than 3.00, so a consensus would be reached in each panel, and both panels could validate the model curriculum at Round Three.

Demographic Data

In order to better understand community college preparation and the needs of business and industry, the necessary information was requested for the two panels. The information was about participant's background and situations in industry and in colleges. As an important part of the study to investigate community college CAD programs and the workplace demands, the demographic data is related and linked with the problem of the study, and the research questions. To collect the demographic data,

the researcher designed the initial instrument with 12 questions in Part A for industrial experts (see Appendix E), and the initial instrument with 18 questions for institutional experts (see Appendix F). The collected data are presented in the following tables as Demographic Data, which is very valuable to assist to understand the problem of the study and to respond to the research questions.

General Description of Participants

Tables 3, 4, and 5 show characteristics of panel members by sex, highest degree held, and major areas of study. As shown in Table 3, the Panel of Industry Exerts consisted of 90% males (27 of 30), 10% females (3 of 30); the Panel of Institution Experts consisted of 90.63% males (29 of 32), and 9.37% females (3 of 32). Table 4 indicates that over sixty-five percent of the Panel of Institution Experts had a degree beyond the Bachelor's, but it was only twenty percent in the Panel of Industry Experts. The highest degree held for the panel of Institution Experts was a Doctorate, but the highest degree for the Panel of Industry Experts was the Master's.

Table 5 shows that the major areas of study varied for the participants. In the Panel of Industry Experts, Design and Drafting, Engineering, and Architecture were the top three majors; in the panel of Institution Experts, Design and Drafting, Education, Engineering, and Industrial Technology were the top four majors.

Table 3

Characteristics of Panel Members by Sex

	Panel of industry experts		Panel of institution experts	
Sex	Number	Percentage	Number	Percentage
Male	27	90.00%	29	90.63%
Female	3	10.00%	3	9.37%
Total	30	100%	32	100%

Table 4

Characteristics of Panel Members by Highest Degree Held

	Panel of industry experts		Panel of institution experts	
Degree	Number	Percentage	Number	Percentage
Doctorate			4	12.50%
Master	6	20.00%	17	53.3%
Bachelor	5	16.67%	7	21.87%
Associate	15	50.00%	4	12.50%
Other*	4	13.33%		
Total	30	100%	32	100%

Note. * "Other" indicates as follows: High school diploma 2
Drafting & design certificate 1
Not specified 1

Table 5

Characteristics of Panel Members by Major Areas of Study

	Panel of industry experts		Panel of institution experts	
Areas	Number	Percentage	Number	Percentage
Architecture	4	13.79%		
Business	2	6.90%	1	3.12%
Design & Drafting	9	31.03%	9	28.13%
Education*	1	3.45%	8	25.00%
Electronics	1	3.45%	1	3.12%
Engineering**	9	31.03%	6	18.75%
Industrial Arts			1	3.12%
Industrial Technology			4	12.50%
Instructional System Technology			1	3.12%
Management	1	3.45%		
Mechanical Technology	1	3.45%		
Science	1	3.45%	1	3.12%
Total	29	100%	32	100%

Note. One panel member of industry experts did not respond to the question.

* "Education," specifies as follows:

Panel of industry experts		Panel of institution experts	
Industrial & Vocational Education	1	Industrial Education	3
		Vocational Education	3
		Technology Education	1
		Education	1

** "Engineering," specifies as follows:

Panel of industry experts		Panel of institution experts	
Civil Engineering	2	Engineering	1
Engineering	3	Mechanical Engineering	3
Mechanical Engineering	4	Architecture Engineering	1

Data about Industrial Experts and CAD Trend

Tables 6 to 12 provided more information about the background of the Panel of Industry Experts and CAD applications in industry.

Job Profile

Table 6 shows that forty-three percent of participants in the Panel of Industry Experts were from manufacturing companies, 36.67% were from design firms, and 13.33 % were from construction companies. Table 7 shows these companies ranged in size from 1 to 24,000 employees. Twenty-six percent of participants were from very small companies with one to ten employees. Table 8 shows there is approximately twenty-seven percent of members of the Panel of Industry Experts were designers, 20% of the members were engineers, 16.67% were managers, and 10% were supervisors. Table 9 indicated that their primary job categories were mechanical (36.76%), civil (33.33%), architectural (26.67%), and CAD/CAM (26.67%).

Table 6

Characteristics of the Panel of Industry Experts by Category of Company

Category of Company	Number	Percentage
Manufacturing	13	43.33%
Construction	4	13.33%
Design firm	11	36.67%
Transportation	1	3.33%
Service	2	6.67%
Research/Development	2	6.67%
Other *	5	16.67%
Total	38**	**

Note. * "Other" specifies as follows:

CAD/GIS contractor	1
Architectural	1
County Government	1
State Government (training)	1
Local Government (utilities)	1

** Four panel members chose more than one category.

Table 7

Characteristics of the Panel of Industry Experts by Company Size

Company size	Number	Percentage
1 – 10	7	25.94%
11 – 20	1	3.70%
21 – 50	3	11.11%
51 – 100	3	11.11%
101 – 200	4	14.82%
201 – 500	1	3.70%
501 – 1000	1	3.70%
1001 – 2000	1	3.70%
2001 – 5000	3	11.11%
5001 – 10000	1	3.70%
10001 and more	2	7.41%
Total	27	100%

Note. Three panel members did not respond to the question.

Table 8

Characteristics of the Panel of Industry Experts by Position Title

Position title	Number	Percentage
Engineer	6	20.00%
Designer	8	26.67%
Technician	2	6.66%
Drafter	1	3.33%
Manager	5	16.67%
Supervisor	3	10.00%
Other *	5	16.67%
Total	30	100%

Note. * "Other" specifies as follows:

Drafting Coordinator	1
Owner	1
Owner/President	1
Research & Development Specialist	1
Technical Support Specialist	1

Table 9

Characteristics of the Panel of Industry Experts by Job Category

Job category	Number	Percentage
Mechanical	11	36.67%
Architectural	8	26.67%
CAD/CAM	8	26.67%
Electrical/Electronics	3	10.00%
Civil	10	33.33%
Other*	3	13.33%
Total	43**	**

Note. * "Other" specifies as follows:

Architectural	1
State Government	1
Environmental	1

** Nine panel members chose more than one job category.

Rich Experience

All the members of the Panel of Industry Experts had industrial experience ranging from 3 to 55 years with an average 23.33 years of experience. A total of years of industrial experience for the panel reached 697 years. At the current position, the panel ranged form one year to 33 years with an average 11.21 years. The details are shown in Table 10.

CAD Trend in Industry

Tables 11 and 12 indicate CAD trend in industry. In the Panel of Industry Experts, over 86% members had Auto CAD experience. Majority of companies (83.33%) have used AutoCAD 2000 and AutoCAD 2002 in the workplace.

Table 10

Characteristics of the Panel of Industry Experts by Years of Experience

	In industry		At the current position	
Years	Number	Percentage	Number	Percentage
1 – 3	1	3.33%	5	17.24%
4 – 10	6	20.00%	13	44.83%
11 – 20	5	16.67%	5	17.24%
21 – 30	11	36.67%	5	17.24%
31 – 40	3	10.00%	1	3.45%
41 – 50	3	10.00%		
51 – 60	1	3.33%		
Total	30	100%	29*	100%

Note. In industry:

Total years of experience for the panel = 697
Average years of experience for the panel = 23.23
Range in years of experience was from three to 55.

At the current position:

Total years of experience for the panel = 325
Average years of experience for the panel = 11.21
Range in years of experience was from one to 33.

* One panel member did not respond to the question.

Table 11

Characteristics of the Panel of Industry Experts by CAD Experience

	CAD Software		CAD Experience	
Software	Number	Percentage	Average year of experience	Range in years of experience
AutoCAD	25	86.21%	8.8	3 - 22
Pro Engineer	6	20.69%	4.9	1 - 10
Solid Works	2	6.90%	0.8	0.5 - 1
AutoCAD Light	6	20.69%	5.5	1 - 14
CAD Key	3	10.34%	2.8	0.5 - 7
Microstation	4	13.79%	10.6	3 - 20
Other**	16	55.17%		
Total	62*	*		

Note. * "Percentage" is based on 29 responses; eighteen panel members have CAD experience with more than one software.

** "Other" specifies the following CAD software:
Two for ANVIL.
One for each software: Soft Desk, Co-Create, Rebis AutoPlant, SDRC, Bently, Personal CAD, CATIA, Generic CAD, Arch Desktop, Iron CAD, Versa CAD, Arc/Info., 3D Home Design Suite, Nova CAD, and Chief Arch.

Table 12

Characteristics of the Panel of Industry Experts by CAD Equipment Used at Work

AutoCAD Version			Equipment		
Version	Number	Percentage	Item	Number	Percentage
AutoCAD R13	1	4.17%	Digitizer	4	7.01%
AutoCAD R14	3	12.50%	Color laser printer	15	26.32%
AutoCAD 2000	12	50.00%	Laser printer	22	38.60%
AutoCAD 2002	8	33.33%	Other*	16	28.07%
Total	24	100%	Total	57	100%

Note. * "Other" specifies as follows:
Five for HP plotter.
One for each item: plot scanner, printer scanner, total station-TDS, OCE 9300 larger format plotter, OCE 9700, pen plotter, Xerox plotter, NT & Unix workstation, plotter, microstation, and desk jet plotter.

Data about Institutional Experts and CAD Programs

Tables 13 to 26 provided the information to describe institutional experts and college CAD programs.

Position Title

Table 13 shows that almost 50% (15 of 32) members of the Panel were program administrators; the rest were faculty. Over one-third (34.38%, 11 of 32) members of the Panel were chairs, and over one-half (53.13%, 17 of 32) members were faculty in regard to position. In addition, 15.62% (5 of 32) members were Full Professors, 18.75% (6 of 32) were Associate Professors, and no Assistant Professors were among them. Nearly two-thirds (65.63%, 21 of 32) were instructors in regard to the academic rank.

Rich Experience

Table 14 demonstrates the characteristics of teaching experience for all members. Thirty-one percent (10 of 32) members of the Panel had teaching experience ranging from 11 to 20 years. The average years of experience for the Panel was 15.72 years ranging from 1 to 35 at the present college. The average years of experience for the Panel at two-year colleges was 17.47 years, ranging form 3 to 35. The average years of experience for 6 members at two-year colleges was 4.83 years ranging form 2 to 11.

Table 13

Characteristics of Panel of Institution Experts by Position Title

	Position	
Title	Number	Percentage
Dean	1	3.12%
Chair	11	34.38%
Program Head	1	3.12%
Program Director	1	3.12%
Program Coordinator	1	3.12%
Faculty	17	53.13%
Total	32	100%

	Academic Rank	
Title	Number	Percentage
Professor	5	15.62%
Associate Professor	6	18.75%
Assistant Professor		
Instructor	21	65.63%
Total	32	100%

Table 14

Characteristics of the Panel of Institution Experts by Teaching Experience

	At present college		At two-year college		At four-year college	
Years	No.	Percentage	No.	Percentage	No.	Percentage
1 – 3	3	9.37%	2	6.25%	3	9.38%
4 – 10	9	28.13%	8	25.00%	2	6.25%
11 – 20	10	31.25%	9	28.13%	1	3.12%
21 – 30	8	25.00%	9	28.13%		
31 – 40	2	6.25%	4	12.50%		
Total	32	100%	32	100%	6	18.75%

Note. At present college:

Total years of experience for the panel = 503
Average years of experience for the panel = 15.72
Range in years of experience was from one to 35.

At 2-year college:

Total years of experience for the panel = 559
Average years of experience for the panel = 17.47
Range in years of experience was from three to 35.

At 4-year college:

Total years of experience for the panel = 29
Average years of experience for the panel = 4.83
Range in years of experience was from two to 11.

Table 15 shows that nearly 60% (19 of 32) member of the Panel had industrial experience from 4 to10 years. A total of years of industrial experience were 285, the average years of industrial experience was 8.91 years ranging from 1 to 30. The characteristics noted that all the members had industrial experience.

Institutional CAD Applications

AutoCAD was the most favorite software for all the members. Table 16 indicated that 100% of the members had AutoCAD experience with an average of 12.0 years ranging from 2 to 20. In addition, 37.50% (12 of 32 members) of the Panel had Solid Works experience and 21.88% (7 of 32) had Pro Engineer experience.

Table 17 shows that approximately 88% (28 of 32 members) of the Panel preferred AutoCAD for CAD programs, one fourth (8 of 32) members of the Panel preferred AutoDesk Inventor, and one eighth (4 of 32) members of the Panel also preferred Solid Works, Pro Engineer, Mechanical Desk Top, and Architectural Desk Top. In addition, Table 18 provided comments from all of the members informing the researcher upon why they preferred these CAD software selections.

Table 15

Characteristics of the Panel of Institution Experts by Industrial Experience

Years	Number	Percentage
1 – 3	5	15.62%
4 – 10	19	59.38%
11 – 20	7	21.88%
21 – 30	1	3.12%
Total	32	100%

Note. Total years of industrial experience = 285
Average years of industrial experience = 8.91
Range in years of industrial experience was from one to 30.

Table 16

Characteristics of the Panel of Institution Experts by CAD Experience

	CAD Software		CAD Experience	
Software	Number	Percentage	Average year of experience	Range in years of experience
AutoCAD	32	100%	12.0	2 - 20
Pro Engineer	7	21.88%	3.7	1 - 9
Solid Works	12	37.50%	2.6	1 - 5
AutoCAD Light	3	9.37%	6.3	1 - 10
CAD Key	6	18.75%	6.2	1 - 10
Microstation	4	12.50%	7.3	3 - 20
Other**	11	34.38%		
Total	71*	*		

Note. * "Percentage" is based on 32 responses; 24 panel members have CAD experience with more than one software.

** "Other" specifies the following CAD software:
Inventor 3
Mechanical Desktop 2
One for each software: Architectural Desktop, HECIX, MicroCADAM, MATRIX-Personal Designer, Computervision, CATIA, and CADDS 4X.

Table 17

Characteristics of the Panel of Institution Experts by Preferred CAD Software

CAD Software	Number	Percentage
AutoCAD	28	87.50%
Auto Desk Inventor	8	25.00%
Solid Works	4	12.50%
Pro Engineer	4	12.50%
Mechanical Desktop	4	12.50%
Microstation	3	9.38%
Architectural Desktop	4	12.5%
Total	54	*

Note. * "Percentage" is based on 31 responses, 7 members have more than one choice.

Table 18

Comments from the Panel of Institution Experts regarding the Best CAD Software for the Program.

Member No.	Name of Software	Comments
1	AutoCAD Mechanical Desktop Inventor	Natural Progression from 2D to 3D.
2	AutoCAD	Most widely used in industry.
3	AutoCAD	Third party add-ons, and it is a great software package.
4	AutoCAD	ProE, Inventor and Microstation are needed.
5	AutoCAD Microstation Solid Works	AutoCAD is widely used in industry, Microstation is used by DOT and their subcontractors, and Solid Works is great for 3D modeling.
6	AutoCAD	Widely used in industry.
7	AutoCAD	Easy to teach and used in industry.
8	AutoDesk Inventor	Advisory committee recommendation, comprehensive education solution, 3D modeling, and student interest.
9	AutoCAD Microstation	AutoCAD is widely used in industry Microstation is used in steel and government projects.
10	Solid Works CATIA	Solid Works is used by smaller companies, CATIA is used by aerospace companies.
11	AutoCAD Inventor 3D Studio Viz Mechanical Desktop Architectural Desktop	Compatibility.
12	AutoCAD	Widely used in industry.

13	AutoCAD	Widely used in industry.
14	AutoCAD Solid Works	Widely used in industry.
15	AutoCAD	75% market share.
16	AutoCAD	High use in service area.
17	AutoCAD	Industry demand.
18	AutoCAD	Widely used in industry.
19	AutoCAD	Industry standards.
20	AutoCAD Solid Works	Industry acceptance.
21	AutoCAD ProE	Industry demand.
22	AutoCAD	Industry acceptance.
23	AutoCAD	Well rounded.
24	AutoDesk Inventor	Parametric modeling software with the support of all the AutoDesk produce lines.
25		
26	AutoCAD	Large market share and is widely used.
27	AutoCAD	AutoCAD is good for 2D and ProE is good for parametric solids.
28	AutoCAD	Most companies use it.
29	Architectural Desktop	Architectural focus of curriculum.
30	AutoCAD	Industry Standard.
31	AutoCAD	Depth and variability.
32	Mechanical Desktop Inventor	Parametric modeling.

Note. Only 31 members responded to this question, member # 25 did not respond.

Offerings and Status

Tables 19 to 24 present the characteristics of CAD programs by number of graduates, specialty offerings, CAD faculty status, course offerings, articulation with industry, and college status. All of the colleges produced a total 80 AS (Associate of Science) degrees each year with an average 8.89 AS in each college ranging from 2 to 12; also produced a total of 349 AAS (Associate of Applied Science) degrees each year with an average 13.42 AAS degrees in each college ranging from 2 to 50 (see Table 19). Eighty-four percent of colleges surveyed in this study offered a Mechanical Specialty, 59.83% of the colleges offered an Architectural Specialty, and 40.63% of the colleges offered a Civil Specialty. These colleges offered a total of 14 specialties (see Table 20). Table 21 indicates that Colleges had an average 2.13 full-time faculty and an average 3.09 part-time faculty in CAD programs.

All of the colleges offered CAD courses with an average 7.72 CAD courses. Nearly 85% of the colleges offered evening courses; nearly 60% of the colleges offered board drawing courses, 22% offered weekend courses, and 16% offered Internet courses for CAD programs (see Table 22).

All of the colleges worked with industry in several ways. Seventy-five percent of the colleges conducted an internship in industry, nearly 66% of colleges hired qualified adjunct faculty from industry, and almost 60% of colleges received donations from industry (see Table 23).

Table 24 showed the detail of college setting. Over 80% of colleges were operated in a semester system; nearly 20% were in a quarter system. In the semester system, the average required credits were 63.86, and the average number of required

Table 19

Characteristics of the Panel of Institution Experts by Number of Graduates

	AS		AAS		Certificate	
Distribution in numbers	Number	Percentage	Number	Percentage	Number	Percentage
0 – 4	3	7.50%	2	1.15%	6	16.07%
5 – 9	1	8.75%	10	20.06%	4	38.89%
10 – 14	6	90.00%	7	24.07%		
15 – 19			2	9.74%	2	47.22%
20 – 24			2	12.61%	1	30.56%
25 – 29						
30 – 34			1	9.17%		
35 – 29						
40 – 44			1	12.03%		
45 – 49						
50 & more			1	14.33%		
Total	80		349		72	

Note. For AS Degrees:
Total number of AS = 80
Average number of AS = 8.89
Range in numbers of AS was from two to 12.

For AAS Degrees:
Total number of AAS = 349
Average number of AAS = 13.42
Range in numbers of AAS was from two to 50.

For Certificates:
Total number of certificates = 72
Average number of certificates = 5.53
Range in numbers was from two to 18.

Table 20

Characteristics of the Panel Institution Experts by Specialties Offered in the Programs

Specialties	Number	Percentage
Mechanical	27	84.38%
Architectural	19	59.38%
Civil	13	40.63%
General	2	6.25%
Technical Illustration	2	6.25%
Computer Aided Drafting& Design	2	6.25%
Structural	2	6.25%
GIS	2	6.25%
Electrical	1	3.13%
3D Visual Animation	1	3.13%
Piping	1	3.13%
CAD/CAM	1	3.13%
Computer Graphics	1	3.13%
Pre-Architecture	1	3.13%
Total	74	*

Note. * Thirty-two members responded to the question. Seven colleges offer only one specialty, ten colleges offer two specialties, seven colleges offer three specialties, and five colleges offer more than three specialties.

Table 21

Characteristics of the Panel of Institution Experts by Faculty Status

	Full-time		Part-time	
Faculty size	Number	Percentage	Number	Percentage
1	13	19.12%	7	7.07%
2	12	35.29%	5	10.10%
3	3	13.24%	1	3.03%
4	3	17.65%	3	12.12%
5	2	14.71%	1	5.05%
6			1	6.06%
7				
8				
9				
10			2	20.20%
11				
12			3	36.36%
Total		100%		100%

Note. For Full-time faculty:
Total number of faculty for the panel = 68.
Average number of faculty for the panel =2.13.
Range number of faculty was from one to five.
For the part-time faculty:
Total number of faculty for the panel =99.
Average number of faculty for the panel=3.09.
Range in number of faculty was from one to twelve.

Table 22

Characteristics of the Panel of Institution Experts by Category of Course Offered

Category	Total of Colleges Offering the Course Category		Sum of Offered Courses	Average Number of Offered Courses
	Number	Percentage		
Total courses	32	100%	478	14.94
Evening courses	27	84.38%	191	5.97
Weekend courses	7	21.88%	23	0.72
CAD courses	32	100%	247	7.72
Board drawing courses	19	59.38%	39	1.22
Internet courses	5	15.63%	15	0.47

Note. Evening courses were offered by 27 colleges for an average of 7.07 courses. Weekend courses were offered by 7 colleges for an average of 3.29 courses. Board drawing courses were offered by 19 colleges for an average of 2.05 courses. Internet courses were offered by 5 colleges for an average of 3 courses.

Table 23

Characteristics of the Panel of Institution Experts by Category of Working with Industry

Category	Number	Percentage
Conduct projects in industry	12	37.50%
Seminars by industry professionals	16	50.00%
Donations form industry	19	59.38%
Qualified adjunct faculty from industry	21	65.63%
Internship in industry	24	75.00%
Other activities	19	59.38%

Note. "Other activities" are specified as follows:
Advisory committee-15
Check out and recommend software-1
Draw and produce prototype-1
Industry surveys-1
Conduct workshop for industry-1
Craft committee-2
Joint course/train program development-1
Talked to other instructors who work in the industry-1

Table 24

Characteristics of the Panel of Institution Experts by College Status Category

Category	Number	Percentage
**Operating system*		
Semester system	25	80.65%
Quarter system	6	19.35%
Total	31	100%
Classification:		
Community college	17	53.13%
Technical college	8	25.00%
Community & technical	5	15.63%
**Other	2	6.25%
Total	32	100%
Financing:		
State support	32	100%
***Local support	2	18.75%

Note. * Two members did not respond to this question. One college offered both semester and quarter systems.

For semester system:

The average credit is 63.86.

The average number of courses is 21.80.

For quarter system:

The average credit is 102.75.

The average number of courses is 29.83.

** "Other" specified as follows:

2-year tech department with state university-1

State wide mission university-1

***6 colleges receive both state and local support

courses was 21.80. In the quarter system, the average required credits were 102.75, and the average number of required courses was 29.83. Over 53% of the colleges were community colleges, 25% were technical colleges, and 16% were community and technical colleges. All of the colleges were state-supported colleges in regard to financing.

Accreditation Conditions

Table 25 indicates that all of the colleges were accredited by 6 major regional agencies: 37.50% by North Central Association of Colleges and Schools, 28.13% by Southern Association of Colleges and Schools, 12.50% by Northwest Association of Schools and Colleges, 9.37% by New England Association of Schools and Colleges, 9.37% by Middle States Association of Colleges and Schools, 3.13% by Western Association of Schools and Colleges. Additionally, 34.38% of the CAD programs were accredited by other agencies such as NAIT or ADDA.

Satisfaction with Program Outcomes

As shown in Table 26, all the members of the Panel of Institution Experts were satisfied with the program outcomes. Among all the members, 54.84% were very satisfied, 32.26% satisfied, and 12.90% slightly satisfied. None of the experts reported less slightly satisfied with their program outcomes.

Table 25

Characteristics of the Panel of Institution Experts by College and Program Accreditation Conditions

Accreditation Agencies	Number	Percentage
College Accreditation by Major Regional Agencies:		
NCA (North Central Association of Colleges and Schools)	12	37.50%
Southern Association of Colleges and Schools	9	28.13%
Northwest Association of Schools and Colleges	4	12.50%
New England Association of Schools and Colleges	3	9.37%
Western Associations of Schools and Colleges	1	3.13%
Middle States Association of Colleges and Schools	3	9.37%
Total	32	100%
Program Accreditation by Other Agencies:		
NAIT (National Association of Industry Technology)	2	6.25%
ADDA (American Design Drafting Association)	8	25.00%
Other (by state university system)	1	3.13%
Total	11	34.38%

Note. All 32 colleges are accredited, accounting for 100%. Additionally, 11 programs have accreditation, accounting for 34.38%.

Table 26

Characteristics of the Panel of Institution Experts by Satisfaction with Program Outcomes

Degree of Satisfaction	Number	Percentage
Very Satisfied	17	54.84%
Satisfied	10	32.26%
Moderately Satisfied	4	12.90%
Slightly Satisfied		
Unsatisfied		
Total	31	100%

Note. One member did not respond to this question.

Summary

This chapter described the methodology employed in this study. Major sections in this chapter included: Research process, Procedures of the Delphi technique for this study, Standards for analysis of data, and Demographic data.

Two nationwide surveys were designed in this study using the Delphi technique. One survey was developed for industrial professionals; another was developed for CAD professors at community colleges. The steps of the Delphi technique consisted of the following: Identifying the Two Panels of Experts, Round One, Round Two, and Round Three.

Standards for the analysis of data such as Likert scale and criteria for a consensus were also discussed. Finally, as an important part of the study to investigate the community college preparation and the workplace demands, Demographic Data was presented, which were related and linked with the problem of the study and the research questions.

Chapter 4

RESULTS

The purpose of this study was to determine what knowledge and skills were needed of CAD students to become successful at work, and how the corresponding community college programs could provide an ideal curriculum for CAD students. A Delphi technique was used to collect data from CAD professors at community colleges and CAD experts in industry. In order to better meet today's business and industry needs, a model curriculum was developed and proposed for CAD associate degree programs.

A three-round Delphi technique was conducted of approximately six months in duration. The third round data indicated that both panels reached a consensus in their separate Delphi's. Therefore, the Delphi process ended at Round Three.

The methodology employed for this study included a pre-Delphi survey and a three-round Delphi process involving industrial experts and community college professors. The initial instruments were used to collect broad feedback from the Panel of Industry Experts and to request CAD curriculum catalogs from the Panel of Institution Experts. In addition, the demographic data were collected from both panels on the initial instruments (see Demographic Data in Chapter Three). Then, the subsequent instruments for Round Two were prepared in regard to the required knowledge and skills. Finally,

the instrument for Round Three was prepared for evaluation of the model curriculum after an analysis of the data from Round Two. All the survey instruments used in this study were developed and designed by the researcher.

The collected data from three rounds were analyzed to respond to the three specific research questions of interest:

1. What knowledge and skills do CAD associate degree students need for successful employment?

2. What were the knowledge and skills taught to CAD associate degree students at community colleges?

3. What was the ideal curriculum for CAD associate degree programs?

Round One: Eliciting Opinions and Catalogs

The purpose of Round One was to obtain individual brainstorming responses on the required knowledge and skills from industrial professionals and to collect CAD associate degree program curriculum catalogs from community college professors. The initial instruments for the two panels were designed to identify the required knowledge and skills expected of CAD associate degree graduates and the knowledge and skills already taught to CAD students at community colleges.

Appendix P provides a summery of feedback from the Panel of Industry Experts with a total of 149 items that relate to the required knowledge and skills. Specifically, these 149 items are included in the seven categories: 1) General Knowledge and Skills, 2) Interpersonal Skills, 3) Basic Drawing Knowledge and Skills, 4) Computer Knowledge

and Skills, 5) CAD Knowledge and Skills, 6) Basic Engineering Analysis and Technical Knowledge and Skills, and 7) Special Knowledge and Skills Needed in the Field.

As can be seen in Table 27, nearly 70% (22 of 32) of catalogs were obtained over the Internet with 10 mailed directly to the researcher. A total of 174 courses were identified from the submitted course curriculum catalogs, and listed in the categories of General Education, Support Courses, Technical Core Courses, and Specialty Courses. The details are shown in Appendix Q. In addition, the Panel of Institution Experts provided valuable comments about CAD programs on the initial questionnaire forms. The comments were listed in Table S1 in Appendix S.

Table 27

Statistics of Collected CAD Curriculum Catalogs from the Panel of Institution Experts

Classification	Number	Percentage
Regular Publication	10	31.25%
Internet Curriculum	22	68.75%
Total	32	100%

Note. Four colleges provided both regular publication and Internet course curriculum.

Round Two: Evaluating the List of Required Knowledge and Skills

Based on an analysis of data from Round One, a list of 51 required knowledge and skills items were created and sent to all the members of the two panels for their evaluation. As shown in Table 28, the Panel of Industry Experts validated all but one of the required knowledge and skills categories. Specifically, 50 items were validated with a mean higher than 3.00, while only # 6 (Chemistry) had a lower mean (2.97). Hence, it seemed reasonable to conclude that these 50 items were the required knowledge and skills of CAD students for successful employment. Thus, this result answered Research Question One.

On the other hand, Table 29 shows that the Panel of Institution Experts validated all but four items: # 4 (Calculus), # 6 (Chemistry), # 47 (Marketing and Sales), and # 48 (Basic Knowledge of Laws). Thus, the 47 validated items were the major knowledge and skills already taught to CAD students at community colleges, a result that answered Research Question Two.

From the results shown in Tables 28 and 29, it was also found that the two panels were in alignment in their rankings of the required knowledge and skills for one category: General Knowledge and Skills. In this category, the highest mean was for Trigonometry (4.59 for industrial professionals, 4.62 for college professors), the lowest mean was for Chemistry (2.97 for industrial professionals, 1.48 for college professors). Though the group mean values were different for each item, the ranking in this category was exactly the same for the two panels. As a result of the evaluation at Round Two, the Panel of Industry Experts disagreed on only one item, but the Panel of Institution Experts disagreed on 4 items. Both panels disagreed on Chemistry.

Table 28

Round Two Results for the Panel of Industry Experts

Item No.	Required knowledge& skills	Mean	Rank	Note
General Knowledge Skills				
1	Algebra	4.45	2	
2	Analytical Geometry	4.24	3	
3	Trigonometry	4.59	1	
4	Calculus	3.14	5	
5	Physics	3.76	4	
6	Chemistry	2.97	6	Disagree
Interpersonal Skills				
7	Public Speaking	4.00	5	
8	English Writing	4.38	4	
9	Communication	4.62	2	
10	Critical Thinking	4.48	3	
11	Problem Solving	4.83	1	
Basic Drafting Knowledge and Skills				
12	Basic Drafting	5.00	1	
13	Descriptive Geometry	4.14	8	
14	Technical Standards	4.41	3	
15	Coordinates Systems	4.31	4	
16	Multiview Drawings	4.45	2	
17	Isometric drawings	4.28	5	
18	Geometric Dimensioning & Tolerance	4.14	8	
19	Basic Mechanical Drafting	4.24	6	
20	Basic Architectural Drafting	4.07	9	
21	Basic Civil Drafting	4.17	7	
Computer Knowledge and Skills				
22	Computer Fundamentals	4.31	3	
23	Computer File Management	4.34	2	
24	Word Processing (e.g. Microsoft Word, Word Perfect)	4.79	1	
25	Software on Windows for PC	4.00	4	
26	Spreadsheets (e.g. Excel)	3.93	5	

27	Basic Application of Internet	3.62	6
28	Basic Programming	3.14	7
CAD Knowledge and Skills			
29	Major CAD Softwares	4.31	2
30	CAD 2D Drawings	4.52	1
31	CAD 3D Modeling	4.31	2
32	Basic CAD Lisp Programming	4.33	5
33	CAD Design Project	3.97	2
34	Customization of Cad Program	3.69	4
Basic Engineering Analysis and Technical Knowledge and Skills			
35	Manufacturing Processes	4.07	4
36	Statistics	3.62	9
37	Materials Processing	3.69	8
38	Strength of Materials	4.07	4
39	Basic Measurement	4.62	2
40	Basic Engineering and Technology Terminology	4.66	1
41	Basic Machining	3.76	7
42	Basic Electronics	3.82	6
43	Basic Construction	4.28	3
44	Basic Surveying	4.00	5
Special Knowledge and Skills Needed in the Field			
45	Design Applications and Practices	4.52	2
46	Special Project in the Field	4.10	4
47	Marketing and Sales	3.07	6
48	Basic Knowledge of Laws	3.41	5
49	Troubleshooting skills	4.31	3
50	Teamwork	4.59	1
51	Leadership Skills	4.52	2

Table 29

Round Two Results for the Panel of Institution Experts

Item No.	Required knowledge & skills	Mean	Rank	Note
General Knowledge and Skills				
1	Algebra	4.59	2	
2	Analytical Geometry	3.76	3	
3	Trigonometry	4.62	1	
4	Calculus	2.45	5	Disagree
5	Physics	3.55	4	
6	Chemistry	1.48	6	Disagree
Interpersonal Skills				
7	Public Speaking	4.21	5	
8	English Writing	4.28	4	
9	Communication	4.69	3	
10	Critical Thinking	4.72	2	
11	Problem Solving	4.86	1	
Basic Drafting Knowledge and Skills				
12	Basic Drafting	4.97	1	
13	Descriptive Geometry	4.55	5	
14	Technical Standards	4.69	4	
15	Coordinates Systems	4.76	3	
16	Multiview Drawings	4.93	2	
17	Isometric drawings	4.69	4	
18	Geometric Dimensioning & Tolerance	4.52	6	
19	Basic Mechanical Drafting	4.76	3	
20	Basic Architectural Drafting	4.14	7	
21	Basic Civil Drafting	3.86	8	
Computer Knowledge and Skills				
22	Computer Fundamentals	4.72	1	
23	Computer File Management	4.69	2	
24	Word Processing (e.g. Microsoft Word, Word Perfect)	4.24	4	
25	Software on Windows for PC	4.14	6	
26	Spreadsheets (e.g. Excel)	4.21	5	

27	Basic Application of Internet	4.28	3	
28	Basic Programming	3.03	7	
CAD Knowledge and Skills				
29	Major CAD Softwares	4.45	3	
30	CAD 2D Drawings	4.90	1	
31	CAD 3D Modeling	4.62	2	
32	Basic CAD Lisp Programming	3.42	6	
33	CAD Design Project	4.24	4	
34	Customization of Cad Program	3.52	5	
Basic Engineering Analysis and Technical Knowledge and Skills				
35	Manufacturing Processes	4.52	3	
36	Statistics	3.38	9	
37	Materials Processing	3.93	5	
38	Strength of Materials	3.52	7	
39	Basic Measurement	4.62	2	
40	Basic Engineering and Technology Terminology	4.72	1	
41	Basic Machining	4.14	4	
42	Basic Electronics	3.55	6	
43	Basic Construction	3.48	8	
44	Basic Surveying	3.24	10	
Special Knowledge and Skills Needed in the Field				
45	Design Applications and Practices	4.31	2	
46	Special Project in the Field	3.55	5	
47	Marketing and Sales	2.76	7	Disagree
48	Basic Knowledge of Laws	2.97	6	Disagree
49	Troubleshooting skills	3.93	4	
50	Teamwork	4.76	1	
51	Leadership Skills	4.24	3	

In addition, the members of the two panels provided valuable comments about the required knowledge and skills on the questionnaire forms. The comments from the Panel of Industry Experts at Round Two are listed in Table R1 in Appendix R, while the comments from the Panel of Institution Experts at Round Two are listed in Table S2 in Appendix S.

Round Three: Validating the Model Curriculum

At the last stage of the Delphi process, a proposed model curriculum for CAD associate degree programs was developed to address the third research question. Table 30 showed the rating results for the proposed model curriculum for CAD associate degree programs. The group mean for the Panel of Industry Experts was 4.61, while the group mean for the Panel of Institution Experts was 4.34. Both group means were higher than 3.00, thus validating the proposed model curriculum. Therefore, the validated curriculum became an ideal model curriculum for CAD associate degree programs.

The group mean value of the Panel of Industry Experts was higher than the mean value of the Panel of Institution Experts (4.61 versus 4.34). It seemed that there was a difference of perception between the two panels. A possible reason might have been that among the surveyed industrial professionals, 97% of them (29 of 30) were from mechanical, architectural and civil areas as their major job categories, so perhaps they had been more focused on these areas. In addition, another possible reason might have been the fact that faculty had high satisfaction with their program outcomes (for example, 54.84% very satisfied, 32.26% satisfied, only 12.90% slightly satisfied).

Table 30

Round Three Rating Results

Rating Scale	Panel of Industry Experts		Panel of Institution Experts	
	Number	Percentage	Number	Percentage
5-Strongly Agree (SA)	17	60.71 %	12	41.38.%
4-Agree (A)	11	39.29 %	15	51.72.%
3-Moderately Agree (MA)			2	6.90 %
2-Disagree (D)				
1-Strongly Disagree (SD)				
Total	28	100 %	29	100 %
Group Mean	4.61		4.34	

Note. 28 responses were received for the Panel of Industry Experts.
29 responses were received for the Panel of Institution Experts.

A mean value of 3.00 was assigned as criteria of consensus in this study. For the Panel of Industry Experts, the group mean 4.61 > 3.00, so a consensus was reached. For the Panel of Institution Experts, the group mean 4.34 > 3.00, so a consensus was reached.

Additionally, the members of both panels provided valuable comments about the model curriculum on the questionnaire forms. The comments from the Panel of Industry Experts at Round Three are listed in Table R2 in Appendix R, while the comments from the Panel of Institution Experts at Round Three are listed in Table S3 in Appendix S.

In order to better meet today's business and industry needs, the model curriculum for CAD associate degree programs was created. The intent of this part of the study was to propose a model curriculum to prepare students to become technicians in industry. Technicians use mathematics, science, and engineering to solve technical problems in manufacturing and construction, and they assist engineers and designers to complete the various assignments in research and development. This requires creativity, good communication skills, and the ability to work with others. Especially, industry is requiring technicians to develop products using CAD systems.

The model curriculum provides a solid theoretical foundation, classroom studies, and laboratory practice for students. These demands are combined with CAD applications that teach basic engineering principles, problem solving, critical thinking, communication, and technical skills. The curriculum also provides competency in CAD technology programs for students who desire employment in the drafting and design field upon graduation. The validated model curriculum for CAD associate programs is presented in Table 31. The curriculum includes 24 courses in four categories: 1) Support courses, 2) Technical Core Courses, 3) Specialty Elective Courses, and 4) Technical Elective Courses.

Table 31

A validated course curriculum for CAD Associate Degree Programs

Number	Course title and description
SUPPORT COURSES	
1	**Microcomputer Applications** Provides an introduction to microcomputer hardware, software and applications. Emphasizes computer literacy, the Windows operation system, computer programming, and industrial orientation. *Other Similar Titles:* Computer Fundamentals, Introduction to computers.
2	**Interpersonal Communications** Focuses on the process of interpersonal communications as a dynamic and complex system of interactions. Stresses the importance of applying interpersonal communication theory in work, family, and social relationships.
3	**Technical Writing** Requires students to prepare technical reports for various purposes using standard research techniques, documentation and formatting as appropriate. Requires student to demonstrate both communication and written competencies. *Other Similar Titles:* Technical Report Writing.
TECHNICAL CORE COURSES	
4	**Engineering Graphics** Introduction to drafting applications. Strengthens basic drafting skills to proficient technician level. Areas of study include drafting tools, sketching, measurement, lettering, geometric construction, orthographic projections, pictorial drawings, sectional views, dimensioning, and tolerancing. *Other Similar Titles:* Engineering Drawing, Technical Graphics.
5	**Descriptive Geometry** Introduces fundamental principles in developing graphical solutions to engineering problems with imagination and visualization. Applies concepts of true length, line intersections, true shape, revolutions and developments using successive auxiliary views.
6	**CAD Fundamentals** Introduces the concepts and skills required in Computer-Aided Drafting and Design (CAD). Topics include an overview of CAD and system, use of

software, drawing layout, and standard graphics commands for two-dimensional drawings. AutoCAD is the primary software used in this course.
Other Similar Courses: Introduction to AutoCAD, Computer-Aided Drafting and Design.

7 **Advanced CAD**

Focuses on advanced CAD features that include fundamentals of three-dimensional modeling for design. Topics include overview of modeling, graphic manipulation, part structuring, coordinate system, and developing strategy of model geometry.
Other Similar Titles: 3D Modeling, AutoCAD 3-D, and Advanced Computer-Aided Drafting.

8 **Manufacturing Processes**

A basic survey of manufacturing processes, tools and equipment used by modern industry to convert bars, forgings, castings, plates and sheet materials into finished products. Includes basic mechanics of materials removal and forming metallurgy, quality control, and safety operations. Also introduces non-traditional manufacturing techniques.
Other Similar Titles: Engineering Processes and Procedures, Manufacturing Technology.

9 **Applied Statics**

Studies applied mechanics dealing with bodies at rest. Covers units, vectors, moments and couples, planar force systems, distributed forces, analysis of structures (trusses and frames) and friction.
Other Similar Titles: Statics, Applied Mathematics.

10 **Strength of Materials**

Studies internal stresses and physical deformations caused by externally applied loads to structural members. Covers stress and strain, shear stress, properties of areas, shearing force and bending moment, deformation of beams, columns and combined stresses. Teaches various materials' physical and mechanical properties.
Other Similar Titles: Engineering Materials.

SPECIALTY ELECTIVE COURSES
MECHANICAL SPECIALTY

11 **Mechanical Drafting**

Introduces the set of concept of working drawings both in detailing and assembly. Preserves fastening devices, thread symbols and nomenclature, surface texture symbols, classes of fits, and the use of parts lists, titles and revision blocks. Introduces the basics of product design and the design process.

12 **Tool Design**

Introduces the processes of drafting and design as applied to tooling. Emphasizes tooling, locators, supports, holding devices, clearances, and design as it pertains to jig and fixture.
Other Similar Titles: Jig and Fixture Design.

13 **Mechanical Design Project**

Presents practical solutions to mechanical design problems. Studies the design of machine elements including shafts, bearings, keys, pins, and springs. Includes the geometry and drafting of cams, and gears and the study of linkages.
Other Similar Titles: Machine Design.

ARCHITECTURE SPECIALTY

14 **Architectural Drafting**

Focuses on the architectural drafting of commercial or residential buildings. Covers problems of space planning, design, materials, HVAC systems and construction methods. Develops working drawings and presentation drawings. Requires students to complete research on a limited number of construction materials and methods.
Other Similar Titles: Architectural Drawing.

15 **Building Codes and Standards**

Provides technical information covering pertinent sections of the Building Code Standards necessary for building inspectors and related workers in the trade.
Other Similar Titles: Construction Codes.

16 **Architectural CAD**

Presents advanced computer-aided design topics including latest technological methodology and standards related to architectural drawings and design, and construction. Includes all necessary drawings utilizing CAD such as the site, floor plan, foundation, elevation, and details needed for the construction process.
Other Similar Titles: Architectural Computer Aided Design.

CIVIL SPECIALTY

17 **Civil Drafting**

Studies civil drafting and design practice and preparation of drawings used in the civil engineering industry. Students are required to complete projects relating to survey data, profiles and cross sections, and subdivision, site and grading plans, and basic earthwork calculations.

18 **Fundamentals of Surveying**

Introduces surveying equipment, procedures for performing measurements, turning angles, determining grades, and other field

applications. Covers surveying techniques and computations using the level, chain, and transit in calculating areas, lines, and grades.
Other Similar Titles: Surveying, Introduction to Surveying.

19 **Structural Drafting**

Focuses on detailing commercial structural members, their connections, materials and methods of construction. Concentrates on traditional materials, such as reinforced concrete, masonry, steel, and timber.
Other Similar Titles: Structural Detailing.

TECHNICAL ELECTIVE

20 **CAD Programming and Customizing**

Focuses on advanced CAD features, various methods of customizing CAD system, and CAD Lisp programming.
Other Similar Titles: CAD Customization, CAD Programming and Application.

21 **Geometric Dimensioning and Tolerancing**

Introduces the fundamental principles of geometric dimensioning and tolerancing according to the latest ANSI standards. Applies geometric dimensioning and tolerancing symbols along with tolerances of form, orientation, run-out, and location.
Other Similar Titles: Introduction to Geometric Dimensioning and tolerancing.

22 **Technical Standards and Terminology**

Technical information covering pertinent ANSI standards and terminology in engineering and technology.
Other Similar Titles: Engineering Orientation, Introduction to Technology.

23 **Special Projects**

Study of special problems such as advanced CAD topics, CAD updating skills, and software applications or completion of a special project not covered in previous courses.
Other Similar Titles: Special Problem in CAD, Special Topics.

24 **Portfolio Development**

Focuses on the student's final portfolio for graduation and preparation for the job interview. Finalizes design project demonstrating required knowledge and skills for degree achievement presentation. Every student must submit a copy of final portfolio for departmental archives.
Other Similar Titles: Portfolio Preparation.

Note. Suggested General Education courses: Fundamentals of Public Speaking, English Composition, College Algebra, Geometry/Trigonometry, Physics, Social/Humanities Elective.

The purpose of Support Courses is to enhance student's ability and skills in microcomputer applications, interpersonal communications, and technical writing. As can be seen in Table 31, Microcomputer Application course (# 1) emphasizes computer literacy, the Windows operation system, computer programming, and industrial orientation, which provide a foundation for students to pursue more CAD courses in the curriculum. Interpersonal Communications and Technical Writing courses (# 2 and # 3) focus on the process of interpersonal and writing communications as a dynamic system of interactions in industry.

The purpose of Technical Core Courses is to provide a necessary training for students in drafting, CAD concepts and applications, manufacturing processes, and engineering analysis. This category includes seven courses that are required for all CAD students. Engineering Graphics and Descriptive Geometry (# 4 and # 5) are the first core drawing courses, introducing students to the basic drafting knowledge and skills, as well as the fundamental principles in graphical solutions to engineering problems. With the necessary drafting and computer knowledge, then CAD fundamentals and Advanced CAD (# 6 and # 7) introduce the concepts and skills required in CAD, focusing on two-dimensional drawings and three-dimensional modeling, respectively.

Next, one course focuses on manufacturing processes, and two courses focus on engineering analysis. Manufacturing Processes course (# 8) provides a basic survey of all the manufacturing processes in industry. Applied Statics and Strength of Materials courses (# 9 and # 10) provide the necessary engineering analysis for students such as in the areas of applied mechanics, mechanical properties, internal stresses, and physical deformation of industrial materials.

After completion of Support Courses and Technical Core Courses, CAD students are ready to take Specialty Elective Courses. Though a variety of specialty for CAD programs exist at community colleges, it was found that Mechanical, Architecture, and Civil Specialties were the most popular for CAD programs. For this reason, only these three specialties were chosen in the curriculum. Each specialty consists of three courses. Mechanical Drafting, Tool Design, and Mechanical Design Project (# 11, # 12 and # 13) provide the necessary training and practice in Mechanical Specialty. Architectural Drafting, Building Codes and Standards, and Architectural CAD (# 14, # 15 and # 16) provide more technical information and standards, as well as enhance students' drafting and CAD ability in the architectural area. Civil Drafting, Fundamentals of Surveying, and Structural Drafting (# 17, # 18 and # 19) focus on civil drafting and design practice, survey applications, and detailing commercial structural applications in the civil engineering industry.

Technical Elective courses provide more options for students in technical training. Five courses were arranged in this category and each one could be applied to any specialty with a specific focus. For example, the first focus is to enhance student's CAD ability. CAD Programming and Customizing (# 20) focuses on advanced features and applications for all specialties in CAD programs. The second focus is the latest standards. Geometric Dimensioning and Tolerancing (# 21) introduces the fundamental principles and applications of geometric dimensioning and tolerancing according to the latest American National Standard Institute (ANSI) standards. Technical Standards and Terminology (# 22) also provides more information about ANSI standards and introduces terminology in engineering and technology.

The next focus is CAD applications and the creation of a student's portfolio. The Special Projects (# 23) provides students with an opportunity to work on a special problem or to conduct a special project not covered in previous courses. Portfolio Development (# 24) requires students to complete a final portfolio as a degree requirement for graduation, as well as student's achievement for job interview.

Summary

Chapter Four focused on the results of the three Delphi rounds: 1) Round One: Eliciting Opinions and Catalogs; 2) Round Two: Evaluating the List of Required Knowledge and Skills; and 3) Round Three: Validating the Model Curriculum.

At Round One, broad feedback from the Panel of Industry Experts was solicited with a total of 149 items received, relating to the required knowledge and skills. On the other hand, all 32 CAD program curriculum catalogs were received from the Panel of Institution Experts. A total of 174 courses were identified from the submitted catalogs, relating to the knowledge and skills already taught to CAD students at community colleges.

At Round Two, 50 items of knowledge and skills were validated by the Panel of Industry Experts, and 47 items were validated by the Panel of Institution Experts. These results answered Research Questions One and Two, respectively.

At the last stage of the Delphi process—Round Three, both Panels validated a model curriculum with 24 courses in four categories. This ideal curriculum provided a combination of solid theoretical foundation, classroom studies, and laboratory practice for CAD associate degree students. It also answered Research Question Three.

Chapter 5

DISCUSSION, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of this chapter is to conduct a discussion of findings and results in this study, to draw conclusions, to address implications for action on delivery of the ideal curriculum, and to offer recommendations for future research. Specifically, Chapter Five includes these four sections: 1) A Discussion on Findings and Results, 2) Conclusions, 3) Implications for Action, and 4) Recommendations for Future Studies. Several issues were highlighted in the first discussion section, including comments on the Delphi process, and suggestions for CAD program enhancement. Conclusions were listed in the second section. Next, how to deliver the ideal curriculum was introduced as an extended topic for this study. Finally, in the fourth section, recommendations were made for possible future research.

A Discussion of Findings and Results

Comments on the Delphi Process

The Delphi process was the major research method employed in this study to gather the necessary data. The opinions of the two panels were solicited three times by

means of survey instruments in order to validate a proposed model curriculum for CAD associate degree programs.

At Round Three, a group consensus was reached on the model curriculum in both panels. During the three-round process, the responses of each panel were tracked separately. Based on the results of this study, it was found that the Delphi technique was an appropriate and effective approach to validate the model curriculum. In addition, this study verified that the Delphi process was a time consuming process. It took approximately six months to collect data through three rounds in this study. If a consensus was not reached, it would take more time over more rounds.

Another concern was that selecting qualified participants as members of the two panels was very critical and difficult to the Delphi process. The researcher had to spend much time communicating with potential candidates to form a panel with enough qualified members, and also communicating with all the panel members to expedite the process at each round. It was sometimes disappointing that the response from individual panel members could not be received on time. Patience, consistency, and confidence are necessary requisites for those who employ a Delphi research technique.

It was found in the Delphi process that the instruments used in the process played a very important role in collecting all the necessary data. A good instrument could save much time and make the process more efficient so that a consensus could be reached more quickly. In this study, all the instruments were developed and designed by the researcher, which the final results showed to be effective.

Suggestions for CAD Program Enhancement

Based on an analysis of demographic data in Chapter Three, it was found that CAD professors of community colleges had professional backgrounds and rich educational and industrial experience. For example, nearly forty-seven percent of members of the Panel of Institution Experts were chairpersons or administrators of CAD programs; over thirty-four percent of members were Professors and Associate Professors. In addition, all of the members have had an average of 17.47 years of teaching experience at two-year college level, and an average of 8.91 years of industrial experience. Clearly, their professional background and rich experience offered much for validating a model curriculum for CAD programs.

It was also found that 87.50% of CAD faculty had a bachelor's or higher degree. Other details included that 12.50% of CAD faculty had a doctorate degree; 53.13% had a master's degree, and 21.87% had a bachelor's degree. However, only 12.50% of CAD faculty had an associate degree. It was hoped that all CAD faculty would have a bachelor's or higher degree, and more faculty would obtain a master's or doctorate degree in the future to upgrade the faculty body. A higher level of credentials for faculty could enhance CAD programs.

The demographic data analysis reported that AutoCAD was dominant in industry for CAD applications, and it also was a primary software package at community colleges. All the surveyed colleges have employed AutoCAD and all CAD program faculty members have had AutoCAD experience with an average of 12 years. In addition, they also had experience with other CAD software. Thus, upgrading AutoCAD and other

CAD software packages in alignment with the latest technological developments would be a significant aid to CAD programs.

Another suggestion is that CAD professors continue working with industrial professionals to enhance CAD programs. As the demographic data reported, many activities were effective including conducting projects and internships with industry, offering seminars presented by industrial professionals, obtaining donations from industry, and recruiting qualified faculty from industry. These activities all help enhance the quality of CAD programs.

Aligning college preparation with the needs in industry is significantly important to CAD programs at community colleges. In this study, the results from three rounds were presented in Chapter Four. At Round Two, the Panel of Industry Experts validated fifty items of required knowledge and skills of CAD graduates for successful employment. The Panel of Institution Experts validated forty-seven items that were already taught to CAD students at community colleges. What was the difference between the two panels? Only three items differed: Calculus (# 4), Marketing and Sales (# 47), and Basic Knowledge of Laws (# 48).

According to an investigation of CAD curriculum catalogs that were collected, it was found that only a few two-year colleges provided courses in calculus, marketing and sales, and basic knowledge of laws for CAD students. Usually, calculus is one of the necessary courses for a four-year program, while marketing and sales, and basic knowledge of laws might be elective courses. More importantly, the Panel of Institution Experts did not validate these three items. Therefore, the courses related to these three items of knowledge and skills were not included in the model curriculum. However, it

might be beneficial to students to have knowledge and skills in these areas. It is suggested that CAD programs may provide these courses as additional electives for CAD graduates to enhance their knowledge and skills, as well as assist them in successful employment.

Conclusions

The following conclusions were drawn based on the findings, results, and discussions in this study:

1. The Delphi technique was used to obtain data and reach a consensus of opinions for both industrial professionals and CAD professors at community colleges. Through three rounds in the Delphi process, a consensus of both panels was reached, and a model curriculum for CAD associate degree programs was validated by the two panels. The results proved that the Delphi technique, although time consuming, was an appropriate and effective research approach for this study.

2. The Panel of Industry Experts identified fifty items of the required knowledge and skills of CAD graduates for successful employment. On the other hand, the Panel of Institution Experts identified forty-seven items that were already taught to CAD students. More importantly, forty-seven items were validated identically by the two panels, and thus, should be included in a model curriculum as key elements. In addition, three more items identified by the Panel of Industry Experts might be considered as extra elective courses for students. This conclusion was related to the Research Questions One and Two.

3. The proposed curriculum was validated by the two panels to be an ideal model curriculum. This curriculum was developed and designed based on the results from the first two rounds, in particular, on the forty-seven items of knowledge and skills identified by the two panels. As an ideal curriculum, the model curriculum provides a combination of solid theoretical foundation, classroom studies, and laboratory practices for CAD associate degree students. This conclusion was related to the Research Question Three.

4. It was found that AutoCAD software has been dominant in industry for CAD applications. From the survey, 86.21% of industrial professionals have had AutoCAD experience with an average of 8.8 years, and more than eighty-three percent of companies have used AutoCAD 2000 or AutoCAD 2002. In addition, Pro Engineer and other CAD software packages have been used in industry. Therefore, it is advisable that CAD students master AutoCAD and other necessary software packages for successful employment. Furthermore, CAD programs at community colleges should keep the AutoCAD package as the primary CAD software for their programs and continue to upgrade the software and other software packages to meet the needs of business and industry.

Implications for Action

As a result of this study, a validated model curriculum for CAD associate degree programs was presented. The purpose of this section is to address the issue: How to make the validated curriculum deliverable at community colleges? Two emphases are highlighted in this section: General Education courses, and necessary adjustments.

First, the offering of General Education courses should be highlighted in the process of delivery. General Education offering provides a necessary foundation of knowledge and skills within liberal arts, mathematics, science, social science, and humanities. It was found that all the surveyed colleges provided General Education courses as part of requirements for an associate degree. As showed in Appendix Q, all of the colleges offered 32 General Education courses, accounting for roughly one-fifth of the total 174 courses offered.

As a core curriculum, 24 courses in four categories are listed in Table 31. In addition to the core curriculum, a list of the suggested General Education courses is also listed in the note portion of the table. Therefore, a combination of General Education courses and the core curriculum is offered to students as an ideal curriculum, which would be a deliverable approach to developing a well-rounded CAD associate degree graduate or a competent entry-level CAD technician in industry.

Associate Degree, in general, includes Associate Applied Science (AAS) and Associate of Science (AS) degrees. Usually, CAD students pursue an AAS as a terminate degree for employment or pursue an AS for transferring to a four-year university. The survey results showed that 26 colleges offered AAS, and 10 colleges offered AS degrees for CAD programs. The total number of AAS recipients for 26 colleges was 349, and the total number of AS recipients for 10 colleges was 80 (see Table 19). Obviously, both AAS and AS require General Education courses. However, AS focuses more on General Education elements, AAS focuses more on technical disciplines. Both degrees are available for CAD students to choose.

Secondly, adjustments may be necessary to accommodate General Education courses and the core curriculum. The necessary adjustments could be made for an individual college in regard to required number of courses or credit hours. On the one hand, the number of courses may be adjusted. For example, some colleges may offer one specialty, and other colleges may offer two or more specialties, which would vary the number of courses.

On the other hand, adjustments for credit hours may be made. The survey results showed that the total of credit hours for an associate degree were approximately 64 credits, while approximately 22 courses were required for an associate degree (see Table 24). Most courses in General Education and the core curriculum are three-credit hour courses, but some of them could be adjusted. For example, Physics may be assigned as a three or four credit hour course; Technical Standards and Terminology may be assigned as a three or two credit hour, even one credit hour course. The purpose of adjustments is to provide the best curriculum offering to students for an individual college.

In summary, a combination of General Education courses and the core curriculum (24 courses in four categories) would be an ideal CAD curriculum. Moreover, adjustments may be necessary to accommodate General Education courses and the core curriculum courses for an individual college in the delivery process to better meet business and industry needs and to better serve students.

Recommendations for Future Studies

The following recommendations for future research are offered based on the findings, results and discussions in this study:

1. According to the findings from the pre-survey project and the literature review, it was found that CAD/CAM applications in industry are expected to continue to expand in the future. This study focused on the CAD portion, but the CAM portion should also be a focus. It is recommended that a similar study on CAM in public post-secondary education be conducted as an extension of this study in the future.

2. It is recommended that a future study on CAD programs at four-year colleges and universities be conducted. The intent of CAD associate degree programs is to prepare students to become technicians in industry, while bachelor's degree programs are for engineers. It would be interesting to find out what is the difference of CAD programs between two-year colleges and four-year universities in the United States.

3. In this study, the investigation of CAD programs at community colleges only focused on faculty members as participants. However, an investigation of CAD students or graduates is necessary. It would be very useful to find out their thoughts, opinions, and feedback on CAD programs. Therefore, to expand the study, it is recommended that a survey study for CAD students and graduates be conducted in the future.

4. It was found from the literature that CAD programs in post-secondary education are available in many countries in the world. It is recommended that a similar study on CAD programs in international higher education be highlighted in the future. This recommended study could interest and benefit educators and professionals worldwide.

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APPENDIXES

APPENDIX A

SUMMARY OF PUBLIC COLLEGES OFFERING CAD PROGRAMS

APPENDIX A

Summary of Public Colleges Offering CAD Programs

Region	No.of States	No. of Two-year Colleges	No. of Four-year Colleges	No. of Certificate Programs
Region I				
Northeast	10	33		10
Region II				
Southeast	10	93	3	25
Region III				
Midwest	18	142	3	58
Region IV				
West	12	55	3	44
TOTAL	50	323	9	137

Note. Summarized by the researcher based on the information from the *Directory of Public Vocational-Technical Schools, Colleges, and Institutions in the U.S.A.* (Gabriel, 1998)

APPENDIX B

DISTRIBUTION OF PUBLIC COLLEGES OFFERING CAD PROGRAMS

APPENDIX B

Distribution of Public Two-Year Colleges Offering CAD Programs

Region I—Northeast

State	No. of Two-year Colleges	No. of Four-year Colleges	No. of Certificate Programs
Connecticut	2		
Delaware			
Maine	1*		
Massachusetts	2		1
New Hampshire	4		2
New Jersey	5		1
New York	8		1
Pennsylvania	10		4
Rhode Island	1		1
Vermont			
SUBTOTAL	33	0	10

Region II—Southeast

Alabama	15	1	6
Florida	19		1
Georgia	4	1	2
Maryland	8		4

Mississippi	13		4
N. Carolina	14		3
S. Carolina	3		1
Tennessee	6		2
Virginia	9		2
W. Virginia	2	1	
SUBTOTAL	93	3	25

Region III—Midwest

Arkansas	5		5
Illinois	21		12
Indiana	2**		1
Iowa	8		
Kansas	1		
Kentucky	2		
Louisiana	3		1
Michigan	19		6
Minnesota	10		3
Missouri	3	2	1
Montana		1	
Nebraska	3		1
N. Dakota	1		
Ohio	17		5

Oklahoma	7		4
South Dakota			
Texas	25		17
Wisconsin	15		2
SUBTOTAL	142	3	58

Region IV—West

Alaska			
Arizona	5		4
California	29		26
Colorado	6		4
Hawaii			
Idaho		1	
Nevada	2		2
New Mexico	5	1	4
Oregon	2		
Utah		1	
Washington	5		4
Wyoming	1		
SUBTOTAL	55	3	44
TOTAL	323	9	137

Note: * denotes one state technical college system.
** denotes one Ivy Tech State College system, 1 two-year university.

APPENDIX C

LIST OF COLLECTED PUBLIC COLLEGE ASSOCIATE DEGREE CAD CATALOGS

List of Collected Public College Associate Degree CAD Catalogs

1. Pellissippi State Technical Community College, Knoxville, Tennessee 46208
2. Daytona Beach Community College, Daytona Beach, Florida 32114
3. Lewis & Clark Community College, Godfrey, IL 62035
4. Truckee Meadows Community College, Reno, Nevada 89512
5. North Harris Montgomery Community College District- North Harris College, Houston, TX 77073
6. Chattanooga State Technical Community College, Chattanooga, Tennessee 37406
7. Southern Utah University, Cedar City, Utah 84720
8. Missouri Southern State College, Joplin, Missouri 64801
9. Portland Community College, Portland, Oregon 97219
10. Pennsylvania College of Technology, Williamsport, Pennsylvania 17701
11. Wisconsin Indianhead Technical College, Superior, Wisconsin 54880
12. DeAnza College, Cupertino, California 95014
13. Springfield Technical community College, Springfield, Massachusetts 01101
14. Antelope Valley College, Lancaster, California 93536
15. American River College, Sacramento, California 95841
16. Ivy Tech State College, Indianapolis, Indiana 46208

APPENDIX D

THE PRE-SURVEY QUESTIONNAIRE

The Pre-Survey Questionnaire

1. What is your current job?

   1) Engineer 2) Designer 3) Architect 4) Technician
   5) Drafter 6) CAD/CAM user 7) Other

2. What is your job category?

   1) Mechanical 2) Architectural 3) CAD/CAM 4) Civil
   5) Electronic 6) Construction 7) Other

3. How long have you worked at the current position? How long have you worked in industry?

4. What is your perception of competencies for two-year CAD related associate degree students to meet workforce requirements in industry?

5. What are the general skills needed for CAD associate degree students?

6. What are the specific skills needed for CAD associate degree students?

7. What kind of equipment or hardware does your company have?

8. What kind of special CAD software is for your job? How long have you used the hardware?

9. Does your company have any two-year associate degree CAD graduates?

   1) Yes 2) No

10. Have you supervised any two-year associate degree CAD graduates?

    1) Yes 2) No

11. If you chose "Yes" for questions 9 or 10, are you satisfied with their work? Why or why not?

12. What are your perspectives of competencies for two-year associate degree CAD students in the future?

13. In comparison with associate degree students, what do you think of competencies of bachelor degree students?

14. What are CAD trends for equipment, hardware and software in industry?

15. What are your suggestions to improve two-year CAD associate degree program curriculums in public post-secondary education to meet the challenge in the future?

APPENDIX E

INITIAL COVER LETTER AND INSTRUMENT FOR INDUSTRY EXPERTS

Date

Name
Address
City, State, Zip code

Dear Name:

This letter is to cordially invite you to participate in a nationwide study. The purpose is to determine what skills and knowledge are needed to empower CAD technology students to become successful in the workplace. As an expert in the design and drafting field, you have been randomly identified from the American Design Drafting Association (ADDA) list to become a member of the Panel of Industry Experts. All members of the panel were chosen because of their profession and geographic representation.

Your input is very critical to this study. The Delphi technique is the research method. First, this study determines what skills and knowledge are needed by students to become successful in the workplace. Next, based on feedback from you and other industry experts, and college professors, a new curriculum model will be proposed. This curriculum model will be sent to you and other panel members for your evaluation. Finally, I will share the results with you and other panel members after the process is completed. I realize that time is scarce for busy professionals such as yourself; however, the included initial questionnaire should take approximately 10 minutes of your time to complete, the following questionnaires should take only 5-10 minutes each.

Your responses will be kept confidential and in no way will your name and your company's name be connected to the data you provide.

As an educator, a member of ADDA, and a doctoral student at Indiana State University, I greatly appreciate your help. If you accept my invitation, please return the completed questionnaire in the postage-paid, return-addressed envelope ASAP by (date), which will indicate your consent to participate in this study. In a few weeks you will receive the next questionnaire. If you have any questions, please feel free to call me or contact me via e-mail.

Thank you very much for your assistance!

Sincerely,

Ran Duan
Chairperson and Professor
Design Technology Department
Ivy Tech State College
Columbus, Indiana 47203

Phone: 812-372-9925 ext. 148
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

Industrial Professionals
The Initial Questionnaire

INSTRUCTIONS:

The purpose of this instrument is to identify the skills and knowledge required in the workplace for successful CAD technology students. Please consider each item carefully before recording your response. This information will be used for research purposes only. Your name and your company name will not be associated with the data so that the information you provided will remain anonymous and confidential.

Thank you very much for your help!

Please indicate:

Name:_____

Company name:_____

Phone number:_____

Fax number:_____

E-mail:_____

Part A: Background Information

1. Sex: M_____ F_____

2. Highest degree held: a. Associate_____ b. Bachelor_____
   c. Master_____ d. Doctorate_____ e. Other_____

3. My major area of study was:_____

4. Basically, your company is: a. Manufacturing_____ b. Construction_____
   c. Design firm_____ d. Transportation_____ e. Service_____
   f. Research/Development_____ g. Other_____

5. Estimate how many employees at your company: _____

6. Title of your present position:
   a. Engineer_____ b. Designer_____ c. Architect_____
   d. Technician_____ e. Drafter_____ f. Manager_____
   g. Supervisor_____ h. Other_____

7. What is your job category?
   a. Mechanical_____ b. Architectural_____ c. CAD/CAM_____
   d. Electric/Electronics_____ e. Civil_____ f. Other_____

8. How long have you worked at the current position? Number of years_____

9. How long have you worked in industry? Number of years_____

10. Have you taught at a college? a. Yes_____ b. No_____
    If yes, years of your teaching _____ title of course_____

11. What CAD software have you used? How long with each software?
    a. AutoCAD_____years_____ b. ProEngineer_____years_____
    c. SolidWorks_____years_____ d. AutoCAD Light_____years_____
    e. CAD Key_____years_____ f. Other_____years_____

12. Indicate CAD equipment used by your company:
    a. Light pen_____ b. Digitizer_____ c. Color laser printer_____
    d. Laser printer_____
    e. Other equipment_____
    f. AutoCAD version_____

Part B: Your Opinion on Required Skills and Knowledge
In this part solicit your ideas with the issue:

What are the required skills and knowledge for CAD technology associate degree graduates to become successful in the workplace?

Please write your ideas in each area. The more detailed you write the better.

Area I. Basic drawing skills and knowledge
Example: Technical graphics (traditional board drawing), Descriptive geometry, etc.
Please write items below.

1.

2.

3.

4.

5.

Area II. Computer and CAD skills and knowledge
Example: Computer fundamentals skills, 2D CAD fundamental skills, etc. Please write items below.

1.

2.

3.

4.

5.

Area III. Basic engineering analysis skills and knowledge
Example: Statics, Strength of materials, etc. Please write items below.

1.

2.

3.

4.

5.

Area IV. Special skills and knowledge needed in the field
Example: Manufacturing process, special design project, etc. Please write items below.

1.

2.

3.

4.

5.

Thank you again for your participation in this study!

Ran Duan
Chairperson, Design Technology Department
Ivy Tech State College
Columbus, Indiana 47203

812-372-9925 ext. 148 (office)
812-379-4490 (home)
812-372-0311 (fax)
E-mail: xduan@ivytech.edu

APPENDIX F

INITIAL COVER LETTER AND INSTRUMENT FOR INSTITUTION EXPERTS

Date

Name
Address
City, State, Zip code

Dear Name:

This letter is to cordially invite you to participate in a nationwide study. The purpose is to determine what skills and knowledge are needed by CAD technology students to become successful in the workplace. As an expert of CAD technology at a public two-year college, you have been randomly identified from the directory of public technical-vocational colleges to become a member of the Panel of Institution Experts. All members of the panel were chosen because of their profession and geographic representation.

Your input is very critical to this study. A Delphi technique is the research method. First, this study investigates what skills and knowledge are taught to CAD technology students. For this purpose, I ask you to provide me your associate degree program course curriculum catalog. Next, based on feedback from you and other college professors, as well as from the panel of Industry Experts, a model course curriculum for CAD technology associate degree programs will be proposed. This curriculum model will be sent to you and other panel members for your evaluation. Finally, I will share the results with you and other panel members after this process is completed. I realize that time is scarce for busy professors such as yourself; however, the included initial questionnaire should take approximately 10 minutes of your time to complete, the following questionnaires should take only 5-10 minutes each.

Your responses will be kept confidential and in no way will your name and your institution name be connected to the data you provide.

As an educator, a colleague, and a doctoral candidate at Indiana State University, I greatly appreciate your help. If you accept my invitation, please return the completed questionnaire and include a course curriculum catalog in the postage-paid, return-addressed envelope ASAP by (date) at your convenience, which will indicate your consent to participate in this study. In a few weeks, you will receive the next questionnaire. If you have any questions, please feel free to call me or contact me via e-mail. If you feel another member of your department would be more appropriate to participate in the study, please forward this letter to that individual.

Thank you very much for your assistance!

Sincerely,

Ran Duan
Chairperson and Professor
Design Technology Department
Ivy Tech State College
Columbus, Indiana 47203

Phone: 812-372-9925 ext. 148
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

CAD Technology Associate Degree Programs
The Initial Questionnaire

INSTRUCTIONS:

The purpose of this instrument is to investigate how CAD technology associate degree programs prepare students with the required skills and knowledge to meet the demands of business and industry. Please consider each item carefully before recording your response. This information will be used for research purposes only. Your name and institution name will not be associated with the data so that the information you provided will remain anonymous and confidential.

Thank you very much for your help!

Please indicate:

Name: _____

School name: _____

Phone number: _____

Fax number: _____

E-mail: _____

---

1. Sex a. M_____ b. F_____

2. Highest degree held: a. Associate_____ b. Bachelor_____ c. Master_____
   d. Doctorate_____ e. Other _____

3. My major area of study was:_____

4. Title of your present position:
   a. Chair_____ b. Professor_____ c. Associate Professor_____
   d. Assistant Professor_____ e. Instructor_____
   f. Other_____

5. Indicate number of years of your teaching experience:
   a. At present college _____ b. At two-year colleges _____
   c. At four-year colleges _____

6. Have you had industrial experience? a. Yes_____ b. No_____
   If yes, number of years _____

7. Indicate CAD software used in your program and how long you have used it:
   a. AutoCAD_____years_____ b. ProEngineer_____years_____
   c. SolidWorks_____years_____ d. AutoCAD Light_____years_____
   e. CAD Key_____years_____ f. Other_____years_____

8. What CAD software do you think are the best for your program?
   Name of software_____
   Reasons_____

9. Indicate the number of graduates each year in your program:
   a. AS_____ b. AAS_____ c. Certificate_____

10. How many credit hours are required for associate degree in your program?
    If on a semester system: a. Credits:_____ b. Number of courses:_____
    If on a quarter system: c. Credits:_____ d. Number of courses:_____

11. What kind of specialties do you offer in your program?
    a. Architectural_____ b. Mechanical_____ c. Civil_____
    d. Technical Illustration_____ e. Other_____

12. Indicate the number of faculty in your program:
    a. Full-time faculty_____ b. Part-time faculty_____

13. Indicate the number of courses offered in your program during a semester:
    a. Total courses_____ b. Evening courses_____
    c. Weekend courses_____ d. CAD courses_____
    e. Board drawing courses_____ f. Internet courses_____

14. How do you work with industry to enhance your program?
    a. Conduct projects in industry_____
    b. Seminars by industry professionals_____
    c. Donation from industry_____
    d. Qualified adjunct faculty from industry_____
    e. Internship in industry_____
    f. Other activities _____

15. Is your program accredited? a. Yes_____ b. No_____
    If yes, indicate the accreditation agency:
    NAIT (National Association of Industrial Technology)_____
    ADDA (American Design Drafting Association)_____
    Other accreditation agencies_____

16. Indicate the category of your college:
    a. Community college_____ b. Technical college_____
    c. Community and technical college_____ d. Other_____

17. Your college is: a. State supported_____ b. Locally supported_____

18. Indicate how well you are satisfied with your program outcomes?
    a. Very satisfied_____ b. Satisfied_____
    c. Moderately satisfied_____ d. Slightly satisfied_____
    e. Unsatisfied_____

    Comments:_____
    _____
    _____

APPENDIX G

ROUND ONE FOLLOW-UP E-MAIL

Date

E-mail Address

Dear

A couple of weeks ago I e-mailed you with the Industry (or Institution) Experts survey questionnaire for the CAD associate degree programs. I really want to keep you as a panel member for this nationwide study.

So far I have not received your completed initial questionnaire back to me, could you please return it to me at your convenience as soon as possible if you have not already returned it. Your assistance is greatly appreciated!

Have a nice summer! Looking forward to hearing from you soon.

Best wishes,

Ran Duan
Chair and Professor
Design Technology Department
Ivy Tech State College
Columbus In, 47203

812-972-9925 ext. 148
812-372-0311 (fax)
E-mail: xduan@ivytech.edu

Subject: Re: Questionnaire
Date: Wed, 29 May 2002 10:15:21 -0500
From: Xin-Ran Duan <xduan@ivytech.edu>
Organization: Ivy Tech State College
To: <chall@customelec.com>, xduan@ivytech.edu

Dear

Good morning!

I am glad to hear from you. Thank you very much for your quick response and support!

I am looking forward to your completed questionnaire. Then, you will receive the next questionnaire in a couple of weeks.

I will talk to you later.

Have a wonderful summer!

Best wishes,

Ran Duan
Professor and Chair
Design Technology department
Ivy Tech State College
Columbus, IN 47203

xduan@ivy.tec.in.us or xduan@ivytech.edu

wrote:

> *Dear Ran,*
> *I would like to thank you for incorporating me into your study.*
> *I have received, filled in, and returned your questionnaire.*
> *Should you have any questions or comments for me after*
> *receiving my form, please feel free to contact me.*
> *I will eagerly await the next questionnaire, and the results.*
> *Best regards,*
>
> *Manufacturing Engineer*
> *Cad Systems Coordinator*
> *Commercial Sales / Marketing*
>
>
> *Toll Free 1-877-RELY-CEI or 1-877-735-9234*
> *Ph: 607.432.3880*
> *F: 607.432.3913*
> *E-mail - chall@customelec.com*
> *Web - http://www.customelec.com*

APPENDIX H

ROUND TWO COVER LETTER AND INSTRUMENT

FOR INDUSTRY EXPERTS

Date

«Title» «FirstName» «LastName»
«Company Address»
«Address»
«City», «State» «Zipcode»

Dear «FirstName»:

Thank you very much for accepting the invitation to participate in this study. Your valuable input and response to the initial questionnaire are greatly appreciated.

You and other experts from sixteen states provided 149 items of knowledge and skills required for CAD students, which I have combined into the Round Two instrument containing 51 items. As you can see your participation is critical to the success of the study.

Once again, the purpose of this study is to determine what skills and knowledge are needed of CAD students to become successful in the workplace, and how the corresponding community college programs can provide an ideal curriculum for CAD students. The Delphi process was developed to obtain group input from the panel of experts.

The enclosed Round Two questionnaire will take 5-10 minutes of your time to complete. Please return it to me in the enclosed postage-paid, return-addressed envelope, ASAP by (date), 2002 at your earliest convenience. If you have any questions, please feel free to call me or contact me via e-mail.

Thank you very much for your assistance!

Sincerely,

Ran Duan
Chairperson and Professor
Design Technology Department
Ivy Tech State College
Columbus, Indiana 47203

Phone: 812-372-9925 ext.148
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

ROUND 2 QUESTIONNAIRE
INDUSTRIAL EXPERTS

INSTRUCTIONS:

Based on the broad feedback from all of the panel members, the following items are concentrated for your evaluation. Your input will remain anonymous and confidential!

Please rate your level of agreement with the listed required knowledge and skills for CAD associate degree graduates to become successful in the workplace. Your valuable input is greatly appreciated!

For each item, please make only one choice. Thank you!

Please indicate:
Name:_____ Address:_____

	Agree			Disagree	
	Strongly Agree	Agree	Moderately Agree	Disagree	Strongly Disagree
General Knowledge and Skills					
1. Algebra	____	____	____	____	____
2. Analytical Geometry	____	____	____	____	____
3. Trigonometry	____	____	____	____	____
4. Calculus	____	____	____	____	____
5. Physics	____	____	____	____	____
6. Chemistry	____	____	____	____	____
Interpersonal Skills					
7. Public Speaking	____	____	____	____	____
8. English Writing	____	____	____	____	____
9. Communication	____	____	____	____	____
10. Critical Thinking	____	____	____	____	____
11. Problem Solving	____	____	____	____	____
Basic Drafting Knowledge and Skills					
12. Basic Drafting	____	____	____	____	____

		Agree			Disagree	
		Strongly Agree	Agree	Moderately Agree	Disagree	Strongly Disagree
13.	Descriptive Geometry	____	____	____	____	____
14.	Technical Standards	____	____	____	____	____
15.	Coordinates Systems	____	____	____	____	____
16.	Multiview Drawings	____	____	____	____	____
17.	Isometric Drawings	____	____	____	____	____
18.	Geometric Dimensioning & Tolerance	____	____	____	____	____
19.	Basic Mechanical Drafting	____	____	____	____	____
20.	Basic Architectural Drafting	____	____	____	____	____
21.	Basic Civil Drafting	____	____	____	____	____
Computer Knowledge and Skills						
22.	Computer Fundamentals	____	____	____	____	____
23.	Computer File Management	____	____	____	____	____
24.	Word Processing (e.g. micro word, word perfect)	____	____	____	____	____
25.	Software on Windows for PC	____	____	____	____	____
26.	Spreadsheets (e.g. excel)	____	____	____	____	____
27.	Basic Application of Internet	____	____	____	____	____
28.	Basic Programming	____	____	____	____	____
CAD Knowledge and Skills						
29.	Major CAD softwares	____	____	____	____	____
30.	CAD 2D Drawings	____	____	____	____	____
31.	CAD 3D Modeling	____	____	____	____	____
32.	Basic CAD Lisp Programming	____	____	____	____	____
33.	CAD Design Project	____	____	____	____	____
34.	Customization of CAD Program	____	____	____	____	____

	Agree			Disagree	
	Strongly Agree	Agree	Moderately Agree	Disagree	Strongly Disagree
Basic Engineering Analysis, and Technical Knowledge and Skills					
35. Manufacturing Processes	____	____	____	____	____
36. Statics	____	____	____	____	____
37. Materials Processing	____	____	____	____	____
38. Strength of Materials	____	____	____	____	____
39. Basic Measurement	____	____	____	____	____
40. Basic Engineering & Technology Terminology	____	____	____	____	____
41. Basic Machining	____	____	____	____	____
42. Basic Electronics	____	____	____	____	____
43. Basic Construction	____	____	____	____	____
44. Basic Surveying	____	____	____	____	____
Special Knowledge and Skills Needed in the Field					
45. Design Applications & Practices	____	____	____	____	____
46. Special Project in the Field	____	____	____	____	____
47. Marketing & Sales	____	____	____	____	____
48. Basic Knowledge of Laws	____	____	____	____	____
49. Troubleshooting Skills	____	____	____	____	____
50. Teamwork	____	____	____	____	____
51. Leadership Skills	____	____	____	____	____

Additional Comments:

_____

_____

Thank you again for your participation in this study!

Ran Duan
Chairperson and Professor
Design Technology Department
Ivy Tech State College
Columbus, IN 47203

812-372-9925 ext. 148 (office)
812-379-4490 (home)
812-372-0311 (fax)
E-mail: xduan@ivytech.edu

APPENDIX I

ROUND TWO COVER LETTER AND INSTRUMENT FOR INSTITUTION EXPERTS

Date

Name
Address

Dear

Thank you very much for accepting the invitation to participate in this study. Your response and assistance are greatly appreciated.

You and other members of the Panel of Institution Experts from twenty-three states provided me with valuable information and program catalogs; in addition, industry experts provided me with broad ideas of knowledge and skills required for CAD students to become successful in the workplace. I have combined the input from the two panels into the Round Two instrument containing 51 items of required knowledge and skills for your evaluation. As you can see your participation is critical to the success of the study.

Once again, the purpose of this study is to determine what skills and knowledge are needed of CAD students to become successful in the workplace, and how the corresponding community college programs can provide an ideal curriculum for CAD students. The Delphi process was developed to obtain group input from the panel of experts.

The enclosed Round Two questionnaire will take 5-10 minutes of your time to complete. Please return it to me in the enclosed postage-paid, return-addressed envelope, ASAP by (date) 2002 at your earliest convenience. If you have any questions, please feel free to call me or contact me via e-mail.

Thank you again for your assistance!

Sincerely,

Ran Duan
Chairperson and Professor
Design Technology Department
Ivy Tech State College
Columbus, Indiana 47203

Phone: 812-372-9925 Ext.148
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

ROUND 2 QUESTIONNAIRE
INSTITUTION EXPERTS

INSTRUCTIONS:

Based on the broad feedback from all of the members of two panels, the following items are concentrated for your evaluation. Your input will remain anonymous and confidential!

Please rate your level of agreement with the listed required knowledge and skills for CAD associate degree graduates to become successful in the workplace. Your valuable input is greatly appreciated!

For each item, please make only one choice. Thank you!

Please indicate:
Name:_____ Address:_____
Phone: _____ _____
E-mail: _____ _____

	Agree			Disagree	
	Strongly Agree	Agree	Moderately Agree	Disagree	Strongly Disagree
General Knowledge and Skills					
1. Algebra	____	____	____	____	____
2. Analytical Geometry	____	____	____	____	____
3. Trigonometry	____	____	____	____	____
4. Calculus	____	____	____	____	____
5. Physics	____	____	____	____	____
6. Chemistry	____	____	____	____	____
Interpersonal Skills					
7. Public Speaking	____	____	____	____	____
8. English Writing	____	____	____	____	____
9. Communication	____	____	____	____	____
10. Critical Thinking	____	____	____	____	____
11. Problem Solving	____	____	____	____	____
Basic Drafting Knowledge and Skills					
12. Basic Drafting	____	____	____	____	____

		Agree			Disagree	
		Strongly Agree	Agree	Moderately Agree	Disagree	Strongly Disagree
13.	Descriptive Geometry					
14.	Technical Standards					
15.	Coordinates Systems					
16.	Multiview Drawings					
17.	Isometric Drawings					
18.	Geometric Dimensioning & Tolerance					
19.	Basic Mechanical Drafting					
20.	Basic Architectural Drafting					
21.	Basic Civil Drafting					
Computer Knowledge and Skills						
22.	Computer Fundamentals					
23.	Computer File Management					
24.	Word Processing (e.g. micro word, word perfect)					
25.	Software on Windows for PC					
26.	Spreadsheets (e.g. excel)					
27.	Basic Application of Internet					
28.	Basic Programming					
CAD Knowledge and Skills						
29.	Major CAD softwares					
30.	CAD 2D Drawings					
31.	CAD 3D Modeling					
32.	Basic CAD Lisp Programming					
33.	CAD Design Project					
34.	Customization of CAD Program					

	Agree			Disagree	
	Strongly Agree	Agree	Moderately Agree	Disagree	Strongly Disagree
Basic Engineering Analysis, and Technical Knowledge and Skills					
35. Manufacturing Processes	____	____	____	____	____
36. Statics	____	____	____	____	____
37. Materials Processing	____	____	____	____	____
38. Strength of Materials	____	____	____	____	____
39. Basic Measurement	____	____	____	____	____
40. Basic Engineering & Technology Terminology	____	____	____	____	____
41. Basic Machining	____	____	____	____	____
42. Basic Electronics	____	____	____	____	____
43. Basic Construction	____	____	____	____	____
44. Basic Surveying	____	____	____	____	____
Special Knowledge and Skills Needed in the Field					
45. Design Applications & Practices	____	____	____	____	____
46. Special Project in the Field	____	____	____	____	____
47. Marketing & Sales	____	____	____	____	____
48. Basic Knowledge of Laws	____	____	____	____	____
49. Troubleshooting Skills	____	____	____	____	____
50. Teamwork	____	____	____	____	____
51. Leadership Skills	____	____	____	____	____

Additional Comments:

_____

_____

Thank you again for your participation in this study!

Ran Duan
Chairperson and Professor
Design Technology Department
Ivy Tech State College
Columbus, IN 47203

812-372-9925 ext. 148 (office)
812-379-4490 (home)
812-372-0311 (fax)
E-mail: xduan@ivytech.edu

APPENDIX J

ROUND TWO FOLLOW-UP E-MAIL

Subject: Institution Experts follow-up
Date: Fri, 19 Jul 2002 14:52:09 -0500
From: Xin-Ran Duan <xduan@ivytech.edu>
Organization: Ivy Tech State College
To: .@TVCC.EDU, xduan@ivytech.edu

Dear

Several weeks ago I sent a letter dated June 21, 2002 to you to thank you for your accepting the invitation to participate my nationwide investigation study. I greatly appreciate your help!

Based on the valuable input from you and other members of two panels of experts, a list of required knowledge and skills for successful CAD students has been developed containing 51 items for your evaluation. This list is attached with that letter. Hope you received them. So far I have not heard from you yet, however I really want to get your opinion and feedback to develop a model of curriculum.

If you could take 5-10 minuets to complete the questionnaire and return it to me ASAP at your convenience, I would be very grateful to you for your support.

If you did already, please ignore this message.

I am looking forward to your response.

I attach the round two questionnaire (the list) below for you.

Thank you very much!

Have a wonderful summer!

Best wishes,

Ran Duan
Chair and Professor
Design Technology department
Ivy Tech State College
Columbus, Indiana 47203

Phone: 812-372-9925 Ext. 148
Fax: 812-372-0311
e-mail: xduan@ivytech.edu

ROUND 2 QUESTIONNAIRE INSTITUTION EXPERTS.doc	**Name:** ROUND 2 QUESTIONNAIRE INSTITUTION EXPERTS.doc **Type:** Winword File (application/msword) **Encoding:** base64

Subject: Round 2 Questionnaire
Date: Fri, 21 Jun 2002 10:58:57 -0500
From: Xin-Ran Duan <xduan@ivytech.edu>
Organization: Ivy Tech State College
To: sanste@pathwaynet.com, xduan@ivytech.edu

To:

Dear

Thank you very much for your wonderful feedback on the initial questionnaire! I am proud of having you as a valuable panel member.

Based on the input from you and other panel members, the Round 2 Questionnaire was ready and mailed to you today. Hope you can get it soon.

Look forward to your opinions on the Round 2 questionnaire.

Have a great weekend!

Ran Duan
Chair and Professor
Design Technology Department
Ivy Tech State College
Columbus, IN 47203

812-372-9925 ext. 148
812-372-0311 (fax)
e-mail: xduan@ivytech.edu

APPENDIX K

ROUND THREE COVER LETTER FOR INDUSTRY EXPERTS

September 17, 2002

«Title» «FirstName» «LastName»
«Company»
«Address1»
«City», «State» «PostalCode»

Dear «FirstName»:

Greetings to you for the fall season! Thank you very much for your quick response to the second round regarding the required knowledge and skills for CAD students in this study!

As you know, it takes a while to collect all of the responses from the two nationwide panels. For the final stage, I have drawn up a proposed course curriculum for the CAD associate degree programs for your evaluation. The curriculum is based on the valuable feedback and information from you and all of the other members of the two panels. According to an investigation of the course catalogs provided by the Panel of Institution Experts, it has been found that there are many specialties related to CAD programs with a variety of courses offered to students. However, this proposed course curriculum only contains a limited number of the most important core courses in regard to the relevant required knowledge and skills; therefore, it could not cover all courses needed in industry. This curriculum has to be a condensed list of selected courses. For this reason, only the top three most popular specialties are included in this curriculum: Mechanical (offered by 84 % of colleges), Architectural (offered by 59 % of colleges), and Civil (offered by 41 % of colleges).

The enclosed third round questionnaire will take 5-10 minutes of your time to complete. You only need to choose a rating number for the curriculum evaluation. Please return it to me in the provided envelope by September 30, 2002 at your earliest convenience. You can also send me an e-mail regarding your choice at xduan@ivytech.edu or fax the first page and the last page (Page 4) of the questionnaire to my attention at 812-372-0311, so this project can be completed in a timely fashion. Your responses will be kept strictly confidential, as promised.

Thank you for your assistance! If you have any questions, please feel free to contact me at any time.

Sincerely,

Ran Duan
Chair and Professor
Design Technology Department
Ivy Tech State College
Columbus, Indiana 47203

Phone: 812-372-9925 ext. 148
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

APPENDIX L

ROUND THREE COVER LETTER FOR INSTITUTION EXPERTS

September 17, 2002

Professor «FirstName» «LastName»
«College»
«Address1»
«Address2»
«City», «State» «PostalCode»

Dear «FirstName»:

Greetings to you for the fall semester! Thank you very much for your quick response to the second round regarding the required knowledge and skills for CAD students in this study!

As you know, it takes a while to collect all of the responses from the two nationwide panels. For the final stage, I have drawn up a proposed course curriculum for the CAD associate degree programs for your evaluation. The curriculum is based on the valuable feedback, information, and course catalogs from you and all of the other members of the two panels. According to an investigation of the provided course catalogs, it has been found that there are many specialties related to CAD programs with a variety of courses offered to students. However, this proposed course curriculum only contains a limited number of the most important core courses in regard to the relevant required knowledge and skills. I was unable to cover all courses from the given catalogs in a wide range of existing programs, so this curriculum has to be a condensed list of selected courses. For this reason, only the top three popular specialties are included in this curriculum: Mechanical (offered by 84 % of colleges), Architectural (offered by 59 % of colleges), and Civil (offered by 41 % of colleges).

The enclosed third round questionnaire will take 5-10 minutes of your time to complete. You only need to choose a rating number for the curriculum evaluation. Please return it to me in the provided envelope by September 30, 2002 at your earliest convenience. You can also send me an e-mail regarding your choice at xduan@ivytech.edu or fax the first page and the last page (Page 4) of the questionnaire to my attention at 812-372-0311, so this project can be completed in a timely fashion. Your responses will be kept strictly confidential, as promised.

Thank you for your assistance! If you have any questions, please feel free to contact me at any time.

Sincerely,

Ran Duan
Chair and Professor
Design Technology Department
Ivy Tech State College
Columbus, Indiana 47203

Phone: 812-372-9925 ext. 148
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

APPENDIX M

ROUND THREE INSTRUMENT

ROUND 3 QUESTIONNAIRE
EVALUATION OF PROPOSED COURSE CURRICULUM

INSTRUCTIONS:

Based on the broad valuable feedback from all of the members of two panels, the following is a proposed course curriculum for CAD Associate Degree programs for your evaluation. Your input will remain anonymous and confidential!

Please rate your level of agreement with the proposed course curriculum at the end of the questionnaire (page 4). You just need to choose a rating number from 5 – 1 for your choice. Thank you!

Please indicate:

Name _____ Address: _____
Phone: _____ _____
E-mail: _____ _____

GENERAL EDUCATION REQUIREMENTS

Suggested Courses:
Fundamentals of Public Speaking (Oral Communication Requirement, 97% of panel members agree)
English Composition (Written Communication Requirement, 97% agree)
College Algebra (Math Requirement, 100% agree)
Geometry/Trigonometry (Math Requirement: Geometry, 97% agree; Trigonometry, 97% agree)
Physics (Science Requirement, 93% agree)
Social/Humanities Elective

SUPPORT COURSES

1. **Course Title: Microcomputer Applications**

Description: Provides an introduction to microcomputer hardware, software, and applications. Emphasizes computer literacy, the Windows operation system, computer programming, and industrial orientation.
Note: Related to the required knowledge and skills, computer fundamentals, 100% agree; file management, 93% agree; word processing, 93% agree; software on Windows for PC, 93% agree; spreadsheets, 93% agree; basic application of Internet, 90% agree; basic programming, 79% agree.
Other Similar Titles: Computer Fundamentals, Introduction to Computers.

2. **Title: Interpersonal Communications**

Description: Focuses on the process of interpersonal communications as a dynamic and complex system of interactions. Stresses the importance of applying interpersonal communication theory in work, family, and social relationships.
Note: Communication, 100% agree; critical thinking, 100% agree; problem solving, 100% agree.

3. **Title: Technical Writing**

Description: Requires students to prepare technical reports for various purposes using standard research techniques, documentation and formatting as appropriate. Requires student to demonstrate both communication and written competencies.
Note: Communication, 100% agree; English writing, 97% agree; technical standard, 100% agree.
Other Similar Titles: Technical Report Writing

TECHNICAL CORE COURSES

4. **Title: Engineering Graphics**

Description: Introduction to drafting applications. Strengthens basic drafting skills to proficient technician level Areas of study include drafting tools, sketching, measurement, lettering, geometric construction, orthographic projections, pictorial drawings, sectional views, dimensioning, and tolerancing.
Note: Basic drawing, 100% agree; coordinates system, 100% agree; multiview drawings, 100% agree; isometric

drawings, 100% agree; technical standard, 100% agree; basic measurement, 100% agree.
Other Similar Titles: Engineering Drawing, Technical Graphics.

5. **Title: Descriptive Geometry**
Description: Introduces fundamental principles in developing graphical solutions to engineering problems with imagination and visualization. Applies concepts of true length, line intersections, true shape, revolutions and developments using successive auxiliary views.
Note: Descriptive geometry, 93% agree.

6. **Title: CAD Fundamentals**
Description: Introduces the concepts and skills required in Computer-Aided Drafting and Design (CAD). Topics include an overview of CAD and system, use of software, drawing layout, and standard graphics commands for two-dimensional drawings. AutoCAD is the primary software used in this course.
Note: CAD 2D drawings, 100% agree.
Other Similar Titles: Introduction to AutoCAD, Computer-Aided Drafting and Design.

7. **Title: Advanced CAD**
Description: Focuses on advanced CAD features that include fundamentals of 3-dimensional modeling for design. Topics include overview of modeling, graphic manipulation, part structuring, coordinate system, and developing strategy of model geometry.
Note: CAD 3D modeling, 100% agree.
Other Similar Titles: 3D Modeling, AutoCAD 3-D, Advanced Computer-Aided Drafting.

8. **Title: Manufacturing Processes**
Description: A basic survey of manufacturing processes, tools and equipment used by modern industry to convert bars, forgings, casings, plates and sheet materials into finished products. Includes basic mechanics of materials removal and forming, metallurgy, quality control, and safety of operations. Also introduces non-traditional manufacturing techniques.
Note: Manufacturing processes, 100% agree; material processing, 97% agree.
Other Similar Titles: Engineering Process and Procedures, Manufacturing Technology.

9. **Title: Applied Statics**
Description: Studies applied mechanics dealing with bodies at rest. Covers units, vectors, forces, equilibrium, moments and couples, planar force systems, distributed forces, analysis of structures (trusses and frames) and friction.
Note: Statics, 93% agree.
Other Similar Titles: Statics, Applied Mechanics.

10. **Title: Strength of Materials**
Description: Studies internal stresses and physical deformations caused by externally applied loads to structural members. Covers stress and strain, shear stress, properties of areas, shearing force and bending moment, deformation of beams, columns and combined stresses. Teaches various materials' physical and mechanical properties.
Note: Materials processing, 97% agree; strength of materials, 97% agree.
Other Similar Titles: Engineering Materials

SPECIALTY ELECTIVE COURSES
MECHANICAL SPECIALTY (Offered by 84% of colleges)

11. **Title: Mechanical Drafting**
Description: Introduces the set of concept of working drawings both in detailing and assembly. Preserves fastening devices, thread symbols and nomenclature, surface texture symbols, classes of fits, and the use of parts lists, titles and revision books. Introduces the basics of product design and the design process.
Note: Basic mechanical drafting, 93% agree.

12. **Title: Tool Design**
Description: Introduces the processes of drafting and design as applied to tooling. Emphasizes tooling, locators, supports, holding devices, clearances, and design as it pertains to jig and fixture.
Note: Basic mechanical drafting, 93% agree; geometric dimensioning and tolerancing, 93% agree.

Other Similar Title: Jig & Fixture Design

13. Title: Mechanical Design Project
Description: Presents practical solutions to mechanical design problems. Studies the design of machine elements including shafts, bearings, keys, pins, and springs. Includes the geometry and drafting of cams, and gears and the study of linkages.
Note: Manufacturing process, 100% agree; basic machinery, 100% agree; basic mechanical drafting, 93% agree; design applications and practice, 100% agree.
Other Similar Titles: Machine Design

ARCHITECTURAL SPECIALTY (Offered by 59% of colleges)

14. Title: Architectural Drafting
Description: Focuses on the architectural drafting of commercial or residential buildings. Covers problems o space planning, design, materials, HVAC systems and construction methods. Develops working drawings and presentation drawings. Requires students to complete research on a limited number of construction materials and methods.
Note: Basic architectural drafting, 93% agree.
Other Similar Titles: Architectural Drawing

15. Title: Building Codes and Standards
Description: Provides technical information covering pertinent sections of the Building Code Standards necessary for building inspectors and related workers in the trade.
Note: Technical standards, 100% agree; basic construction, 97% agree.
Other Similar Title: Construction Codes

16. Title: Architectural CAD
Description: Presents advanced computer-aided design topics including latest technological methodology and standards relating to architectural drawings and design, and construction. Includes all necessary drawings utilizing CAD such as the site, floor plan, foundation, elevation, and details needed for the construction process.
Note: Basic architectural drafting, 93% agree; CAD design project, 93% agree.
Other Similar Titles: Architectural Computer Aided Design

CIVIL SPECIALTY (Offered by 41% of colleges)

17. Title: Civil Drafting
Description: Studies civil drafting and design practice and preparation of drawings used in the civil engineering industry. Students are required to complete projects relating to survey data, profiles and cross sections, and subdivision, site and grading plans, and basic earth work calculations.
Note: Basic construction, 97% agree; basic survey 97% agree, basic civil drafting, 93% agree.

18. Title: Fundamentals of Surveying
Description: Introduces surveying equi8pment, procedures for performing measurements, turning angles, determining grades, and other field applications. Covers surveying techniques and computations using the level, chain, and transit in calculating areas, lines, and grades.
Note: Basic surveying, 97% agree.
Other Similar Titles: Surveying, Introduction to Surveying.

19. Title: Structural Drafting
Description: Focuses on detailing commercial structural members, their connections, materials and methods of construction. Concentrates on traditional materials, such as reinforced concrete, masonry, steel, and timber.
Note: Basic construction, 97% agree; basic civil drafting, 93% agree.
Other Similar Titles: Structural Detailing

TECHNICAL ELECTIVE

20. Title: CAD Programming and Customizing
Description: Focuses on advanced CAD features, various methods of customizing CAD system, and CAD Lisp Programming.
Note: Customization of CAD program, 86% agree; basic CAD Lisp programming, 83% agree.
Other Similar Titles: CAD Customization, CAD Programming and Application.

21. Title: Geometric Dimensioning and Tolerancing
Description: Introduces the fundamentals principles of geometric dimensioning and tolerancing according to the latest ANSI standards. Applies geometric dimensioning and tolerancing symbols along with tolerances of form, orientation, run-out, and location.
Note: Geometric dimensioning and tolerance, 93% agree; basic measurement, 100% agree.
Other Similar Titles: Introduction to Geometric Dimensioning and Tolerancing

22. Title: Technical Standards and Terminology
Description: Technical information covering pertinent ANSI standards and terminology in engineering and technology.
Note: Technical standards, 100% agree; basic engineering and technology terminology, 100% agree.
Other Similar Titles: Engineering Orientation, Introduction to Technology.

23. Title: Special Projects
Description: Study of special problems such as advanced CAD topics, CAD updating skills, and software applications or completion of a special project not covered in previous courses.
Note: CAD design project, 93% agree; design application and practice, 100% agree; special project in the field, 93% agree.
Other Similar Titles: Special Problem in CAD, Special Topics.

24. Title: Portfolio Development
Description: Focuses on the student's final portfolio for graduation and preparation for the job interview. Finalizes design project demonstrating required knowledge and skills for degree achievement presentation. Every student must submit a copy of final portfolio for departmental archives.
Note: Design application and practice 100% agree; special projects in the field, 93% agree.
Other Similar Titles: Portfolio Preparation

Using a five-point scale, please evaluate the above proposed curriculum and choose only one number for your choice.

5 – Strongly Agree; 4 – Agree; 3 – Moderately Agree, 2 – Disagree, 1 – Strongly Disagree.

Please indicate your Choice: _____

Additional Comments:

_____
_____
_____
_____

Thank you again for your participation in this study!

Ran Duan
Chairperson and Professor
Design Technology Department
Ivy Tech State College
Columbus, IN 47203

812-372-9925 Ext. 148 (office)
812-379-4490 (home)
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

APPENDIX N

ROUND THREE FOLLOW-UP E-MAIL AND FAX

Subject: Re: my response... looks good Re: Letter and Curriculum
Date: Tue, 08 Oct 2002 10:37:25 -0500
From: Xin-Ran Duan <xduan@ivytech.edu>
Organization: Ivy Tech State College
To: @Cummins.com, xduan@ivytech.edu

Thank you so much for your quick response and comments! I appreciate your support in this study.

Have a nice day!

Ran

@Cummins.com wrote:

> *I've ranked the curriculum a 5 and think it looks good!*
> *(See attached file: ROUND 3 QUESTIONNAIRE-2.doc)*
> ---
> *Name: ROUND 3 QUESTIONNAIRE-2.doc*
> *ROUND 3 QUESTIONNAIRE-2.doc Type: Winword File (application/msword)*
> *Encoding: base64*

Subject: Curriculum evaluation-last stage
Date: Fri, 04 Oct 2002 15:18:07 -0500
From: Xin-Ran Duan <xduan@ivytech.edu>
Organization: Ivy Tech State College
To: celler@wallace.edu, xduan@ivytech.edu

TO:

Dear

Good afternoon!

Thank you very much for your participating in the CAD nationwide survey study!

At the last stage of the study, I mailed a letter of September 17, 2002 with attached Round 3 instrument (proposed curriculum) to you for your review, hope you got them.

So far I have not heard from you. If you have not received them, please let me know, I can e-mail it to you right away. Please take 5-10 minutes review it, e-mail or fax your evaluation result to me ASAP at your earliest convenience. If you received them, and mailed it back to me already, please disregard this message.

If you have any question, please e-mail me or call me at 812-372-9925 ext. 148 at any time.

Thank you very much for your support in this study!

Have a wonderful weekend!

Best wishes,

Ran Duan
Chair and Professor
Design Technology Department
Ivy Tech State College
Columbus, Indiana 47203

Phone: 812-372-9925 ext. 148
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

Subject: Re: curriculum evaluation-last stage
Date: Fri, 04 Oct 2002 15:28:18 -0700
From: @clackamas.cc.or.us>
To: <xduan@ivytech.edu>

Ran,

The survey was mailed a few days ago. good luck.

>>> Xin-Ran Duan <xduan@ivytech.edu> 10/04/02 01:54PM >>>
TO:

Dear

Good afternoon!

Thank you very much for your participating in the CAD nationwide survey study!

At the last stage of the study, I mailed a letter of September 17, 2002 with attached Round 3 instrument (proposed curriculum) to you for your review, hope you got them.

So far I have not heard from you. If you have not received them, please let me know, I can e-mail it to you right away. Please take 5-10 minutes review it, e-mail or fax your evaluation result to me ASAP at your earliest convenience. If you received them, and mailed it back to me already, please disregard this message.

If you have any question, please e-mail me or call me at 812-372-9925 ext. 148 at any time.

Thank you very much for your support in this study!

Have a wonderful weekend!

Best wishes,

Ran Duan
Chair and Professor
Design Technology Department
Ivy Tech State College
Columbus, Indiana 47203

Phone: 812-372-9925 ext. 148
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

Ivy Tech State College
4475 Central Avenue
Columbus, IN 47203
www.ivytech.edu

Date 10-1-2002

Number of pages
including cover sheet: 6

To:

Of:

CC:

FAX: 602-553-0083

From:
Ran Duan

Phone: 812.372.9925 ext. 148

FAX: 812.372.0311

Remarks ☐ Urgent ☒ For your review ☒ Reply ASAP ☐ Please comment

Comments:

Dear

It is very nice for me to talk to you today on the phone. The encluded are the original letter and the instrument at round three for you. Please fax or e-mail your evaluation results A.S.A.P. I greatly appreciate your support in this study.

Have a nice day!

Ran

APPENDIX O

DISTRIBUTION OF PANEL MEMBERS BY GEOGRAPHIC LOCATIONS IN THE UNITED STATES

Distribution of Panel Members by Geographic Locations in the United States

Northwest region		
States	Panel of Industry Experts	Panel of Institution Experts
Connecticut		1
Maine		3
New York	3	2
Pennsylvania	1	
Subtotal 4 states	4	6

Southeast region		
States	Panel of Industry Experts	Panel of Institution Experts
Alabama		2
Florida	1	1
Georgia		2
Maryland	1	
Mississippi	1	1
North Carolina	1	
South Carolina	1	
Tennessee		1
Virginia		1
Subtotal 9 states	5	8

Midwest region

States	Panel of Industry Experts	Panel of Institution Experts
Indiana	6	3
Iowa	2	
Michigan	3	1
Minnesota		1
Missouri		1
Nebraska		1
Ohio	1	2
Oklahoma		1
Texas		1
Wisconsin	2	1
Subtotal 10 states	14	12

West region

States	Panel of Industry Experts	Panel of Institution Experts
Arizona	1	
California	5	1
New Mexico		1
Oregon		2
Utah	1	1
Washington		1
Subtotal 6 States	7	6
Total 29 States	(From 15 States)30	(From 23 States) 32

APPENDIX P

ROUND ONE RESPONSES OF INDUSTRY EXPERTS –

REQUIRED KNOWLEDGE AND SKILLS

CATEGORIES IDENTIFIED FROM FEEDBACK

APPENDIX P

Round One Responses of Industry Experts - Required Knowledge and Skills Categories Identified from the Feedback

Category	Number of Knowledge and Skills Statements by Category	
General Knowledge & Skills		
Algebra	5	
Analytical Geometry	6	
Trigonometry	5	
Calculus	2	
Physics	2	
Chemistry	2	
Subtotal		22
Interpersonal Skills		
Public Speaking	4	
English Writing	3	
Communication	3	
Ability to Ask Questions	3	
Critical Thinking	1	
Problem Solving	2	
Team Building & Working	2	
Subtotal		18
Basic Drafting Knowledge & Skills		
Basic Drafting	13	
Descriptive Geometry	2	
Technical Standards	2	
Coordinates Systems	2	
Multiview Drawings	1	
Isometric drawings	3	
Geometric Dimensioning & Tolerance	1	
Basic Mechanical Drafting	1	
Basic Architectural Drafting	1	
Basic Civil Drafting	1	
Subtotal		27
Computer Knowledge & Skills		
Computer Fundamentals	8	

Computer File Management	1	
Word Processing	2	
Software on Windows for PC	2	
Spreadsheets	1	
Basic Application of Internet	1	
Basic Programming	1	
Subtotal		16
CAD Knowledge & Skills		
Basic CAD	3	
CAD 2D Drawings	9	
CAD 3D Modeling	6	
Basic CAD Lisp Programming	2	
CAD Design Project	1	
Customization of CAD Program	2	
Subtotal		23
Basic Engineering Analysis & Technical Knowledge and Skills		
Manufacturing Processes	5	
Statistics	4	
Materials Processing	5	
Strength of Materials	6	
Basic Measurement	1	
Basic Engineering &Technology Terminology	1	
Basic Machining	3	
Basic Electronics	2	
Basic Construction	1	
Basic Surveying	3	
Subtotal		31
Special Knowledge & Skills Needed in the Field		
Design Applications & Practices	2	
Special Project in the Field	1	
Marketing & Sales	1	
Basic Knowledge of Laws	1	
Research and Development	1	
Professional Behavior	1	
Troubleshooting skills	2	
Teamwork	2	
Leadership Skills	1	
Subtotal		12
Total		149

APPENDIX Q

ROUND ONE RESPONSES OF INSTITUTION EXPERTS

CLASSIFICATION OF COURSE OFFERINGS

IDENTIFIED FROM COLLECTED CATALOGS

APPENDIX Q

Round One Responses of Institution Experts - Classifications of Course Offerings Identified from the Collected CAD Catalogs

Categories	Number of Courses by Category	
General Education		
College Algebra	3	
Technical Math	3	
Trigonometry	3	
Technical Calculus	2	
Technical Physics	4	
English Composition	4	
Fundamentals of Public Speaking	3	
Introduction to Psychology	1	
Introduction to Sociology	1	
American History	4	
Communication Requirement	4	
Subtotal		32
Support Courses		
Micro-computer Applications	5	
Other Support Courses	3	
Subtotal		8
Technical Core Courses		
Descriptive Geometry	1	
Manufacturing Process	1	
Geometric Dimensioning & Tolerance	1	
Materials Strength & Process	3	
Engineering Graphics	5	
Technical Illustration	2	
CAD Fundamentals	2	
Intermediate CAD	2	
CAD Mechanical Drafting	2	
Solid Works	1	
Survey & Computer Aided Drafting	1	
Advanced CAD	3	
CAD Animation	2	
Pro E Fundamentals	1	
Micro-station 2-D	1	
Micro-station 3-D	1	
Auto CAD Lisp Programming	1	
CAD Customization	3	
Other CAD Courses	4	
Introduction to Technology	3	
Piping Drafting	1	
Engineering Methods	1	
Parametric Design	1	
Other Drafting Courses	8	
Subtotal		51

Mechanical Specialty Courses		
Mechanical Drafting	4	
Machine Drafting	2	
Jig & Fixture Design	2	
Advanced Machine Drafting	2	
Power Transmission	1	
CAD/CAM	2	
CNC	2	
Other Mechanical Courses	16	
Subtotal		31
Architectural Specialty Courses		
Architectural Drafting	3	
Architectural CAD	1	
Advanced Architectural CAD	1	
Building Codes & Standards	2	
Principals of Design	1	
Architectural Rendering & Illustration	2	
Cost Estimating & Materials	2	
Construction Practice	2	
Other Architectural	3	
Subtotal		17
Civil Specialty Courses		
Civil Drafting & Design	4	
Surveying	2	
Commercial Construction	4	
Residential Planning	1	
Map Drawing	2	
Structural Steel Detailing	1	
Fundamentals of Geographic Information System	1	
Other Civil Courses	2	
Subtotal		17
Other Specialties		
Computer Graphics	4	
Electrical	3	
Other	11	
Subtotal		18
Total		174

Note. One course may have different titles. For example, Introduction to Psychology and General Psychology are considered the same course, as are Descriptive Geometry and Applied Descriptive Geometry.

APPENDIX R

COMMENTS OF INDUSTRY EXPERTS FROM ROUNDS TWO AND THREE

Table R1

Round Two Additional Comments from the Panel of Industry Experts

Member No.	Comments
3	I think a solid foundation in operating a CAD program is more important than knowing how to tweak the software that should come later with on the job experience.
5	Many of these items are critical tools drafters use daily.
13	For SRCN students 1 year apprentice in each field –commercial construction and residential construction.
19	(1) Teamwork skills are a must. (2) CAD technicians not only need to know how to take red lines off, but also check for mistakes not seen by the team leader.
23	Depending on the area of specialization, say my area, architectural—knowledge of basic construction would be very important – jobsite experience a definite plus. This would include developing field measuring skills.
27	A student must have practical experience, not just theory.
29	My comments are based on what I find most beneficial in the environmental department.

Note. Only the above seven members provided additional comments.

Table R2

Round Three Additional Comments From the Panel of Industry Experts

Member No.	Comments
1	I have had applicants who, during an interview, did not know what a pipe flange was! Some could not identify a clevis. There has got to be a way to introduce common mechanical and piping components to students that are in a machine design program. Another problem is spelling. I have interviewed graduate engineers who had misspelled words in their resumes.
2	I agree with your choices of courses 100%. I would give your proposed curriculum a 5. I think this will go a long way in helping you r students be prepared for their choice of careers. I think they will be well rounded into any field.
3	More emphasis on suggested public speaking, composition and math skills—perhaps part of special projects or portfolio development.
5	Sorry for the tardy response, as I was on vacation. I strongly agree (5) with your proposed curriculum.
7	I think this curriculum will greatly enhance the graduating students' abilities and knowledge.
9	The proposed curriculum is excellent. I strongly agree with the Civil Specialty of your proposal. I also strongly agree in the Support and Technical Core Courses. My evaluation of the complete proposal is a 5.
10	It sounds like a very good program. Well done.
11	Transportation engineering and design should be included under civil section. Another Area for consideration would be hazardous materials.
15	Very tough curriculum, but looks like it will provide well prepared/rounded engineer to society.
19	I believe the rating for this is 1-5 with five being the highest, record my response as 5(highest). The curriculum model looks very good.
21	Nice job!

22	I feel you have covered all of the courses required for the industry. A student taking your program would be ready for the outside world of drafting.
23	#15 Building codes and standards is a very god addition to architectural.
24	For GD&T, isn't it now ASME(rather than ANSI)? Good support and technical core courses.
25	I don't believe a large amount of time should be spent on #8, 9, & 10. These are typically engineering courses.
27	Include # 19 with items 14, 15, and 16. Can be kept as the same course number, just required for both areas.
28	I would like to see a basic fluid mechanics class if possible.
30	I feel that you have done a very complete job instructing a new course curriculum. Keep in touch.

Note. Only the above eighteen members provided extra comments.

APPENDIX S

COMMENTS OF INSTITUTION EXPERTS FROM ROUNDS ONE, TWO AND THREE

Table S1

Round One Additional Comments from the Panel of Institution Experts

Member No.	Comments
2	Excellent job placement, positive student surveys, good facility with current software.
3	We never stop changing and upgrading.
4	My biggest problem is that industry needs good people that they hire my students away from school before they can graduate; my graduation numbers are very low.
6	Instruction based recruiting policy could be improved with help from an organized recruiting office. Area is economically depressed have to convince students to leave area for jobs.
7	We have Skills/USA (VICA) winners that represent Minnesota at the nationals.
8	We have developed a 2-year and 3-year graduation plans. See enclosed brochures.
9	It is getting harder to place students in local jobs – Students have unrealistically high expectations for their first job after graduation and this has been very difficult to correct.
10	Catalogue about a year behind—D&D curriculum on page 63 Course descriptions, pp. 100-102.
11	Go to our website and check out www.ycty.net .
12	We have approximately 90% placement in out program.
15	Engineering Graphics: AAS; Arch Graphics: AAS; Civil Engineer: AAS at our school. Keep in touch!
16	It is very difficult to determine which if any new CAD programs should be taught. New software packages appear frequently. I'm very satisfied with the program being taught this year. But, will it be good enough for next year?
18	I have a high drop out rate but if they all graduated there would not be enough jobs for them. My best students are the ones who plan to transfer to a 4-year school.

Note. Only the above thirteen members provided additional comments.

Table S2

Round Two Additional Comments from the Panel of Institution Experts

Member No.	Comments
6	Some drafting programs go overboard and try to turn it into a mini engineering course. I think this defeats the purpose of training drafters. They do need a well-rounded drafting curriculum, but their future earnings does not warrant training them as junior engineers.
7	Mechanical drafting and design technology. We prepare our students to be drafters with light design—first year learn to draw, second year learn to think.
8	We have a mechanical program. Archi and civil do not apply.
10	Trig—right triangles and oblique triangles, physics and algebra—applied technical orientation.
11	Go to our web site www.yctc.net and see our course descriptions.
12	To be successful in the design industry there must be some level of mastery in all the proceeding topics. I apologize for not getting this back to you sooner.
15	Good luck.
24	It is important t to help students get a clear view of his or her ability so they can train for he appropriate leadership position. Career dreams motivated by greed are worse than useless.
28	Importance will vary depending on degree being studied.
30	One CAD software is enough—if they know one they can easily adapt to others on the job.

Note. Only the above ten members provided the additional comments.

Table S3

Round Three Additional Comments from the Panel of Institution Experts

Member No.	Comments
3	I think this is a very strong curriculum. If a college will apply this curriculum, the students should not have a problem getting a job.
4	I give the overall curriculum a rating of four. The couple of items that I would look at would be the Interpersonal Communications class. I would think that your English and speech classes would give the students the skill they would need in those areas. The only other area would be the course on Applied Statics in your core course area. I think it would be suited for the Architectural and Civil Specialty. I would add a class in Applied Mechanics to the Mechanical Specialty to equal the course number in the given areas. I hope that this is of some help.
5	Somewhere in here (especially in Civil) you should include some work in GIS, maybe Arc View or some similar software.
7	Good job!
10	Mechanical Design Curriculum. Do not believe there is enough emphasis on Solids modeling with "Industrial Equal" software, i.e. sound works pro-engineer and Catiai. We just added CATIA due to its use in large assemblies and the aircraft industry. Offer Solid works and Pro-engineer.
12	I believe this would be an excellent curriculum! Thanks for allowing me to participate.
14	This looks real good and a very workable plan. Thanks!
15	Very good!
17	I strongly agree with the proposed curriculum. I think that it looks very in-depth and comprehensive when including the options. This curriculum very much resembles my existing, and the options that I would like to put into place.
18	The only reason that I didn't pick 5 is that I believe statics and strength of materials should be combined into one course at the associate degree level. In preparation for a technician job rather than an engineering job. Good job!

23	Looks like you've done a lot of work with this survey. Well done!
24	This is an outstanding curriculum. Students completing these courses in the pattern of a concentration should have tools necessary to complete successfully in the entry-level work force.
25	I think the descript geom could be wrapped into other courses rather than offering it stand-alone. You're welcome.
26	Animation and rendering for arch. Option GIS and GPS for Civil option.
28	The traditional student get course #1 in high school. At CMTC we've eliminated this course in order to offer higher level CAD based courses. 3-D FEA and Dynamics, using software in what is needed by DOS in the mechanical field. Architectural and Civil courses also need to be using more advanced solutions beyond 3D CAD.
32	Thank you for the opportunity to be involved.

Note. Only the above sixteen members chose to provide additional comments.

APPENDIX T

FINAL THANK-YOU LETTER TO TWO PANELS

December 17, 2002

Name
Address
Zip code

Dear name:

This letter is to appreciate your support to my study and to share the final result of the study with you.

In October, I mailed the Round Three cover letter and questionnaire with a proposed model curriculum to you for your evaluation. You and other panel members quickly responded the questionnaire to me and provided valuable comments. As a result, both the Panel of Industry Experts and the Panel of Institution Experts reached a consensus separately and finally validated the model curriculum. I am pleased that this nationwide Delphi study has obtained good results and achieved its goal. The enclosed is a validated model curriculum with 24 courses in 4 categories for your reference.

I am proud to have very devoted experienced experts such as you to participate in the study. During the past six months, all of the members of the two panels from 29 states have input very much to the study through three rounds. I greatly appreciate your expertise, time, and comments!

Again, thank you so much for your support!

The holiday season is approaching us, I wish for you to have a wonderful Christmas and Happy New Year!

Best wishes to you and your family.

Sincerely,

Ran Duan
Chair and Professor
Design Technology Department
Ivy Tech Tech State College

Phone: 812-372-9925 Ext. 148
Fax: 812-372-0311
E-mail: xduan@ivytech.edu

Enclosure: A Greeting Card
A Validated Model Curriculum