AN OCCUPATIONAL SURVEY TO DETERMINE THE ENTRY LEVEL CAD SKILLS AND COMPETENCIES REQUIRED BY EMPLOYERS OF CIVIL ENGINEERING TECHNICIANS IN THE NORTHEAST WISCONSIN TECHNICAL COLLEGE DISTRICT

by

Gene R. Francisco

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Investigation Advisor

The Graduate School
University of Wisconsin-Stout
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The Graduate School
University of Wisconsin-Stout
Menomonie, Wisconsin 54751

ABSTRACT

	Francisco,	Gene	R.
Writer	(Last name)	(First)	(Initial)

An Occupational Survey to Determine the Entry Level CAD Skills and Competencies Required by Employers of Civil Engineering Technicians in the Northeast Wisconsin Technical College District

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The purpose of this study was to identify the CAD related technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician.

The majority of employers represented in this study are civil engineering firms, governmental agencies, and surveying firms. Overall, civil engineering firms along with governmental agencies employ the greatest number of drafters.

Civil drawings, survey maps, and topographical drawings are the most commonly prepared drawings by the respondents. Other reported drawing types include architectural, electrical/electronic, landscaping, structural, and technical illustrations.

Almost all of the respondents use a CAD system for drafting functions. AutoCAD is the primary CAD platform used. Microstation is also used, but to a much lesser extent.

Of the employers that use CAD software, most use at least one collaborative software package with their primary CAD platform. Eagle Point is the most common

collaborative software utilized. AutoCAD Land Development Desktop (ALDD) was noted to be the next commonly used collaborative software.

Out of the 24 basic CAD skills that were listed on the survey, 14 were considered to be valid curriculum items and will be either retained or added to the program curriculum. Six of the 24 items will be reviewed for being valid curriculum items, and four of the items will not be included in the curriculum. Overall, most basic CAD skills were performed frequently or considered important.

Out of the 29 advanced CAD skills that were listed on the survey, none were considered to be valid curriculum items. Sixteen of the 29 items will be reviewed for being valid curriculum items, and 13 of the items will not be included in the curriculum. Overall, most advanced CAD skills were not performed frequently nor considered important.

Out of the 15 basic architectural drawing skills that were listed on the survey, none were considered to be valid curriculum items. Eight of the 15 items will be reviewed for being valid curriculum items, and seven of the items will not be included in the curriculum. Overall, most basic architectural drawing skills were not performed frequently nor considered important.

None of the six basic structural drawing skills that were listed on the survey were considered to be valid curriculum items. One of the six items will be reviewed for being a valid curriculum item, and five of the items will not be included in the curriculum. Overall, most basic structural drawing skills were not performed frequently nor considered important.

Out of the six basic civil drawing skills that were listed on the survey, five were considered to be valid curriculum items and will be retained or added. One of the six items will be reviewed for being a valid curriculum item, and none of the items will be removed from the curriculum. Overall, most basic civil drawing skills were performed frequently and considered important.

Out of the six basic electrical/electronic drawing skills that were listed on the survey, none were considered to be valid curriculum items or items to be reviewed for being valid curriculum items. As such, none of the six of the items will be included in the curriculum. Overall, none of the basic electrical/electronic drawing skills were performed frequently or considered important.

Out of the 11 basic pneumatic/hydraulic drawing skills that were listed on the survey, none were considered to be valid curriculum items or items to be reviewed for being valid curriculum items. Overall, none of the basic pneumatic/hydraulic drawing skills were performed frequently or considered important.

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Chapter I

Introduction to the Study

Background of the Problem

Computer-aided design (CAD) is helping industry increase competitiveness by enabling research and design work to be transformed into finished products with higher quality and at lower cost (Byrum Skinner, 1996). By automating the routine work of replicating objects, CAD frees up time so that designers can spend more time during the design process. Productivity and profitability ratios within architectural firms that utilize CAD over traditional drafting methods (TRAD) have been estimated to be as high as 20:1 (Byrum Skinner, 1996).

CAD technology is based on the use of a computer to display graphic images. The images are based on mathematical coordinates existing in the computer as digital electronic data and can be in either two-dimensional (2D) or three-dimensional (3D) forms. Using input devices such as a mouse or digitizing tablet, CAD allows for replication, translation, scaling, rotation, and transformation of graphical images. As such, CAD operators can manipulate images in moments that used to take hours and days with paper and pencil (Bone, 1994).

CAD has been in existence for over 40 years. In the late 1950s and early 1960s, researchers developing interactive computer graphics used computer screens to display and manipulate objects. One of the earliest forms of CAD was developed by the Department of Defense in 1963 and was called Sketchpad (Bone, 1994). Sketchpad users could draw pictures on a screen with a light pen wired to the computer. With the

development of faster, smaller and less costly computers, CAD has become popular for drafting and related engineering analysis. Due to the relative simplicity of building design, architects were among the first users of CAD (Bone, 1994). Today, "everything from new car designs to homes, high-rises, and machine parts are coming to life on computer screens, and modern technology is advanced with each keystroke" (Byrum Skinner, 1996).

Within the construction industry, higher quality images resulting from the use of CAD heightens bidding accuracy and provides the architect, engineer and contractor the opportunity to visualize construction before it takes place (Marr, 1998). Clients can instantly see the results of changes, and once completed, the architect can take clients on an animated walk-through of the entire building, allowing them to explore every element of the design. Bone (1994) has indicated that architectural, engineering, and construction (AEC) software was the fasting growing area of the CAD industry.

Today, simple forms of CAD are often used by drafters as an electronic drawing board. With few exceptions, the civil engineering profession has been using CAD as a drafting tool that has been separate from the design function (Griggs, 1998).

In more complex installations, CAD is combined with computer-aided engineering (CAE) applications to help engineers and technicians analyze and improve designs through modeling and simulation before structures are actually built (Bone, 1994). It is now possible to model a structure and observe deflections under a series of loading conditions. Prior to this, it was necessary to perform the calculations first and then plot the deflections making computations very slow (Griggs, 1998).

The future will have an experienced CAD technician input design parameters. The detailed design, along with drawings, will then be completed by computer (Griggs, 1998). As such, students of today's CAD technology must be well grounded in both theory and technical procedures to understand what they are doing and how they are doing it (Suddath, 1994).

Changing CAD technology has a profound impact upon civil engineering technology curriculum. Advances in technology (caused by the rapid pace of development in computers) are changing the demand for workers who develop, maintain, and use that technology (Bone, 1994). As the technology changes, instructors of CAD training must also change yet keep the focus of the curriculum on the particular skills and competencies that are required by industry (Yuen, 1990). While CAD instruction is necessary to prepare civil engineering technicians for industry needs, it is important to note that the CAD system is nothing more than a tool in the hands of the designer and that computers cannot draw by themselves. Therefore, curriculum needs to continue to include the basic drawing fundamentals and the use of basic drawing tools (Yuen, 1990).

The associate degree Civil Engineering Technology program at Northeast Wisconsin Technical College (NWTC) in Green Bay, Wisconsin provides training in AutoCAD 2000 and SDRMap (a related CAD design software package). Graduates of the program typically are employed by architectural, engineering, surveying, and construction firms with a significant number of graduates also employed by local and state governments. As such, CAD competency needs of the employers of graduates from the program vary. A recent evaluation of the program (Phase II in-depth evaluation, 1998) indicated that an

evaluation of the current CAD software and competencies taught within the Civil Engineering Technology program should be made as compared to industry needs.

A study of industry-required CAD competencies of Civil Engineering Technology program graduates at NWTC has never been performed. Oehler (1976) conducted an occupational survey of industrial drafting needs within the NWTC district in 1976; however, the study was not specific to civil engineering technician employers, as well as the study (being relatively dated) does not address required CAD competencies.

Statement of the Problem

Engineering, surveying, and construction firms with varying CAD related needs employ graduates of the Civil Engineering Technology program at NWTC. As such, concern has developed among some employers of civil engineering technicians from the NWTC program regarding the CAD competencies taught to students and the selection of CAD software packages being utilized for instruction in the program.

Purpose of the Study

In order for civil engineering technician graduates to effectively meet the CAD needs of industry, a curriculum must be developed based on the CAD related technical skills and competencies required by industry employers of civil engineering technicians. Before such technical skills and competencies can be included in a curriculum, they must first be identified and then must be reviewed and revised periodically to keep up with the changing occupational requirements.

The purpose of this study was to identify the CAD related technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician. Once this has been established, it will then be possible to incorporate these changes into the Civil Engineering Technology program curriculum at NWTC.

Research Objectives

A study of industry-required CAD competencies of entry-level civil engineering technology program graduates at NWTC has never been performed. The objectives of this study are to:

1. Determine the CAD skills and competencies that are required by employers of civil engineering technicians.
2. Determine differences in required CAD competencies as they relate to employer type (i.e. surveyor, engineer, contractor, etc.).
3. Determine the types of CAD drawings that are prepared by civil engineering technicians.
4. Determine the CAD software packages currently being used by employers of civil engineering technicians.

Significance of the Study

An occupational analysis can accurately determine the CAD related technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician. After these skill and competency levels have been implemented

in the curriculum, program students will know exactly what is expected of them once they become employed as a civil engineering technician. Upon satisfactory completion of the program, graduates should possess the basic skills and competencies necessary in the civil engineering technology profession.

The CAD curriculum within the Civil Engineering Technology program at NWTC was developed as a result of advisory committee input and instructor expertise. An occupational survey of required CAD skills and competencies has never been performed. Once the needs of employers have been identified through an analysis, the CAD related curriculum can be reviewed for conformity with these needs.

Limitations of the Study

The following may be limitations of the study:

1. Some sampling bias may be incorporated into the findings if employers that may have a negative attitude toward NWTC receive the survey. Without also surveying employer attitudes toward the college and the program, the effects of this bias can not be accounted for.

2. The rate of response is an unknown limitation. Measures will be taken to secure a response rate of at least seventy percent.

3. Some of the sample population may no longer be in the same form of business as they were when they originally hired civil engineering technicians from the program. Therefore, their CAD needs may have changed and may not be typical or representative of needs of current employers of civil engineering technicians.

4. The sample to be surveyed will only be selected from one population: employers of civil engineering technicians from NWTC. Employers from other technical colleges with similar programs will not be surveyed; therefore, the conclusions derived from this research will only be intended for the improvement of NWTC's CAD curriculum.

Definition of Terms

AEC: Architectural, engineering, and construction

CAD: Computer-aided design.

CAE: Computer-aided engineering.

Civil engineering technology: The applied use of mathematics and science to the design and construction of public works.

Competencies: Sufficient knowledge or skills possessed by an individual needed to perform a task.

Computer-aided design: Using the computer to create, modify or evaluate product design. In architecture and civil engineering, CAD includes drawing, drafting, and modeling, as well as the management of information.

Curriculum: The general overall plan of instruction offered.

Design: The entire process of conceptualizing and documenting a project, including all stages of drawing.

Drafting: Drawing a preliminary sketch or plan.

Digitize: The process by which the coordinates of a point are stored in the computer.

GIS: Geographic information systems.

Mouse: A hand-operated graphic input device. Moving the mouse makes the cursor move in a corresponding direction, and at a corresponding rate. A mouse does not digitize. Instead, it remembers points incrementally. All program locations are given n terms of distance and direction from the immediately preceding point.

Occupational analysis: Analyzing each individual component or task that is necessary for successful performance in a career.

Software: The programs that make computers do the tasks needed.

TRAD: Traditional drafting methods.

Methodology

A survey instrument was developed based on occupational analysis instruments utilized in similar types of studies. The survey instrument was reviewed for content validity by three instructors of CAD and then was pilot tested using several local individuals familiar with CAD use in industry. Upon completion of the pilot testing, the revised survey instrument was mailed to 63 employers of civil engineering technicians. The employer sample was obtained from a list of civil engineering technology employers provided by the NWTC Student Employment Services office. Follow-up mailings were made to the employers to increase the response rate.

Upon receipt of the completed survey instruments, analyses were performed on the data. Information analyzed were: CAD skills that are required of civil engineering technicians in their workplace; the differences in required CAD competencies as they relate to employer type; the types of CAD drawings that are prepared by civil engineering technicians; and the CAD software packages currently being used in their firms.

Summary

Instructors of CAD training must keep the focus of the curriculum on the particular skills and competencies that are required by industry. A study of industry-required CAD competencies of entry-level civil engineering technology program graduates at NWTC has never been performed. The purpose of this study was to identify the CAD related technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician. This information will then be incorporated into the Civil Engineering Technology program curriculum at NWTC.

The following chapters document the literature reviewed in preparation for this study, detail the methods and procedures used in the research, present results and discussion of the research findings, and summarize conclusions and recommendations gathered from the research.

Chapter II

Review of Related Literature

Introduction

Computer-aided design (CAD) is helping industry increase competitiveness by enabling research and design work to be transformed into finished products with higher quality and at lower cost. This is accomplished by automating the routine work of replicating objects. As such, CAD frees up time so designers can spend more time during the design process thereby increasing productivity and profitability ratios.

Advances in technology (caused by the rapid pace of development in computers) are changing the demand for workers who use CAD technology. As the technology changes, instructors of CAD training must also change yet keep the focus of the curriculum on the particular skills and competencies that are required by industry. Students of today's CAD technology must be well grounded in both theory and technical procedures to understand what they are doing and how they are doing it (Suddath, 1994).

In order for civil engineering technology graduates to effectively meet the CAD needs of industry, a curriculum must be developed based on the CAD related technical skills and competencies required by industry employers of civil engineering technicians. Before such technical skills and competencies can be included in a curriculum, they must first be identified and then must be reviewed and revised periodically to keep up with the changing occupational requirements.

Purpose of the Study

The purpose of this study was to identify the CAD related technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician. Once this has been established, it will then be possible to incorporate these changes into the Civil Engineering Technology program curriculum at Northeast Wisconsin Technical College (NWTC).

A survey instrument was developed based on occupational analysis instruments utilized in similar types of studies. The survey was mailed to 63 employers of civil engineering technicians in the summer of 2000. Analyses were performed on the data received from the completed surveys. Information analyzed were: CAD skills that are required of civil engineering technicians in their workplace; the differences in required CAD competencies as they relate to employer type; the types of CAD drawings that are prepared by civil engineering technicians; and the CAD software packages currently being used in their firms.

Need for an Occupational Analysis

In 1998, an in-depth evaluation of the Civil Engineering Technology program at NWTC was performed (Phase II in-depth evaluation, 1998). Results of the program evaluation indicated several important observations:

1. Some employers indicated they now expect 2-year (associate degree) engineering technicians to take on responsibilities previously expected of 4-year (bachelor's degree) engineers.

2. Employers have indicated that there will be an increase in the use of design software in the future.

3. The evaluation team feels that the existing data collection and design software (Sokkia SDRMap) needs to be replaced and the program should adopt software that reflects what is being used in industry.

The observations and recommendations from the program evaluation concern themselves with the changing needs of industry with respect to those who use CAD. Instructors need to keep the focus of CAD curriculum on the particular skills and competencies that are required by industry for the drafting and design function (Yuen, 1990). As such, an occupational analysis of the CAD skills and competencies required by industry is required. Failure to understand these changing needs will result in failure of the program to provide competent graduates. "If graduates of vocational-technical programs can't get hired in their chosen field of study because they lack relevant skills, those vo-tech programs will not be able to sustain themselves" (Suddath, 1994).

In 1976, Oehler (1976) conducted a study to determine the industrial drafting needs and requirements within the current NWTC district area. This study is the most recent evaluation of employer drafting needs (that included civil employers) within the NWTC district that this researcher has found. Specifically, Oehler's study surveyed drafting employment trends, employer opinions of drafting equipment needed, skills and knowledge needed by drafters, and technical knowledge desired of draftsmen. The survey was conducted among industrial employers of mechanical draftspersons.

The study is not relevant today for several reasons. Due to the time at which the study was performed, CAD use was virtually non-existent; therefore, CAD skills and

competencies were not evaluated in the study. The study did not address the industry needs for design skills. Additionally, the study surveyed all industrial employers of drafting graduates. As a result, the majority of responses were from manufacturing types of industries where drawing types and drafting skills required are substantially different than those required by employers of civil engineering technicians. Oehler did not provide a breakdown of required CAD skills and competencies by industry type.

It should be noted that substantial literature exists concerning the skills and competencies needed by designers in the mechanical fields. This is likely due to the fact that the majority of CAD opportunities in industry are within manufacturing firms.

Conversely, few sources of literature concerning the skills and competencies needed by CAD operators in the architectural, engineering, and construction (AEC) areas were found. Studies of CAD employers in the Marshfield, Wisconsin area (Marks, 1984) and the Saginaw, Michigan area (Irwin, 1992) found that only 46% and 22%, respectively, of the industries that use CAD or drafting classified themselves as architectural or civil firms.

Required Technical Skills and Competencies

The National Coalition for Advanced Manufacturing (NACFAM), under a grant from the U.S. Department of Education has developed national occupational skill standards for computer-aided drafting and design (National Coalition for Advanced Manufacturing, 1994). The standards were developed by committees of technically knowledgeable CAD users from across the U.S. and were validated by several hundred other CAD users. The skill standards reflect industry needs from training programs,

students, and future employees and are aimed at the beginning CAD user. The skill standards are broken down into four main technical areas: fundamental drafting skills, fundamental computer skills, basic CAD skills, and advanced CAD skills. The skill standards have been prepared for use in curriculum development by trainers of CAD technology and for use by employers of CAD technicians for preparation of job descriptions and establishment of hiring criteria. It should be noted that these required technical competencies have direct implications for the knowledge and attitudes that CAD technicians must have (Pedras & Hoggard, 1985). These knowledge and attitude requirements are addressed later in this chapter.

Several state agencies have developed technical skill and competency standards for CAD technicians. Of interest to this research are the Occupational Competency Analysis Profile (OCAP) for drafting developed by the Ohio Department of Education (1995) and the technical committee report for drafting and design technology by the Idaho State Department of Education (1990). Both documents identify competency standards for basic drafting skills, basic and advanced CAD skills, and architectural and civil/survey drawings. Review of both documents indicates that many of the drafting and CAD standards are similar to those developed by NACFAM.

Software specific competencies are also of issue as per the program evaluation recommendations. According to Suddath (1994), it is not necessary to match the exact brand of CAD software used by local industry. Rather, an industrial advisory committee should provide guidance as to selection of an "industry standard" CAD software package. Dr. Gary S. Godfrey, Associate Professor in the College of Technology, Engineering and Management at the University of Wisconsin - Stout also indicates this to be true in that

entry level CAD skills are transferable between most software packages (G. S. Godfrey, personal communication, June 22, 2000). However, where advanced, in-depth experience is needed, training should be performed using the actual software that is going to be utilized.

Research by Irwin (1992) indicated that AutoCAD was the most popular brand of CAD software utilized in the Saginaw, Michigan area. Godfrey also indicates that AutoCAD is one of the most popular brands of CAD software being utilized currently (G. S. Godfrey, personal communication, June 22, 2000). A study concerning the brands of CAD software currently being used by employers of civil engineering technicians was not found during this literature review.

The literature also indicates that opposing schools of thought exist concerning the need for manual drafting competencies within the CAD training curriculum. Per Yuen (1990), computers cannot draw by themselves, nor do they understand basic drafting skills and that a CAD system is nothing more than a tool in the hands of a drafter. Therefore, teachers need to include the basic drawing fundamentals and the use of basic drawing tools in the drafting curriculum, along with CAD instruction. Begler (1998) has indicated that manual drafting courses are required precursors to CAD drafting courses in that manual drafting teaches accuracy of measurement as well as neatness and work ethic. Research by Becker (1991) indicates that traditional methods used in teaching drafting are very important and will be needed in teaching CAD. It should be noted that the majority of literature supporting training of manual drafting is somewhat dated in that much of industry was still using manual drafting techniques when the literature was published. As recognized by Yuen (1990), “the amount of time devoted to manual

drafting will decrease in coming years as the transition to CAD by industry becomes more complete."

Godfrey (G. S. Godfrey, personal communication, June 22, 2000) has indicated that there is no need to teach manual drafting skills, as they are not used in industry today. Drafting skills can be learned just as easily on the computer. Furthermore, Godfrey indicates that students who learn drafting skills initially with CAD are more successful than students who learn drafting manually then move into CAD. While supporting the teaching of traditional drafting methods, research by Becker (1991) indicates that CAD should be taught prior to traditional drafting methods, and that whether teaching traditional drafting, CAD, or both, the basic components of drafting were taught. Godfrey has indicated that technical sketching by hand should be kept within the curriculum.

Required Academic Skills and Competencies

In addition to technical skills, the NACFAM standards also indicate the related academic skills necessary for proficient CAD use. With acquisition of these skills, it is assumed the CAD technician has writing capabilities, a technical vocabulary, can use the algebraic order of operations to solve problems and generate conclusions, and can use computers to process information for mathematical applications and problem solving (National Coalition for Advanced Manufacturing, 1994). The principal source of the related academic competencies is based on work by Snyder (1990). Review of the literature also indicates that both the Ohio (Ohio Department of Education, 1995) and

Idaho (Idaho State Department of Education, 1990) CAD and drafting competency standards also provide academic standards similar to those given by NACFAM.

Required Employability Skills and Competencies

A list of employability skills was also evaluated by NACFAM based on the SCANS (Secretary's Commission on Achieving Necessary Skills) commission (U.S. Department of Labor, 1991). Employability skills are defined as skills and behaviors that are known, valued, and practiced in the workplace. The employability skills indicated by NACFAM are considered desirable for CAD users in order to become better workers. Employability skills can be grouped in to eight major topical areas: use of resources, interpersonal relations, use of information, understanding systems and processes, application of appropriate technology, thinking skills, personal qualities, and general knowledge of the industry.

As with the NACFAM competency standards, both the Ohio and Idaho standards also provide employability competency standards. The Ohio and Idaho employability competency standards contain some of the same competencies as outlined by the NACFAM standards.

Problem solving skills among CAD operators were commonly referenced in the literature as being critical to success. Too often, classroom instruction directs the student to duplicate a drawing out of a book. In the CAD workplace, however, exact drawings or even sketches may not be available, yet the CAD operator is responsible for figuring out what needs to be done. Few employers want CAD operators who transfer information

from paper to computer, but rather want to hire people who think through problems themselves (Byrum Skinner, 1996).

The National Academy of Sciences prepared a report concerning employers' views of required workplace competencies (National Academy of Sciences, 1984). The report, developed by a panel of public and private sector employers, indicates that too many graduates of high school and college enter the work force without adequate command of core employability competencies. These competencies include reasoning and problem solving, reading, writing, computation, oral communication, interpersonal relationships, and personal habits and attitudes (Long, 1984).

Employees working in the industry have identified several personal qualities necessary to succeed in the CAD field (Bone, 1994). These qualities are attention to detail, the ability to communicate, having an interest in technology, and being a team player.

Adaptation to Change

The field of civil engineering, which is the oldest of the branches of engineering, has seen more changes in the last twenty years than in any comparable period in history. This rate of change today makes it necessary that professionals in the civil engineering field are taught how to learn on their own (Griggs, 1998).

A National Academy of Sciences panel of public and private sector employers found the major asset required by employers of graduates seeking upwardly mobile careers is the ability to learn and to adapt to changes in the workplace (Long, 1984). Employee

adaptability plays a critical role in determining individual and company success in CAD related fields (Byrum Skinner, 1996).

Architects and engineers who work with CAD predict steady workplace change thereby requiring a need to update skills and knowledge continually (Byrum Skinner, 1996). As such, there is a need for frequent validation of the content and strategies appropriate for a CAD curriculum (Becker, 1991).

Irwin (1992) indicated that most CAD skills are typically acquired on the job in lieu of a formal training program, and in a recent study of industrial drafting workplaces, Mercer (2000) found that 68% of surveyed CAD users did not receive training on their system. Therefore, dedicated users are forced to train themselves as changes take place.

Summary

Advances in technology are changing the demand for workers who use CAD technology. As the technology changes, instructors of CAD training must also change yet keep the focus of the curriculum on the particular skills and competencies that are required by industry.

The observations and recommendations from the program evaluation concern themselves with the changing needs of industry with respect to those who use CAD. As such, an occupational analysis of the CAD skills and competencies required by industry is required.

In 1976, a study was conducted to determine the industrial drafting needs and requirements within the current NWTC district area. The study is not relevant today as CAD skills and competencies were not evaluated, and the majority of responses were

from manufacturing types of industries where drawing types and drafting skills required are substantially different than those required by employers of civil engineering technicians.

Substantial literature exists concerning the skills and competencies needed by designers in the mechanical fields. Conversely, few sources of literature concerning the skills and competencies needed by CAD operators in the architectural, engineering, and construction areas were found.

The National Coalition for Advanced Manufacturing has developed national occupational skill standards for computer-aided drafting and design. Additionally, several state agencies have also developed technical skill and competency standards for CAD. The skill standards cover technical, academic, and employability competencies that are required by employers. These competency standards can be used for development of CAD related curriculum.

With respect to employability skills, several references in the literature have indicated that problem-solving skills are required of CAD technicians. This is especially true as employers now expect associate degree engineering technicians to take on responsibilities previously expected of bachelor degree engineers.

Another major skill required by employers of graduates is the ability to learn and to adapt to changes in the workplace. Employee adaptability plays a critical role in determining individual and company success in CAD related fields.

Chapter III

Methods and Procedures

Introduction

The purpose of this study was to identify the computer-aided design (CAD) technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician. Once this has been established, it will then be possible to incorporate these changes into the Civil Engineering Technology program curriculum at Northeast Wisconsin Technical College (NWTC).

This chapter discusses the methods of the study, sample selection, instrumentation, procedures followed in conducting the survey, and data analysis methods. It is the intent of this chapter to provide the reader with a detailed account of the methods and procedures that were used so that this study could be replicated or further studies could be made within the same guidelines as this study.

Method of Study

In order to determine the CAD related technical skill and competency requirements of employers of civil engineering technicians, an occupational analysis in the form of a survey instrument was developed. In constructing the survey instrument, a variety of types of reference materials were reviewed. Textbooks and standard drafting manuals, as well as nationally and state established standards, were used to develop the recognized skills identified on the survey instrument. Journals and periodicals were reviewed for the purpose of determining current opinions, ideas, developments and trends in industry as

they relate to use of CAD within the architectural, engineering and construction (AEC) fields.

A survey instrument was chosen as the primary method for determining the required skills and competencies needed by employers of CAD technicians. The selection of this method is based on research methods utilized in similar studies (Irwin, 1992; Marks, 1984; Oehler, 1976) where CAD occupational competencies needed in industry were determined utilizing survey instruments.

The instrument was divided into two sections. The first section surveyed basic demographic information for each organization as well as the types of drawings performed, types of software utilized, internal training opportunities, and design related expectations for CAD technicians. The second section surveyed the skills and competencies required by employers in the areas of basic and advanced CAD use as well as determined the requirements for various forms of drawings that may be prepared within the AEC areas.

It should be noted that in addition to technical skills, the literature review indicated that academic and employability skills were also of importance by employers utilizing CAD. Due to the broad nature of these skills and competencies, they were not included as part of the survey instrument. As such, this study concerns itself only with required technical skills and competencies needed by employers.

The sample of employers surveyed was developed from a list of employers of past NWTC graduates. The list was prepared by NWTC, and contains approximately 71 employers since 1990. Surveys were sent to all employers on the list with the exception

of those who did no wish to participate in the study or whose addresses had changed and could not be obtained.

Sample Selection

The subjects selected in this survey were employers who have hired civil engineering technicians from the NWTC Civil Engineering Technology program between the years of 1990 and 1999. Seventy-one employers were determined from a list compiled by NWTC.

It should be noted that there are more employers who have actually hired graduates from the program than listed in the report. This is likely due to the fact that some graduates did not report their employers to NWTC upon graduation or when surveyed by the school. As such, employer data for these graduates is unknown.

As the number of employers listed in the NWTC report is manageable for survey purposes, all employers listed in the report were requested to take part in the survey. A listing of the employers contacted to participate in the survey is attached as Appendix A to this study.

The organizations indicated on the NWTC list of employers represent surveying, civil engineering, architectural, construction, and governmental related organizations. This listing of organizations seems to represent a wide variety of employer types, functions and sizes.

Some organizations on the list have facilities in varying geographic locations that have hired NWTC graduates. In such cases, each facility that hired a graduate of the

program was considered an employer and was surveyed. CAD software types and required competencies can vary between facilities within the same organization.

In addition to the known employers of civil engineering technicians as determined from the NWTC employer list, there are many other possible employers of civil engineering technicians. However, because of the significant differences in requirements between on employer types (surveyor, architect, engineer, contractor, etc.) as well as differences within employer types, the researcher felt that the most representative data would be gathered from known employers of NWTC Civil Engineering Technology program graduates.

There were no geographic restrictions on the sample. Most employers of civil engineering technicians as determined from the NWTC employer list are located within the northeast Wisconsin geographic area. However, many are from other areas of Wisconsin with several being from other states including Colorado, Texas, and Minnesota.

Instrumentation

The instrument used was a form of occupational analysis survey (see Appendix B). The purpose of the survey was to identify the CAD related technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician.

The content of the survey was derived from several sources. Textbooks and standard drafting manuals, as well as nationally and state established standards, were used to develop the recognized skills identified on the survey instrument. Journals and

periodicals were reviewed for the purpose of determining current opinions, ideas, developments and trends in industry as they relate to use of CAD within the AEC fields. The technical competency portion of the survey instrument utilized by Oehler (1976) was used as a guide for format of the required skills and competencies section.

General information.

Questions 1 through 6 are demographic questions asked to determine the organization type, overall organization size, drafting department size, types of drawings prepared by the organization, use of traditional drafting methods, and whether or not the organization utilizes CAD. Organization type was compared to the required CAD and drawing skill responses to determine if any relationships exist between the skills and organization type. It should be noted that if the organization did not utilize CAD, the respondent was asked only to reply to those questions that did not refer to CAD use.

Data obtained from questions 7 and 8 was used to determine the types of CAD applications that are being used by employers of civil engineering technicians.

Questions 9 and 10 obtained data concerning training beyond the technical college. Due to the continual change occurring within the field, continual training in the workplace is required. Data obtained from these questions was used to determine to what extent CAD training should be performed prior to graduation as well as if continued training after graduation is occurring.

The traditional role of the CAD technician in the AEC area is primarily of a drafting function. From the literature review, a current trend in the AEC area is development of 3-dimensional modeling of structures with design being performed within the computer

by the CAD technician and not by the engineer. Questions 11 and 12 were asked to gauge to what extent this is happening amongst employers of civil engineering technicians from NWTC.

Required skills and competencies.

The importance and frequency of use of basic CAD skills and advanced CAD skills are determined in questions 1 through 55. The primary source for the basic and advanced CAD skills portion of the survey was derived from national occupational skill standards (National Coalition for Advanced Manufacturing, 1994) for CAD. State CAD skill standards developed by the Idaho State Department of Education (1990) and the Ohio Department of Education (1995) were also verified against the NACFAM standards and found to be similar.

Questions 56 through 105 determine the importance and frequency of use of specific drawing type skills. The contents of this portion of the survey instrument were derived from the Idaho standards, construction related drafting textbooks, and current curriculum based on program advisory committee recommendations. The drawing types selected in the survey represent the types of drawings that are typically prepared within the AEC area. Other types of drawing skill standards, such as mechanical design, were not included as part of the survey. The respondent was also able to enter non-listed drawing type skills in this section.

The required skills and competencies section of the survey provided an extensive list of various CAD and drawing related technical skills and competencies. The survey respondents were asked to rate these skills and competencies on the basis of frequency of

performance and degree of importance. The rating of frequency of performance was used to categorize competencies as to whether the competency should be included, reviewed, or removed from the civil engineering technology CAD drafting curriculum. The average rating of degree of importance was applied to competencies within the included and reviewed categories to determine the relative importance among items. The five possible responses provided in the survey for frequency of performance were: daily, frequently, occasionally, seldom and never. For the purposes of data analysis, each of the responses corresponds to a number on a Likert scale, five through one, respectively. The three possible responses provided in the survey for degree of importance were: essential, moderate and trivial which corresponded to a number on a Likert scale, three through one, respectively.

Pilot Study

The proposed survey instrument was mailed to three instructors of CAD at NWTC for the purpose of determining content validity. Each CAD instructor also teaches in one of three fields of study: mechanical design, industrial model building, and civil engineering technology. As such, each CAD instructor was able to evaluate the content of the basic and advanced CAD skills portions of the survey. The CAD instructor from the civil engineering technology field was able to evaluate the basic drawing competencies portion of the survey as well as the general information portion concerning CAD platforms and collaborative add-on CAD software packages.

Based on the evaluation of the survey by each CAD instructor, the content of the survey instrument was revised accordingly to reflect the recommendations of these CAD

instructors. In summary, the revisions made generally involved clarification of terminology, especially in the required skills and competencies section of the survey instrument. Care was taken to keep the terminology in this section as close to the language used in the skill standards from NACFAM (1994), Idaho State Department of Education (1990) and the Ohio Department of Education (1995) from which the survey required skills and competencies section was based.

A pilot test was conducted using three CAD technicians from a local civil engineering consulting firm. These subjects were chosen because of geographic convenience (all were in Green Bay, Wisconsin) so that the pilot surveys could be easily monitored and collected.

The pilot surveys were hand-delivered and no additional instructions were provided other than the written instructions on the survey itself. Each participant was given three days to complete the survey. Upon completion of the pilot survey, the researcher personally collected the results and interviewed each of the respondents for the purpose of finding flaws in the instrument.

Results of the pilot test indicated the participants felt comfortable with the survey format, instructions, content and the time required to complete it. Some comment was made concerning the unfamiliarity with some of the terminology used in the required skills and competencies section. Each participant did indicate that the terminology not initially understood was, however, readily defined in most CAD reference books. As such, the survey was not revised after pilot testing.

Procedures Followed

Upon completion of the pilot survey, the revised survey instrument was sent to employers of civil engineering technicians from NWTC that were willing to participate in the study. The survey was specifically directed to the managers of the CAD or drafting departments at each employer location.

The 71 selected participants, as determined from the NWTC employer list, were contacted by mail before the survey was sent. This initial letter (Appendix C) informed them that they have been selected to participate in a survey that is designed to aid in CAD and drafting curriculum development with the Civil Engineering Technology program at NWTC. The estimated length of time for the survey was indicated, as was the date the survey was to be mailed to them. The participants were asked to return an enclosed response card (Appendix D) if they did not wish to participate in the survey. This method was used with the intent of making the subjects feel committed once they received the survey. It was also intended to let each of them know ahead of time that a survey will be forthcoming so they could reserve a time in their schedules for its completion.

Ten days after the initial letter was sent to the survey sample, a second letter (Appendix E) was sent to them along with the survey itself. The only employers that were not sent a survey were those who returned the reply card received in the first mailing indicating that they were not interested in participating in the survey.

The participants were asked to return the completed survey by the date indicated. This was approximately two weeks after the surveys were mailed. If no correspondence was received from the participants (i.e. completed survey or reply card) at the end of the

two week period, a letter (Appendix F) was sent reminding the participants of the importance of the survey and urging them to complete it and forward the results.

The breakdown for the rate of response is as follows. Seventy-one initial participation letters were sent to the employers identified on the NWTC civil engineering technician employer list. Three of the 71 employers responded asking not to participate in the study. Five of the 71 letters were not deliverable by the Post Office. Sixty-three surveys were sent to the remaining sample of employers. Out of these 63 surveys sent, 29 were never returned and 34 were returned for an overall response rate of 54.0%.

Once all of the completed surveys were received, the researcher tabulated the results. These tabulations indicated which CAD technical skills and competencies as well as which types of drawings are used frequently and are important to various employers of civil engineering technicians. Information concerning CAD software selection, training, and design utilization of CAD software was also obtained.

Limitations

The research sample that was surveyed represents a population of recorded employers of civil engineering technicians from NWTC from 1990 through 1999. This is a limited source but yet is the only population where it is assured that respondents are actual employers of civil engineering technicians that may perform drafting functions and utilize CAD software.

Because the sample represents only employers of graduates from the NWTC Civil Engineering Technology program, the application of the results of this study are expected

to be limited in scope. The conclusions derived from this research should be used for the improvement of the NWTC Civil Engineering Technology program curriculum only.

Unknowns

The most evident unknown in this survey was the rate of response. The anticipated explanation for non-response would be lack of interest, time constraints, or relocation of employer with no forwarding address.

Some sampling bias may have resulted if employers that had a negative attitude toward NWTC received the survey. Additionally, some employers, believing their response to be non-relevant, may not have responded if they did not utilize CAD or drafting in their organizations.

Decision Table

The researcher tabulated the response to each of the survey questions. Each of the items was processed to obtain the number of respondents, frequencies, percentages, and means and standard deviations for the skill/competency related questions.

The rating of frequency of performance was used to categorize competencies as to whether the competency should be included, reviewed, or removed from the civil engineering technology CAD curriculum. The average rating of degree of importance was applied to items within the included and reviewed categories to determine the relative importance among items. The mean and standard deviation was used extensively in the decision making process.

All survey items that had a frequency of performance rating of 3.0 and higher and a standard deviation of less than one are considered appropriate curriculum items (see Table 1). These items are expected to be included into the civil engineering technology CAD curriculum. All items that had a rating of 3.0 or higher with a standard deviation greater than 1.0 will be reviewed and questioned for content validity and a decision will be made accordingly.

Table 1

Decision Table Based on Frequency of Performance Mean Value vs. Standard Deviation

	Standard deviation	
Mean value	0.0 to 1.0	Greater than 1.0
4.0 to 5.0	Include	Review
3.0 to 3.9	Include	Review
2.0 to 2.9	Review	Review
1.0 to 1.9	Remove	Remove

Items that received a mean frequency of performance rating of 2.0 to 2.9 will be reviewed and questioned on an individual basis regardless of the standard deviation. Some of these items may already be included in the present curriculum and consideration will be given to dropping or modifying such items. The degree of importance will aid in this decision.

All items that received a mean frequency of performance rating of less than 2.0 will likely be removed from the program curriculum.

Summary

The subjects selected in this survey were employers who have hired civil engineering technicians from the NWTC Civil Engineering Technology program between the years of 1990 and 1999. The employers were determined from a list compiled by NWTC.

Concern has developed among some employers of civil engineering technicians from the NWTC program regarding the CAD competencies taught to students in the program. As such, the purpose of this survey was to identify the CAD technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician.

A pilot study was conducted prior to sending the survey to the entire sample. Three instructors of CAD from varying fields evaluated the content of the survey for validity. Based on the evaluations, the survey content was revised accordingly. Three CAD technicians from a local civil engineering consulting firm were chosen to pilot test the survey. Results of the pilot test indicated the participants felt comfortable with the survey format, instructions, content and the time required to complete it.

Upon completion of the pilot survey, the revised survey instrument was sent to the survey sample. A total of 34 surveys were returned out of 63 that were assumed to have been received by the sample. This resulted in an overall response rate of 54.0%.

Once all of the completed surveys were received, the researcher tabulated the results. These tabulations indicated which CAD related technical skills and competencies were performed frequently within the civil engineering technology profession by itemizing the number of respondents, the frequency of response, the percentage of

responses to each of the items, the mean response, and finally the standard deviation of the responses.

The rating of the frequency of performance of each skill or competency was used to determine if an item should be included, reviewed, or removed from the civil engineering technology CAD curriculum. Items were then reviewed in context to their relative average degree of importance.

Chapter IV

Results and Discussion

Introduction

The purpose of this study was to identify the computer-aided design (CAD) related technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician. Once this has been established, it will then be possible to incorporate these changes into the Civil Engineering Technology program curriculum at Northeast Wisconsin Technical College (NWTC).

Research Objectives

A study of industry-required CAD competencies of entry-level civil engineering technology program graduates at NWTC has never been performed. As such, the data from the surveys was used to:

1. Determine the CAD skills and competencies that are required by employers of civil engineering technicians.
2. Determine differences in required CAD competencies as they relate to employer type (i.e. surveyor, engineer, contractor, etc.).
3. Determine the types of CAD drawings that are prepared by civil engineering technicians.
4. Determine the CAD software packages currently being used by employers of civil engineering technicians.

Methodology

A survey instrument was developed based on occupational analysis instruments utilized in similar types of studies. The survey instrument was reviewed for content validity by three instructors of CAD and then was pilot tested using several local individuals familiar with CAD use in industry. Upon completion of the pilot testing, the revised survey instrument was mailed to 63 employers of civil engineering technicians. The employer sample was obtained from a list of civil engineering technology employers provided by the NWTC Student Employment Services office. Follow-up mailings were made to the employers to increase the response rate.

Upon receipt of the completed survey instruments, analyses were performed on the data. Information analyzed were: CAD skills that are required of civil engineering technicians in their workplace; the differences in required CAD competencies as they relate to employer type; the types of CAD drawings that are prepared by civil engineering technicians; and the CAD software packages currently being used in their firms.

Rate of Response

A total of 63 surveys were sent to a sample of employers of civil engineering technician graduates from NWTC. A list of 71 employers was compiled by NWTC for the years ranging between 1990 and 1999. Surveys were not sent to eight employers on the list as their addresses were not obtainable or they elected not to participate in the study. The results from the survey are presented using quantitative data of frequency, percentage, mean and standard deviation in the following paragraphs.

The rate of response for the employer sample is shown in Table 2. The rate of response does not take into consideration those employers who elected not to participate

in the study or those employers whose addresses were not obtainable. Surveys were not sent to either of these two groups.

Table 2

Number and Percentage of Returned Surveys

Response	Total sent	Number returned	Percentage
Population	63	34	54.0

Out of the 63 surveys that were sent, a total of 29 surveys were not returned for a percentage of 46.0%. There were a total of 34 surveys that were returned for an overall response rate of 54.0%.

General Information

Questions 1 through 6 asked the respondents demographic questions to determine the employer type, overall organization size, drafting department size, types of drawings prepared by the employer, use of traditional drafting methods, and whether or not the employer utilizes CAD. Tables 3 through 8 summarize the replies of the entire survey population to these six questions. Each individual response was listed and tabulated either by number or by number and percentage.

To determine the differences in required skills and competencies as they relate to employer type, Question 1 asked each employer responding to the survey to classify their organization. Table 3 depicts how each respondent of the entire survey population classified their organization. The respondents were only allowed to select one choice. As such, the sum of the percentages equals 100.0%. Several employers chose to be

classified using employer types that were not listed on the survey, while some employer types listed on the survey were never used at all. Table 3 represents only those employer types reported. The results from the remaining questions in this study are correlated to the employer types determined from this question.

Table 3

Employer Type By Number and Percentage

Employer type	Number	Percentage
Civil engineering	11	32.5
Governmental agency	8	23.5
Surveying	5	14.7
Contractor	3	8.8
Consulting engineering	2	5.9
Architectural/engineering	2	5.9
Photogrammetric/mapping	1	2.9
Testing laboratory	1	2.9
Utility	1	2.9
Total	34	100.0

It is important to note that employers can perform other functions in addition to their primary classification. Based on the information contained in Table 3, the majority of employers represented in this study are civil engineering firms, governmental agencies, and surveying firms.

Questions 2 and 3 asked respondents to how many full-time employees are employed at their facility and how many full-time and part-time drafters are employed at their

facility. The number of drafters employed was asked to determine the percentage of drafters employed per employer type as compared to the total number of drafters reported.

Table 4 lists the average number of total full-time employees per facility for each employer type. The total number of full-time and part-time drafters employed by each employer type is also broken down in Table 4. Full-time employees and drafters are those considered working 32 hours or more per week whereas part-time drafters are those considered to work less than 32 hours per week. The actual hours worked per week by part-time drafters was not surveyed.

The 34 employers that responded represent 164 full-time and 77 part-time drafters. It is important to note that civil engineering firms and governmental agencies employ the greatest number of full-time and part-time drafters. Civil engineering firms employ 67 of the 164 (40.9%) full-time drafters and 32 of the 77 (41.6%) part-time drafters represented by the respondents. Governmental agencies employ 23 of the 164 (14.0%) full-time drafters and 27 of the 77 (35.1%) part-time drafters represented. The remaining employer types in the sample employ substantially fewer percentages of full-time and part-time drafters. This assumes that the number and type of employers responding to the survey is representative of the true population of employers of civil engineering technicians from NWTC.

Question 4 was asked to determine the types of drawings prepared by employer type. The number and percentage of respondents for each drawing type based on the total number of respondents is depicted in Table 5. Many employers prepare more than one type of drawing, therefore, the respondents were able to check as many types as were

Table 4

Number of Full-time Employees and Full-time and Part-time Drafters by Employer Type

Employer type	Average full-time employees per facility[a]	Total full-time drafters by all respondents[a]	Total part-time drafters by all respondents[b]
Civil engineering	41	67	32
Governmental agency	71	23	27
Utility	900	20	0
Photogrammetric/mapping	100	15	0
Architectural/engineering	43	15	1
Surveying	11	14	4
Consulting engineering	70	9	9
Contractor	158	1	1
Testing laboratory	13	0	3
Total		167	77

[a]Full-time is considered to be equal to or greater than 32 hours per week. [b]Part-time is considered to be less than 32 hours per week.

applicable to their organization. As such, the sum of the percentages does not equal 100.0%.

Review of data from Table 5 indicates that civil drawings, survey maps, and topographical drawings are the most commonly prepared drawings by the respondents. It should be noted that 8.8% of the respondents do not prepare any drawings.

Table 6 further identifies the drawing types by number per employer type. Review of Table 6 indicates that most employer types, especially major employers of drafters (as

Table 5

Types of Drawings Prepared By Number and Percentage

Type of drawing prepared	Number	Percentage
Civil	29	85.3
Survey maps	25	73.5
Topographical	23	67.6
Structural	11	32.4
Architectural	10	29.4
Landscaping	9	26.4
Technical illustrations	7	20.6
Electrical/electronic	6	17.6
Heating and ventilating	4	11.8
Pneumatic/hydraulic	4	11.8
None	3	8.8
Geophysical	2	5.9

Note. Percentages based on 34 respondents.

determined from Table 4), prepare a wide variety of drawing types. As such, specific drawing types can not be directly correlated to specific employer types. Other reported drawing types include architectural, electrical/electronic, landscaping, structural, and technical illustrations.

The literature review indicates that opposing schools of thought exist concerning the need for traditional drafting (board drafting) competencies. As such, Question 5 was asked to determine the amount of employers that use manual drafting methods.

Table 7 depicts the number of respondents who utilize traditional methods of drafting

Table 6

Drawing Types Prepared Listed By Number of Facilities Responding Per Employer Type

Drawing type	Employer type								
	SU	CE	CO	GO	PM	CN	AE	TL	UT
Civil	4	11	0	8	0	2	2	1	1
Survey maps	5	8	0	6	1	2	2	0	1
Topographical	4	8	0	5	1	2	2	1	1
Structural	0	6	0	0	0	2	2	0	1
Architectural	0	4	0	0	0	2	2	1	1
Landscaping	0	5	0	1	0	0	2	0	1
Technical illustrations	0	2	0	2	0	1	1	0	1
Electrical/electronic	0	2	0	2	0	0	1	0	1
Heating and ventilating	0	3	0	0	0	0	1	0	0
Pneumatic/hydraulic	0	3	0	0	0	0	1	0	0
None	0	0	3	0	0	0	0	0	0
Geophysical	0	0	0	1	0	1	0	0	0

Note. SU = surveying; CE = civil engineering; CO = contractor; GO = governmental agency; PM = photogrammetric/mapping; CN = consulting engineering; AE = architectural/engineering; TL = testing laboratory; UT = utility.

at their facility. Some employers use both traditional and CAD drafting at their facility. Review of Table 7 indicates that 8.8% of the respondents utilize traditional drafting methods either completely or in addition to CAD drafting methods.

Table 7

Employer Use of Traditional Drafting Methods By Number and Percentage

Employer Responses	Number	Percentage
Respondents that use traditional drafting methods	3	8.8
Respondents that do not use traditional drafting methods	31	91.2
Total	34	100.0

Question 6 was asked to determine the amount of employers that utilize CAD drafting. Table 8 depicts the number of respondents by employer type that use a CAD system at their facility. From Table 8, 31 out of the 34 survey respondents (91.2%) use a CAD system for drafting functions. Each individual response was listed and tabulated by number.

Questions 7 and 8 of the survey were asked to determine the types of CAD applications that are being used by employers of civil engineering technicians. Tables 8 and 9 summarize the primary and collaborative CAD software packages, respectively, that are being used as grouped by employer type.

Review of Table 8 indicates that AutoCAD is the primary CAD platform used by 23 out of 31 facilities (74.2%) that utilize CAD. Microstation accounts for 7 out of 31 (22.5%) of the responses. Paydirt, which is actually a specialized earthwork estimating software, was used by 1 of the employers (3.2%), which was a contractor. Further study

Table 8

Primary CAD Software Platforms Used Listed By Number Per Employer Type

	Primary CAD software platform			Total
Employer Classification	AutoCAD	Microstation	Paydirt	using CAD
Architectural/engineering	2	0	0	2
Civil engineering	8	2	0	10
Consulting engineering	1	1	0	2
Contractor	0	0	1	1
Governmental agency	6	2	0	8
Photogrammetric/mapping	0	1	0	1
Surveying	5	0	0	5
Testing laboratory	1	0	0	1
Utility	0	1	0	1
Total	23	7	1	31

Note. Based on 34 respondents.

of Table 8 reveals that 8 out of 10 civil engineering firms (80.0%), and six out of eight of governmental agencies (75.0%) that utilize CAD use AutoCAD as their primary CAD platform. As discussed previously, civil engineering firms and governmental agencies employ the greatest number of drafters.

The use of collaborative CAD software packages with respect to employer type is depicted in Table 9. From the 31 responses gathered from those employers that use CAD software, 23 (74.2%) use at least one collaborative software with their primary CAD platform. When reviewed in context with the total number of responses that utilize CAD from Table 8, five out of the five surveying firms (100.0%), 9 out of 10 civil engineering firms (90.0%), six out of the eight governmental agencies (75.0%), the sole utility, and

both consulting engineers utilize collaborative CAD software packages. The respondents with the classifications of contractor, architectural/engineering, testing laboratory, and photogrammetric/mapping indicated that they did not use collaborative software.

Table 9

Collaborative Software Usage Per Employer Type

Collaborative software usage	Employer type					Total
	SU	CE	GO	UT	CN	
Eagle Point	4	4	3	0	0	11
AutoCAD Land Development Desktop	1	4	0	0	1	6
CAiCE	0	1	1	0	0	2
Autodesk CAD Overlay	0	1	1	0	0	2
Microsoft Visio Tech	0	1	0	0	0	1
Autodesk Civil Design	0	1	0	0	0	1
Autodesk Survey	0	1	0	0	0	1
Haestad Methods WaterCAD	0	1	0	0	0	1
AutoCAD Map	0	0	1	0	0	1
Intergraph SelectCAD	0	0	0	1	0	1
Intergraph SmartSketch	0	0	0	1	0	1
Intergraph I/RAS B and I/RAS C	0	0	0	1	0	1
Geopak	0	0	0	0	1	1
Total using collaborative software	5	9	6	1	2	23

Note. Based on 31 respondents that utilize CAD at their facility. SU = surveying; CE = civil engineering; GO = governmental agency; CN = consulting engineering; UT = utility.

It is important to note that several respondents indicated they use more than one collaborative software package with their CAD platform. As such, the number of

software packages used per employer type in Table 9 may exceed the actual number of respondents using collaborative software for that employer type.

Review of Table 9 indicates that Eagle Point is the most common collaborative software utilized with a total of 11 of the 31 respondents that use CAD (35.5%) using this software. Specifically, four out of five of the surveying firms (80.0%), three out of eight of the governmental agencies (37.5%), and 4 out of 10 of the civil engineering firms (40.0%) surveyed that utilize CAD also utilize Eagle Point.

AutoCAD Land Development Desktop (ALDD) was noted to be the next commonly used collaborative software with a total of 6 of the 31 respondents that utilize CAD (19.4%) using this package. Specifically, 4 out of the 10 of the civil engineering firms (40.0%), one out of five of the surveying firms (20.0%), and one out of two of the consulting engineering firms (50.0%) surveyed that utilize CAD also utilize ALDD.

Questions 9 and 10 of the survey were asked to determine if the employer provides CAD training, and if so, how many hours per year of CAD training is provided by the employer. Table10 summarizes the amount of CAD training per year received by drafters as grouped by employer type. Each individual response was listed and tabulated by number.

O verall, 21 of the 31 employers that utilize CAD (67.7%) indicated that they provide some training on their CAD system. When reviewed in context to the number of respondents that use CAD from Table 8, all of consulting engineering firms, contractors and utilities, as well as 90.0% of civil engineering firms, 75.0% of governmental agencies, 40.0% of surveying firms provide some form of yearly CAD training. This training was 10 or less hours per year for most respondents. None of the

Table 10

Hours of CAD Training Provided Per Year By Employer Type

Employer type	Number of employers by hours CAD training per year				
	0 – 5 hrs	5 – 10 hrs	10 – 25 hrs	25 – 40 hrs	40+ hrs
Civil engineering	4	1	3	1	0
Governmental agency	2	2	2	0	0
Surveying	1	1	0	0	0
Consulting engineering	1	0	0	0	1
Contractor	0	1	0	0	0
Utility	0	0	0	1	0
Architectural/engineering	0	0	0	0	0
Photogrammetric/mapping	0	0	0	0	0
Testing laboratory	0	0	0	0	0
Total	8	5	5	2	1

Note. Based on 31 respondents that utilize CAD at their facility.

architectural/engineering, photogrammetric/mapping, and testing labs surveyed provided any yearly CAD training.

The traditional role of the CAD technician in the AEC area is primarily of a drafting function. From the literature review, a current trend in the AEC area is development of 3-dimensional modeling of structures with design being performed within the computer by the CAD technician and not by the engineer. Questions 11 and 12 were asked to gauge to what extent this is happening amongst employers of civil engineering technicians from NWTC.

Table11 summarizes, by employer type, the number and percentage of drafters expected to perform design functions and the number and percentage of facilities utilizing

CAD for 3-dimensional modeling. The percentages in Table 11 are based on the total number of respondents for each employer type that use CAD at their facilities.

Review of Table 11 indicates that of the total of 31 respondents that utilize CAD, 74.2% expect CAD operators at their facility to perform design functions. Approximately 35.5% utilize CAD software for 3-dimensional modeling.

Table 11

Number and Percentage of Respondents Requiring Drafters to Perform Design and Utilize 3-Dimensional Modeling Listed By Employer Type

	Drafters performing design functions		Employers utilizing CAD for 3-D modeling	
Employer Type	Number	Percentage by employer type	Number	Percentage by employer type
Architectural/engineering	2	100.0	1	50.0
Civil engineering	8	80.0	5	50.0
Consulting engineering	2	100.0	2	100.0
Contractor	1	100.0	1	100.0
Governmental agency	6	75.0	0	0.0
Photogrammetry/mapping	0	0.0	1	100.0
Surveying	3	60.0	0	0.0
Testing laboratory	0	0.0	0	0.0
Utility	1	100.0	1	100.0
Total[a]	23	74.2	11	16.1

Note. Percentages based on the total respondents utilizing CAD per each employer type from Table 8.
[a]Total percentage based on 31 respondents that utilize CAD.

Required Skills and Competencies

Items 1 through 55 of the Required Skills and Competencies section of the survey requested the respondents to rate various skills and competencies relating to basic CAD and advanced CAD on the basis of frequency of performance and degree of importance. The primary source for the basic and advanced CAD skills portion of the survey was derived from national occupational skill standards (National Coalition for Advanced Manufacturing, 1994) for CAD. Space was provided within each section to enable the respondent to enter any additional skills or competencies that may have been omitted or may be considered important in their specific field. It should be noted that questions 1 through 55 were completed only by those employers who utilize CAD at their facilities.

Items 55 through 105 of this section requested the respondents to rate various skills and competencies required for preparation of architectural, structural, civil, electrical/electronic, and pneumatic/hydraulic drawings on the basis of frequency of performance and degree of importance. The contents of this portion of the survey instrument were derived from skill standards developed by the Idaho State Department of Education (1990), construction related drafting textbooks, and current curriculum based on program advisory committee recommendations. Space was provided within each section to enable the respondent to enter any additional skills, competencies or drawing types that may have been omitted or may be considered important in their specific field. All respondents completed questions 55 through 105.

Skills and competencies rating scales.

The survey respondents were asked to rate all of these skills and competencies on the basis of frequency of performance and degree of importance. The rating of frequency of performance was used to categorize competencies as to whether the competency should be included, reviewed, or removed from the civil engineering technology CAD drafting curriculum. The average rating of degree of importance was applied to competencies within the included and reviewed categories to determine the relative importance among items. The five possible responses provided in the survey for frequency of performance were: daily, frequently, occasionally, seldom and never. For the purposes of data analysis, each of the responses corresponds to a number on a Likert scale, five through one, respectively. The three possible responses provided in the survey for degree of importance were: essential, moderate and trivial which correspond to a number on a Likert scale, three through one, respectively.

The frequency of performance and degree of importance response to each of the survey items was tabulated and the averages as well as the standard deviations for both parts of each survey question were calculated and summarized on the tables in Appendixes G through M. The results are listed by employer type. The tables in the appendixes include the question number, number of responses on the rating scale, mean response, standard deviation, and the action to be taken on each individual item.

All survey items that had a frequency of performance rating of 3.0 and higher and a standard deviation of less than or equal to 1.0 are considered appropriate curriculum items. These items are expected to be included into the civil engineering technology CAD curriculum. All items that had a rating of 3.0 or higher with a standard deviation

greater than 1.0 will be reviewed with respect to importance and questioned for content validity and a decision will be made accordingly. Those items to be reviewed with a degree of importance rating of 2.5 to 3.0 will likely be included in the curriculum.

Items that received a mean frequency of performance rating of 2.0 to 2.9 will be reviewed and questioned on an individual basis regardless of the standard deviation. Those items to be reviewed with a frequency of performance rating of 2.0 or greater and with a degree of importance rating of 2.5 to 3.0 will likely be included in the curriculum. Those items to be reviewed with a degree of importance less than 2.5 will likely be reviewed for being valid curriculum items. Some of these items may already be included in the present curriculum and consideration will be given to dropping or modifying such items. All items that received a mean frequency of performance rating of less than 2.0 will likely be removed from the program curriculum.

The response to each survey item was tabulated and the mean and standard deviation for the frequency of performance and the degree of importance was calculated for all employers as well as for each employer type. This information, as well as the action to be taken on each individual item, is presented on tables in the appendixes for each subsection of the required skills and competencies section.

Basic CAD skills.

Questions 1 through 24 asked the 31 respondents that utilize CAD for information regarding the basic CAD skills they feel are required of entry level drafters in the workplace. Results of this section are depicted in the table in Appendix G. It should be

noted that only one representative from each of the employer types of contractor, photogrammetric/mapping, testing laboratory, and utility responded to these questions.

Out of the 24 basic CAD skills that were listed on the survey, 14 (58.3%) were considered to be valid curriculum items and will be retained or added. Six of the 24 items (25.0%) will be reviewed for being valid curriculum items, and four of the items (16.7%) will not be included in the curriculum. A summary of the basic CAD skills and actions to be taken on each item are summarized in Table 12.

General differences between employer types regarding required basic CAD skills were also reviewed. Review of the basic CAD skill usage by employer type (as shown in Appendix G) indicates that testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the

Table 12

Actions To Be Taken On Basic CAD Skills

Basic CAD skills	Action
Create new drawing	Include
Perform drawing set-up	Include
Construct geometric figures	Include
Create text using appropriate style and size to annotate drawings	Include
Use control and accuracy enhancement tools	Include
Identify, create, store, and use appropriate symbols/libraries	Include
Utilize geometry editing commands	Include
Utilize non-geometric editing commands	Include
Control coordinates and display scale	Include

(table continues)

Basic CAD skills	Action
Control entity properties	Include
Use viewing commands	Include
Use standard parts and/or symbol libraries	Include
Plot drawings on media using correct layout and scale	Include
Use layering techniques	Include
Create objects using primitives	Review
Use display commands	Review
Use grouping techniques	Review
Minimize file size	Review
Use query command to interrogate database	Review
Use associative dimensioning correctly	Review
Create wireframe/solid models	Remove
Create 2-D geometry from 3-D models	Remove
Revolve a profile to create a 3-D object	Remove
Create 3-D wireframe models from 2-D geometry	Remove

Note. Based on 31 respondents that utilize CAD.

remaining employer types. Also noted is a substantially higher frequency of performance regarding 3-D skills (Questions 7 through 11) by consulting engineering and utility employers. The photogrammetric/mapping and contractor employers were also noted to have a higher frequency of performance for some 3-D skills.

Five respondents entered other important or frequently used basic CAD skills in the space provided for Question 25. These additional skills were (a) use proper sized text for the appropriate scale, (b) organizing drawings, (c) using viewports, (d) scaling, and (e) understanding paperspace/layout.

Advanced CAD skills.

Questions 26 through 54 asked the 31 respondents that utilize CAD for information regarding advanced CAD skills they feel are required of entry level drafters in the workplace. Results of this section are depicted in the table in Appendix H. It should be noted that only one representative from each of the employer types of contractor, photogrammetric/mapping, testing laboratory, and utility responded to these questions.

Out of the 29 advanced CAD skills that were listed on the survey, none (0.0%) were considered to be valid curriculum items. Sixteen of the 29 items (55.2%) will be reviewed for being valid curriculum items, and 13 of the items (44.8%) will not be included in the curriculum. A summary of the advanced CAD skills and actions to be taken on each item are summarized in Table 13.

Table 13

Actions To Be Taken On Advanced CAD Skills

Advanced CAD skills	Action
Create offset surfaces	Review
Find intersection of two surfaces	Review
Create joined surfaces	Review
Create a fillet or blend between two surfaces	Review
Create cut sections	Review
Trim surfaces	Review
Extend surfaces	Review
Edit control points	Review
Edit primitives	Review

(table continues)

Advanced CAD skills	Action
Extract geometric data	Review
Extract attribute data	Review
Obtain surface properties	Review
Perform customization to improve productivity	Review
Manipulate associated non-graphical data	Review
Use template and library files to establish drawing standard presets	Review
Develop geometry using parametric programs	Review
Create wireframe and/or solid models	Remove
Create non-analytic surfaces using appropriate modeling	Remove
Create analytic surfaces using appropriate modeling	Remove
Create feature based geometry	Remove
Construct and label exploded assembly drawings	Remove
Perform Boolean operations	Remove
Manipulate surface normals	Remove
Modify geometry via Boolean operations	Remove
Perform axis view clipping	Remove
Extract wireframe data from surface/solid geometry	Remove
Shade/render object	Remove
Identify gaps in non-intersecting surfaces	Remove
Obtain mass properties	Remove

Note. Based on 31 respondents that utilize CAD.

General differences between employer types regarding required advanced CAD skills were also reviewed. Review of the advanced CAD skill usage by employer type (as shown in Appendix H) indicates testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the

remaining employer types. Also noted is a substantially higher frequency of performance of all advanced CAD skills (especially those involving 3-D surfaces) by consulting engineering and utility employers. Overall, most advanced CAD skills were not performed frequently nor considered important as is evident by the number of advanced CAD skills that are to be reviewed or removed.

One respondent entered another important or frequently used advanced CAD skill in the space provided for Question 55. This additional skill was the need or willingness for CAD operators to train on their own time.

Basic architectural drawing skills.

Questions 56 through 70 asked all 34 respondents to the survey for information regarding the frequency and importance of basic architectural drawing skills. Results of this section are depicted in the table in Appendix I. It should be noted that only one representative from each of the employer types of photogrammetric/mapping, testing laboratory, and utility responded to these questions.

Out of the 15 basic architectural drawing skills that were listed on the survey, none (0.0%) were considered to be valid curriculum items. Eight of the 15 items (53.3%) will be reviewed for being valid curriculum items, and seven of the items (46.7%) will not be included in the curriculum. A summary of the basic architectural drawing skills and actions to be taken on each item are summarized in Table 14.

General differences between employer types regarding required basic architectural drawings prepared were also reviewed (as shown in Appendix I). Review of Appendix I indicates some architectural drawing skills are required for all employer types.

Table 14

Actions To Be Taken On Basic Architectural Drawing Skills

Basic architectural drawing skills	Action
Interpret vendors catalogs, technical tables and building codes	Review
Prepare floor plan drawings with dimensions	Review
Prepare foundation plan and detail drawings with dimensions	Review
Prepare elevation drawings with elevations	Review
Prepare sections with dimensions	Review
Prepare schedules	Review
Prepare landscape layouts	Review
Prepare plot plan drawings	Review
Build architectural models	Remove
Prepare truss drawings	Remove
Prepare stairway drawings	Remove
Prepare fireplace drawings	Remove
Prepare plumbing plan drawings	Remove
Prepare HVAC drawings	Remove
Prepare electrical plan drawings	Remove

Note. Based on 34 respondents.

Surveying, testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the remaining employer types. Noted is a substantially higher frequency of performance of most types of architectural drawings by architectural/engineering, consulting engineering, civil engineering and utility employers. Overall, most basic architectural drawing skills were not performed

frequently nor considered important as is evident by the number of basic architectural drawing skills that are to be reviewed or removed.

None of the respondents entered other important or frequently used basic architectural drawing skills in the space provided for Question 71.

Basic structural drawing skills.

Questions 72 through 77 asked all 34 respondents to the survey for information regarding the frequency and importance of basic structural drawing skills. Results of this section are depicted in the table in Appendix J. It should be noted that only one representative from each of the employer types of photogrammetric/mapping, testing laboratory, and utility responded to these questions. Additionally, only one of the two architectural/engineering employers responded to the degree of importance portion of each question.

Out of the six basic structural drawing skills that were listed on the survey, none (0.0%) were considered to be valid curriculum items. One of the six items (16.7%) will be reviewed for being valid curriculum items, and five of the items (83.3%) will not be included in the curriculum. A summary of the basic structural drawing skills and actions to be taken on each item are summarized in Table 15.

General differences between employer types regarding required basic structural drawings prepared were also reviewed (as shown in Appendix J). Review of Appendix J indicates that surveying, photogrammetric/mapping, and contractor employer types have substantially less frequencies of performance for most skills as compared to the remaining employer types. Noted is a substantially higher frequency of performance of

Table 15

Actions To Be Taken On Basic Structural Drawing Skills

Basic structural drawing skills	Action
Detail concrete reinforcements	Review
Use structural member and reinforcing concrete manuals/tables	Remove
Detail structural beam connections	Remove
Prepare materials take off lists	Remove
Draw structural framing plans and elevations	Remove
Identify welding symbols	Remove

Note. Based on 34 respondents.

most types of structural drawings by architectural/engineering, consulting engineering, testing laboratory, and utility employers. Overall, most basic structural drawing skills were not performed frequently nor considered important as is evident by the number of basic structural drawing skills that are to be reviewed or removed.

None of the respondents entered other important or frequently used basic architectural drawing skills in the space provided for Question 78.

Basic civil drawing skills.

Questions 79 through 84 asked all 34 respondents to the survey for information regarding the frequency and importance of basic civil drawing skills. Results of this section are depicted in the table in Appendix K. It should be noted that only one representative from each of the employer types of photogrammetric/mapping, testing laboratory, and utility responded to these questions.

Out of the six basic civil drawing skills that were listed on the survey, five of them (83.3%) were considered to be valid curriculum items and will be retained or added. One of the 6 items (16.7%) will be reviewed for being valid curriculum items, and none of the items (0.0%) will be removed from the curriculum. A summary of the basic civil drawing skills and actions to be taken on each item are summarized in Table 16.

Table 16

Actions To Be Taken On Basic Civil Drawing Skills

Basic civil drawing skills	Action
Prepare topographic drawings	Include
Prepare drainage drawings	Include
Prepare plan and profile drawings	Include
Prepare street layout drawings	Include
Prepare contour drawings	Include
Interpret technical standards for soils and construction materials	Review

Note. Based on 34 respondents.

General differences between employer types regarding required basic civil drawings prepared were also reviewed (as shown in Appendix K). Review of Appendix K indicates most civil drawing skills are required for nearly all employer types. Testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the remaining employer types. Overall, most basic civil drawing skills were performed frequently and considered important as is evident by the number of basic civil drawing skills that are to be included or reviewed.

Four respondents entered other important or frequently used basic civil drawing skills in the space provided for Question 85. These additional skills were (a) prepare detail sheets, (b) prepare roadway cross-sections, (c) prepare 3-D terrain model drawings, (d) prepare site plans, and (e) prepare utility plans.

Basic electrical/electronic drawing skills.

Questions 86 through 91 asked all 34 respondents to the survey for information regarding the frequency and importance of basic electrical/electronic drawing skills. Results of this section are depicted in the table in Appendix L. It should be noted that only one representative from each of the employer types of photogrammetric/mapping, testing laboratory, and utility responded to these questions.

Out of the six basic electrical/electronic drawing skills that were listed on the survey, none (0.0%) were considered to be valid curriculum items or items to be reviewed for being valid curriculum items. None of the six items (100.0%) will be included in the curriculum. A summary of the basic electrical/electronic drawing skills and actions to be taken on each item are summarized in Table 17.

General differences between employer types regarding required basic electrical/electronic drawings prepared were also reviewed (as shown in Appendix L). Review of Appendix L indicates that electrical/electronic drawing skills are not performed frequently by most employer types. Noted is a high frequency of performance of all types of electrical/electronic drawings by utility employers. Overall, none of the basic electrical/electronic drawing skills were performed frequently or considered important as is evident in that all basic electrical/electronic drawing skills are to be

Table 17

Actions To Be Taken On Basic Electrical/Electronic Drawing Skills

Basic electrical/electronic drawing skills	Action
Interpret basic electric/electronic standards and symbols	Remove
Prepare schematic drawings	Remove
Prepare cable drawings	Remove
Prepare component drawings	Remove
Prepare logic diagrams	Remove
Prepare control panel drawings	Remove

Note. Based on 34 respondents.

removed.

None of the respondents entered other important or frequently used basic electrical/electronic drawing skills in the space provided for Question 92.

Basic pneumatic/hydraulic drawing skills.

Questions 93 through 103 asked all 34 respondents to the survey for information regarding the frequency and importance of basic pneumatic/hydraulic drawing skills. Results of this section are depicted in the table in Appendix M. It should be noted that only one representative from each of the employer types of photogrammetric/mapping, testing laboratory, and utility responded to these questions.

Out of the 11 basic pneumatic/hydraulic drawing skills that were listed on the survey, none (0.0%) were considered to be valid curriculum items or items to be reviewed for being valid curriculum items. None of the 11 items (100.0%) will be included in the

curriculum. A summary of the basic pneumatic/hydraulic drawing skills and actions to be taken on each item are summarized in Table 18.

Table 18

Actions To Be Taken On Basic Pneumatic/Hydraulic Drawing Skills

Basic pneumatic/hydraulic drawing skills	Action
Interpret basic pneumatic/hydraulic standards and symbols	Remove
Prepare piping drawings	Remove
Prepare isometric drawings	Remove
Prepare sectional diagrams	Remove
Prepare graphical symbols	Remove
Prepare process and instrumentation diagrams	Remove
Prepare combination diagrams	Remove
Prepare pump and motor drawings	Remove
Prepare cylinder and piston diagrams	Remove
Prepare valve drawings	Remove
Prepare pump section drawings	Remove

Note. Based on 34 respondents.

General differences between employer types regarding required basic pneumatic/hydraulic drawings prepared were also reviewed (as shown in Appendix M). Review of Appendix M indicates that pneumatic/hydraulic drawing skills are not performed frequently for most employer types. Noted is a high frequency of performance of all types of pneumatic/hydraulic drawings by utility employers. Overall, none of the basic pneumatic/hydraulic drawing skills were performed frequently or considered

important as is evident in that all basic pneumatic/hydraulic drawing skills are to be removed.

None of the respondents entered other important or frequently used basic pneumatic/hydraulic drawing skills in the space provided for Question 104.

Other drawing types not listed.

Question 105 on the survey instrument was an area where respondents could add other drawing types or skills not listed. Five respondents entered comments in the space provided for Question 105. These comments were (a) use of X references in AutoCAD, (b) use of rastor images, (c) GIS – create topologies, (d) 2-D area maps, (e) plats, (f) C.S.M, and (g) GIS activities.

Additionally, two other comments were provided at the bottom of the last page of the survey. One comment was: "GIS has become very important to us. Perhaps some thought should be given to GIS software and complete GIS project creation (from pipes to parcels including databases). Please include use."

The other comment was as follows: "3-D, 3rd party software is critical for future productivity. Arch. person must know code and have at least one semester in plumbing, HVAC, energy efficiency. Most important design knowledge to advance. Cut the B.S. about not offering to tech. students because compete against Milw. arch. program."

Summary

The majority of employers represented in this study are civil engineering firms, governmental agencies, and surveying firms. Overall, civil engineering firms along with

governmental agencies employ the greatest number of full-time and part-time drafters (54.9% and 76.7%, respectively).

Civil drawings, survey maps, and topographical drawings are the most commonly prepared drawings by the respondents. It should be noted that 8.8% of the respondents do not prepare any drawings. Most employer types, especially major employers of drafters, prepare a wide variety of drawing types. As such, specific drawing types can not be directly correlated to specific employer types. Other reported drawing types (but to a much lesser degree) include architectural, electrical/electronic, landscaping, structural, and technical illustrations.

Approximately 8.8% of the respondents utilize traditional drafting methods either completely or in addition to CAD drafting methods. Almost all of the respondents (91.2%) use a CAD system for drafting functions. AutoCAD is the primary CAD platform used by 74.2% of the respondents that utilize CAD. Microstation accounts for 22.5% of the responses.

Of the employers that use CAD software, 74.2% use at least one collaborative software package with their primary CAD platform. Eagle Point is the most common collaborative software utilized with a total of 35.5% of the respondents that utilize CAD also using this software. AutoCAD Land Development Desktop (ALDD) was noted to be the next commonly used collaborative software with a total of 19.4% of respondents that utilize CAD using this package.

Overall, 67.7% employers that utilize CAD indicated that they provide some training on their CAD system. Typically, this training was 10 or fewer hours per year for most respondents.

Of the total number of respondents that utilize CAD, 74.2% expect CAD operators at their facility to perform design functions. Approximately 35.5% utilize CAD software for 3-dimensional modeling.

Out of the 24 basic CAD skills that were listed on the survey, 14 were considered to be valid curriculum items and will be either retained or added to the program curriculum. Six of the 24 items will be reviewed for being valid curriculum items, and four of the items will not be included in the curriculum.

Testing laboratory and contractor employer types have substantially less frequencies of performance for most basic CAD skills as compared to the remaining employer types. Also noted is a substantially higher frequency of performance regarding 3-D skills by consulting engineering and utility employers. Photogrammetric/mapping and contractor employers were also noted to have a higher frequency of performance for some 3-D skills.

Out of the 29 advanced CAD skills that were listed on the survey, none were considered to be valid curriculum items. Sixteen of the 29 items will be reviewed for being valid curriculum items, and 13 of the items will not be included in the curriculum.

Testing laboratory and contractor employer types have substantially less frequencies of performance for most advanced CAD skills as compared to the remaining employer types. Also noted is a substantially higher frequency of performance of all advanced CAD skills (especially those involving 3-D surfaces) by consulting engineering and utility employers. Overall, most advanced CAD skills were not performed frequently nor considered important as is evident by the number of advanced CAD skills that are to be reviewed or removed.

Out of the 15 basic architectural drawing skills that were listed on the survey, none were considered to be valid curriculum items. Eight of the 15 items will be reviewed for being valid curriculum items, and seven of the items will not be included in the curriculum.

Some architectural drawing skills are required for all employer types. Surveying, testing laboratory and contractor employer types have substantially less frequencies of performance for most architectural drawing skills as compared to the remaining employer types. A substantially higher frequency of performance of most types of architectural drawing skills was noted for architectural/engineering, consulting engineering, civil engineering and utility employers. Overall, most basic architectural drawing skills were not performed frequently nor considered important as is evident by the number of basic architectural drawing skills that are to be reviewed or removed.

None of the six basic structural drawing skills that were listed on the survey were considered to be valid curriculum items. One of the six items will be reviewed for being a valid curriculum item, and five of the items will not be included in the curriculum.

Surveying, photogrammetric/mapping, and contractor employer types have substantially less frequencies of performance for most basic structural drawing skills as compared to the remaining employer types. Noted is a substantially higher frequency of performance of most types of structural drawings by architectural/engineering, consulting engineering, testing laboratory, and utility employers. Overall, most basic structural drawing skills were not performed frequently nor considered important as is evident by the number of basic structural drawing skills that are to be reviewed or removed.

Out of the six basic civil drawing skills that were listed on the survey, five were considered to be valid curriculum items and will be retained or added. One of the six items will be reviewed for being a valid curriculum item, and none of the items will be removed from the curriculum.

Most civil drawing skills are required for nearly all employer types. Testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the remaining employer types. Overall, most basic civil drawing skills were performed frequently and considered important as is evident by the number of basic civil drawing skills that are to be included or reviewed.

Out of the six basic electrical/electronic drawing skills that were listed on the survey, none (0.0%) were considered to be valid curriculum items or items to be reviewed for being valid curriculum items. As such, none of the six of the items will be included in the curriculum.

Electrical/electronic drawing skills are not performed frequently for most employer types. Noted is a high frequency of performance of all types of electrical/electronic drawings by utility employers. Overall, none of the basic electrical/electronic drawing skills were performed frequently or considered important as is evident in that all basic electrical/electronic drawing skills are to be removed or not included in the program curriculum.

Out of the 11 basic pneumatic/hydraulic drawing skills that were listed on the survey, none were considered to be valid curriculum items or items to be reviewed for being valid curriculum items. As such, none of the items will be included in the curriculum.

Pneumatic/hydraulic drawing skills are not performed frequently for most employer types. Noted is a high frequency of performance of all types of pneumatic/hydraulic drawings by utility employers. Overall, none of the basic pneumatic/hydraulic drawing skills were performed frequently or considered important as is evident in that all basic pneumatic/hydraulic drawing skills are to be removed.

Chapter V

Summary, Conclusions and Recommendations

Engineering, surveying, and construction firms with varying CAD related needs employ graduates of the Civil Engineering Technology program at Northeast Wisconsin Technical College (NWTC). As such, concern has developed among some employers of civil engineering technicians from the NWTC program regarding the CAD competencies taught to students and the selection of CAD software packages being utilized for instruction in the program. This study gathered data to address these concerns. In this chapter is a summary of the study, conclusions based upon the results of the study, and recommendations related to the study.

Summary

The summary which follows includes a restatement of the problem, an explanation of methods and procedures, and the major findings.

Restatement of the Problem

In order for civil engineering technician graduates to effectively meet the CAD needs of industry, a curriculum must be developed based on the CAD related technical skills and competencies required by industry employers of civil engineering technicians. Before such technical skills and competencies can be included in a curriculum, they must first be identified and then must be reviewed and revised periodically to keep up with the changing occupational requirements.

The purpose of this study was to identify the CAD related technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician. Once this has been established, it will then be possible to incorporate these changes into the Civil Engineering Technology program curriculum at NWTC.

The objectives of this study are to:

1. Determine the CAD skills and competencies that are required by employers of civil engineering technicians.
2. Determine differences in required CAD competencies as they relate to employer type (i.e. surveyor, engineer, contractor, etc.).
3. Determine the types of CAD drawings that are prepared by civil engineering technicians.
4. Determine the CAD software packages currently being used by employers of civil engineering technicians.

Methods and Procedures

A survey instrument was developed based on occupational analysis instruments utilized in similar types of studies. The survey instrument was reviewed for content validity by three instructors of CAD and then was pilot tested using several local individuals familiar with CAD use in industry. Upon completion of the pilot testing, the revised survey instrument was mailed to 63 employers of civil engineering technicians. The employer sample was obtained from a list of civil engineering technology employers

provided by the NWTC Student Employment Services office. Follow-up mailings were made to the employers to increase the response rate.

Upon receipt of the completed survey instruments, analyses were performed on the data. Information analyzed were: CAD skills that are required of civil engineering technicians in their workplace; the differences in required CAD competencies as they relate to employer type; the types of CAD drawings that are prepared by civil engineering technicians; and the CAD software packages currently being used in their firms.

Major Findings

The majority of employers represented in this study are civil engineering firms, governmental agencies, and surveying firms. Overall, civil engineering firms along with governmental agencies employ the greatest number of full-time and part-time drafters.

Civil drawings, survey maps, and topographical drawings are the most commonly prepared drawings by the respondents. Most employer types, especially major employers of drafters, prepare a wide variety of drawing types. Other reported drawing types (but to a much lesser degree) include architectural, electrical/electronic, landscaping, structural, and technical illustrations.

Almost all of the respondents use a CAD system for drafting functions. AutoCAD is the primary CAD platform used by most of the respondents that utilize CAD. Microstation is also utilized, but to a much lesser extent.

Of the employers that use CAD software, most use at least one collaborative software package with their primary CAD platform. Eagle Point is the most common

collaborative software utilized. AutoCAD Land Development Desktop (ALDD) was noted to be the next commonly used collaborative software.

Most employers that utilize CAD indicated that they provide some training on their CAD system. Typically, this training was 10 or fewer hours per year for most respondents.

Employers that utilize CAD expect CAD operators at their facility to perform design functions. Many utilize CAD software for 3-dimensional modeling.

Out of the 24 basic CAD skills that were listed on the survey, 14 were considered to be valid curriculum items and will be either retained or added to the program curriculum. Six of the 24 items will be reviewed for being valid curriculum items, and four of the items will not be included in the curriculum.

Testing laboratory and contractor employer types have substantially less frequencies of performance for most basic CAD skills as compared to the remaining employer types. Also noted is a substantially higher frequency of performance regarding 3-D skills by consulting engineering and utility employers. Photogrammetric/mapping and contractor employers were also noted to have a higher frequency of performance for some 3-D skills.

Out of the 29 advanced CAD skills that were listed on the survey, none were considered to be valid curriculum items. Sixteen of the 29 items will be reviewed for being valid curriculum items, and 13 of the items will not be included in the curriculum.

Testing laboratory and contractor employer types have substantially less frequencies of performance for most advanced CAD skills as compared to the remaining employer types. Also noted is a substantially higher frequency of performance of all advanced

CAD skills (especially those involving 3-D surfaces) by consulting engineering and utility employers. Overall, most advanced CAD skills were not performed frequently nor considered important.

Out of the 15 basic architectural drawing skills that were listed on the survey, none were considered to be valid curriculum items. Eight of the 15 items will be reviewed for being valid curriculum items, and seven of the items will not be included in the curriculum.

Some architectural drawing skills are required for all employer types. Surveying, testing laboratory and contractor employer types have substantially less frequencies of performance for most architectural drawing skills as compared to the remaining employer types. Noted is a substantially higher frequency of performance of most types of architectural drawing skills by architectural/engineering, consulting engineering, civil engineering and utility employers. Overall, most basic architectural drawing skills were not performed frequently nor considered important.

None of the six basic structural drawing skills that were listed on the survey were considered to be valid curriculum items. One of the six items will be reviewed for being a valid curriculum item, and five of the items will not be included in the curriculum.

Surveying, photogrammetric/mapping, and contractor employer types have substantially less frequencies of performance for most basic structural drawing skills as compared to the remaining employer types. Noted is a substantially higher frequency of performance of most types of structural drawings by architectural/engineering, consulting engineering, testing laboratory, and utility employers. Overall, most basic structural drawing skills were not performed frequently nor considered important.

Out of the six basic civil drawing skills that were listed on the survey, five were considered to be valid curriculum items and will be retained or added. One of the six items will be reviewed for being a valid curriculum item, and none of the items will be removed from the curriculum.

Most civil drawing skills are required for nearly all employer types. Testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the remaining employer types. Overall, most basic civil drawing skills were performed frequently and considered important.

Out of the six basic electrical/electronic drawing skills that were listed on the survey, none (0.0%) were considered to be valid curriculum items or items to be reviewed for being valid curriculum items. As such, none of the six of the items will be included in the curriculum.

Electrical/electronic drawing skills are not performed frequently for most employer types. Noted is a high frequency of performance of all types of electrical/electronic drawings by utility employers. Overall, none of the basic electrical/electronic drawing skills were performed frequently or considered important.

Out of the 11 basic pneumatic/hydraulic drawing skills that were listed on the survey, none were considered to be valid curriculum items or items to be reviewed for being valid curriculum items. As such, none of the items will be included in the curriculum.

Pneumatic/hydraulic drawing skills are not performed frequently for most employer types. Noted is a high frequency of performance of all types of pneumatic/hydraulic drawings by utility employers. Overall, none of the basic pneumatic/hydraulic drawing skills were performed frequently or considered important.

Conclusions

The purpose of this study was to identify the CAD related technical skills and competencies that are required for employability at an entry-level position as a civil engineering technician. Once this has been established, it will then be possible to incorporate these changes into the Civil Engineering Technology program curriculum at NWTC. The conclusions section discusses the findings of the study with respect to the objectives established for the research.

Research Objectives

Conclusions can be reached for each of the four research objectives.

Objective 1.

Determine the CAD skills and competencies that are required by employers of civil engineering technicians.

The traditional role of the CAD technician in the AEC area is primarily of a drafting function. From the literature review, a current trend in the AEC area is development of 3-dimensional modeling of structures with design being performed within the computer by the CAD technician and not by the engineer.

Review of the data indicates that 74.2% of the respondents that utilize CAD expect CAD operators at their facility to perform design functions. Approximately 35.5% utilize CAD software for 3-dimensional modeling. As such, being able to design (in lieu of drafting) and being able to model three dimensionally are competencies that are required

by employers of civil engineering technicians from NWTC. As such, CAD design and 3-D modeling should be included in the civil engineering technology curriculum.

Basic and advanced CAD skills required by employers of civil engineering technicians were also surveyed as part of this research. The primary source for the basic and advanced CAD skills portion of the survey was derived from national occupational skill standards (National Coalition for Advanced Manufacturing, 1994) for CAD.

Basic CAD skills and competencies required by employers of civil engineering technicians from NWTC are listed in Table 19. These skills and competencies should be included in curriculum for the program. None of the advanced CAD skills surveyed were found to be required for inclusion in the program curriculum.

Table 19

Basic CAD Skills and Competencies to be Included in the Curriculum

Basic CAD skills and competencies	Action
Create new drawing	Include
Perform drawing set-up	Include
Construct geometric figures	Include
Create text using appropriate style and size to annotate drawings	Include
Use control and accuracy enhancement tools	Include
Identify, create, store, and use appropriate symbols/libraries	Include
Utilize geometry editing commands	Include
Utilize non-geometric editing commands	Include
Control coordinates and display scale	Include
Control entity properties	Include
Use viewing commands	Include

(table continues)

Basic CAD skills and competencies	Action
Use standard parts and/or symbol libraries	Include
Plot drawings on media using correct layout and scale	Include
Use layering techniques	Include

Note. Based on 31 respondents that utilize CAD.

Several basic and advanced CAD skills were noted to have frequencies of performance that make them acceptable for inclusion in the curriculum but also had large standard deviations and relatively lower degrees of importance. These survey items need to be reviewed further with respect to validity and importance. Basic and advanced CAD skills and competencies that require further review relative to validity and importance are listed in Table 20.

Table 20

Basic and Advanced CAD Skills and Competencies to be Further Reviewed

CAD skills and competencies	Action
Basic CAD skills and competencies	
Create objects using primitives	Review
Use display commands	Review
Use grouping techniques	Review
Minimize file size	Review
Use query command to interrogate database	Review
Use associative dimensioning correctly	Review
Advanced CAD skills and competencies	
Create offset surfaces	Review

(table continues)

CAD skills and competencies	Action
Find intersection of two surfaces	Review
Create joined surfaces	Review
Create a fillet or blend between two surfaces	Review
Create cut sections	Review
Trim surfaces	Review
Extend surfaces	Review
Edit control points	Review
Edit primitives	Review
Extract geometric data	Review
Extract attribute data	Review
Obtain surface properties	Review
Perform customization to improve productivity	Review
Manipulate associated non-graphical data	Review
Use template and library files to establish drawing standard presets	Review
Develop geometry using parametric programs	Review

Note. Based on 31 respondents that utilize CAD.

Objective 2.

Determine differences in required CAD competencies as they relate to employer type (i.e. surveyor, engineer, contractor, etc.).

Review of the basic CAD skill usage by employer type indicates that testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the remaining employer types. Also noted is a substantially higher frequency of performance regarding 3-D skills by consulting engineering and utility employers. The photogrammetric/mapping and contractor

employers were also noted to have a higher frequency of performance for some 3-D skills.

General differences between employer types regarding required advanced CAD skills were also reviewed. Review of the advanced CAD skill usage by employer type indicates testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the remaining employer types. Also noted is a substantially higher frequency of performance of all advanced CAD skills (especially those involving 3-D surfaces) by consulting engineering and utility employers.

Objective 3.

Determine the types of CAD drawings that are prepared by civil engineering technicians.

Civil drawings, survey maps, and topographical drawings are the most commonly prepared drawings by the respondents. Other reported drawing types include architectural, electrical/electronic, landscaping, structural, and technical illustrations. Most employer types, especially major employers of drafters prepare a wide variety of drawing types. Approximately 8.8% of the respondents do not prepare any drawings.

Review of general differences between employer types regarding basic architectural drawing skills indicates some architectural drawing skills are required for all employer types. Surveying, testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the remaining employer types. A substantially higher frequency of performance of most types of architectural

drawings was noted for architectural/engineering, consulting engineering, civil engineering and utility employers.

Surveying, photogrammetric/mapping, and contractor employer types have substantially less frequencies of performance for most basic structural drawing skills as compared to the remaining employer types. Noted is a substantially higher frequency of performance of most types of structural drawings by architectural/engineering, consulting engineering, testing laboratory, and utility employers.

General differences between employer types regarding required basic civil drawings prepared were also reviewed and indicate that most civil drawing skills are required for nearly all employer types. Testing laboratory and contractor employer types have substantially less frequencies of performance for most skills as compared to the remaining employer types.

Electrical/electronic drawing skills are not performed frequently for most employer types. Noted is a high frequency of performance of all types of electrical/electronic drawings by utility employers.

Pneumatic/hydraulic drawing skills are not performed frequently for most employer types. Noted is a high frequency of performance of all types of pneumatic/hydraulic drawings by utility employers.

Basic drawing skills and competencies required by employers of civil engineering technicians from NWTC are listed in Table 21. These skills and competencies will be included in curriculum for the program. Only basic civil drawing skills were found to be required for inclusion in the program curriculum.

Several basic drawing skills were noted to have frequencies of performance that

Table 21

Basic Drawing Skills and Competencies to be Included in the Curriculum

Basic drawing skills and competencies	Action
Basic civil drawing skills	
Prepare topographic drawings	Include
Prepare drainage drawings	Include
Prepare plan and profile drawings	Include
Prepare street layout drawings	Include
Prepare contour drawings	Include

Note. Based on 34 respondents.

make them acceptable for inclusion in the curriculum but also had large standard deviations and relatively lower degrees of importance. These survey items need to be reviewed further with respect to validity and importance. Basic drawing skills and competencies that require further review relative to validity and importance are listed in Table 22.

Table 22

Basic Drawing Skills and Competencies to be Further Reviewed

Basic drawing skills and competencies	Action
Basic architectural drawing skills and competencies	
Interpret vendors catalogs, technical tables and building codes	Review
Prepare foundation plan and detail drawings with dimensions	Review
Prepare elevation drawings with elevations	Review
Prepare sections with dimensions	Review

(table continues)

Basic drawing skills and competencies	Action
Prepare schedules	Review
Prepare landscape layouts	Review
Prepare plot plan drawings	Review
Basic structural drawing skills and competencies	
Detail concrete reinforcements	Review
Basic civil drawing skills and competencies	
Interpret technical standards for soils and construction materials	Review

Note. Based on 34 respondents.

Objective 4.

Determine the CAD software packages currently being used by employers of civil engineering technicians.

Review of the data indicates that 91.2% of the employers use a CAD system for drafting functions. AutoCAD is the primary CAD platform used by 74.2% of the employers that utilize CAD. Microstation accounts for 22.5% of the employers that utilize CAD. Further study reveals that 80.0% of civil engineering firms and 75.0% of governmental agencies that utilize CAD use AutoCAD as their primary CAD platform. Civil engineering firms and governmental agencies employ the greatest number of drafters. As such, NWTC should incorporate the use of AutoCAD into civil engineering technology program curriculum. Supplemental or elective training in the use of Microstation should also be considered.

Approximately 74.2% of the employers use at least one collaborative software package with their primary CAD platform. Eagle Point is the most common

collaborative software utilized with a total of 35.5% of the employers that use CAD also using this software. Specifically, 80.0% of the surveying firms, 37.5% of the governmental agencies, and 40.0% of the civil engineering firms that utilize CAD also utilize Eagle Point.

AutoCAD Land Development Desktop (ALDD) was noted to be the next commonly used collaborative software with a total of 19.4% of the employers that utilize CAD using this package. Specifically, 40.0% of the civil engineering firms, 20.0% of the surveying firms, and 50.0% of the consulting engineering firms that utilize CAD also utilize ALDD.

Based on these results, Eagle Point should be considered included as the primary collaborative software taught within the program curriculum. Consideration should be given to also providing training with the ALDD software.

Recommendations

The recommendations section discusses the recommendations related to this study as well as recommendations for further study.

Recommendations Related to This Study

Based on the results and conclusions of this study, the following items are recommended:

1. The collaborative software packages identified in this study should be integrated into the program curriculum. At present, a different collaborative software package is being utilized that was not identified as being frequently used by employers of the program.

2. The CAD skills and competencies recommended for inclusion in the program should be checked against skills and competencies currently being taught in the curriculum. Those not already being taught should be included, and those identified as not being necessary should be removed.

3. Drawing type skills and competencies recommended for inclusion in the program should be checked against skills and competencies currently being taught in the curriculum. Those not already being taught should be included, and those identified as not being necessary should be removed.

Recommendations for Further Study

Based on the results and conclusions of this study, the following items are recommended for further study:

1. Due to the rapid technological changes that are taking place in the profession, it is recommended that another study should be replicated in two years.
2. Future surveys of this type could be a cooperative effort between the other technical colleges in Wisconsin that offer a formal civil engineering technology program.
3. Due to the large variance in employer types, a larger sample should be obtained to provide more responses per each employer type.
4. The additional skills and comments should be considered in preparation of another occupational survey.
5. The findings of this study should be shared with the program advisory committee and members of the public so it will be evident to them that efforts are being

made to maintain high standards and provide employers with graduates that will adequately meet the needs of industry today.

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Appendix A

NWTC Generated Employer List

Aaron Associates

Aero-Metric, Inc

Air Associates, Inc.

Amelia Systems, Inc.

American LaFrance

City of Appleton, Wisconsin

Village of Ashwaubenon, Wisconsin

Aztec Consultants

Baudhuin, Inc.

Biehl Construction Company, Inc.

Brown County, Wisconsin, Highway Department

CQM, Inc.

Carow Land Surveying

CH2M Hill

Community Engineering Consultants

Data-Tel Communications

Donald H. Nerenhausen & Associates, Inc.

Ellison Electric Supply, Inc.

Foth & Van Dyke

Glen Rueckl Home Building

Graef, Anhalt, Schloemer & Associates

Green & Gold Concrete, Inc.

City of Green Bay, Wisconsin

Green Bay, Wisconsin, Metropolitan Sewerage District

Green Bay, Wisconsin, Water Utility

Harris & Associates

Hebert & Associates, Inc.

City of Janesville, Wisconsin

Kaempfer & Associates, Inc.

City of Manitowoc, Wisconsin

Mau & Associates

Maxim Technologies, Inc.

McMahon Associates

McNulty Surveying & Mapping

Mead & Hunt, Inc.

Meldon & Hant

Miller Engineers

Murphy Concrete Construction

Murphy Construction

National Survey & Engineering

Nolte & Associates

Nordin-Pedersen Associates, Ltd.

Northeast Asphalt, Inc.

Northeast Telephone Company

Oconto County, Wisconsin, Highway Department

Oconto Falls, Wisconsin, Water & Light Commission

Ommni Associates, inc.

Ostrenga Excavating

PTS Contractors, Inc.

Polk County, Wisconsin, Land Surveying Office

QUEST

Colin P. Rayford

Reltech Consulting Services

Richco Structures

River Valley Testing Corporation

Robert E. Lee & Associates, Inc.

City of Sheboygan, Wisconsin

SMI

STS Consultants, Ltd. (Green Bay, Wisconsin office)

STS Consultants, Ltd. (Minneapolis, Minnesota office)

STS Consultants, Ltd. (Schofield, Wisconsin office)

Schneider National, Inc.

Schuler & Associates

Tecumseh Products

U.S. Army Corps of Engineers

US Cellular

Watermolen, Hoffman & Associates, Inc.

Wisconsin Department of Transportation (Green Bay, Wisconsin office)

Wisconsin Department of Transportation (Rhinelander, Wisconsin office)

Wisconsin Public Service Corporation

Appendix B

Occupational Analysis Survey Instrument

NORTHEAST WISCONSIN TECHNICAL COLLEGE

CIVIL ENGINEERING TECHNOLOGY PROGRAM
CAD COMPETENCY QUESTIONNAIRE

GENERAL INFORMATION

1. Which of the following best categorizes your organization (check one)?

   _____ Surveying
   _____ Civil engineering
   _____ Structural engineering
   _____ Environmental services
   _____ Architectural
   _____ Contractor or construction management
   _____ Governmental agency
   _____ Other (please specify) _____

2. Approximately how many people are employed on a full-time basis with your organization (at your facility if your organization has multiple locations)?

3. How many employees in your organization (at your facility) perform drafting on a full or part-time basis?

   _____ Full-time drafters (>32 hrs/wk) _____ Part-time drafters (<32 hrs/wk)

4. What types of drawings does your firm prepare (check all that apply)?

   _____ Architectural
   _____ Civil
   _____ Electrical/electronic
   _____ Geophysical
   _____ Heating and ventilating
   _____ Landscaping
   _____ Maps
   _____ Pneumatic/hydraulic
   _____ Structural
   _____ Technical illustrations
   _____ Topographical
   _____ Other (please specify) _____
   _____ None

Figure B1. Occupational analysis survey instrument.

5. Are traditional methods of drafting (non-CAD) regularly used at your firm?

   _____ Yes _____ No

6. Does your organization currently use a CAD system? (if no, please skip to question number 54 of the 'Required Skills and Competencies' section)

   _____ Yes _____ No

7. What is the primary CAD software platform that your organization is currently using (check one)?

   _____ AutoCAD
   _____ MicroStation
   _____ DATACAD
   _____ IntelliCAD
   _____ CAiCE
   _____ Other (please specify name and manufacturer) _____

8. List below any collaborative add-on CAD software packages (e.g., SDRmap, SelectCAD, GEOPAK Drainage, etc.) that your organization is using with the primary CAD platform selected above.

9. Does your organization provide training on the CAD system you are using? If no, skip to question number 10.

   _____ Yes _____ No

10. How many hours of CAD training does an employee of your organization receive per year (check one)?

    _____ 0 - 5 _____ 5-10 _____ 10-25 _____ 25-40 _____ 40+

11. Are CAD operators within your organization also expected to perform design functions (in contrast to just drafting) using CAD software?

    _____ Yes _____ No

12. Does your organization utilize CAD software for 3-D modeling?

    _____ Yes _____ No

Please continue to the 'REQUIRED SKILLS AND COMPETENCIES' section.

Figure B1. Occupational analysis survey instrument.

INSTRUCTIONS:
For each of the following skills, use a check mark to indicate <u>both</u> the frequency of performance <u>and</u> the degree of importance

		Frequency of Performance					Degree of Importance		
		Daily	Frequently	Occasionally	Seldom	Never	Essential	Moderate	Trivial
	Basic CAD Skills								
1.	Create new drawing								
2.	Perform drawing set up								
3	Construct geometric figures (e.g., lines, splines, circles, and arcs)								
4.	Create text using appropriate style and size to annotate drawings								
5.	Use and control accuracy enhancement tools (e.g., entity positioning methods such as snap and XYZ)								
6.	Identify, create, store, and use appropriate symbols/libraries								
7.	Create wireframe/solid models								
8.	Create objects using primitives								
9.	Create 2-D geometry from 3-D models								
10.	Revolve a profile to create a 3-D object								
11.	Create 3-D wireframe models from 2-D geometry								
12.	Utilize geometry editing commands (e.g., trimming, extending, scaling)								
13.	Utilize non-geometric editing commands (e.g., text, drawing format)								
14.	Control coordinates and display scale								
15.	Control entity properties (e.g., color, line type)								

<u>Figure B1.</u> Occupational analysis survey instrument.

INSTRUCTIONS:

For each of the following skills, use a check mark to indicate <u>both</u> the frequency of performance <u>and</u> the degree of importance

	Frequency of Performance					Degree of Importance		
	Daily	Frequently	Occasionally	Seldom	Never	Essential	Moderate	Trivial
16. Use viewing commands (e.g., dynamic rotation, zooming, panning)								
17. Use display commands (e.g., hidden line removal, shading)								
18. Use standard parts and/or symbol libraries								
19. Plot drawings on media using correct layout and scale								
20. Use layering techniques								
21. Use grouping techniques								
22. Minimize file size								
23. Use query command to interrogate database (e.g., entity characteristics, distance, area, status)								
24. Use associative dimensioning correctly								
Basic CAD Skills Not Listed								
25.								
Advanced CAD Skills								
26. Create wireframe and/or solid models								
27. Create non-analytic surfaces using appropriate modeling (e.g., non-analytic: NURBS, B-spline, Gordon, Bezier, Coons)								

<u>Figure B1.</u> Occupational analysis survey instrument.

INSTRUCTIONS:

For each of the following skills, use a check mark to indicate <u>both</u> the frequency of performance <u>and</u> the degree of importance

	Frequency of Performance					Degree of Importance		
	Daily	Frequently	Occasionally	Seldom	Never	Essential	Moderate	Trivial
28. Create analytic surfaces using appropriate modeling with planes and analytic curves (e.g., conic, cylinder, revolution, ruled)								
29. Create offset surfaces								
30. Find intersection of two surfaces								
31. Create joined surfaces								
32. Create a fillet or blend between two surfaces								
33. Create feature based geometry (e.g., holes, slots, rounds)								
34. Create cut sections								
35. Construct and label exploded assembly drawings								
36. Perform Boolean operations (e.g., union, subtraction, intersection)								
37. Trim surfaces								
38. Manipulate surface normals								
39. Extend surfaces								
40. Edit control points (e.g., surfaces, Bezler)								
41. Modify geometry via Boolean operations								
42. Edit primitives (e.g., moving, copying, resizing)								
43. Perform axis view clipping								

<u>Figure B1.</u> Occupational analysis survey instrument.

INSTRUCTIONS:

For each of the following skills, use a check mark to indicate <u>both</u> the frequency of performance <u>and</u> the degree of importance

	Frequency of Performance					Degree of Importance		
	Daily	Frequently	Occasionally	Seldom	Never	Essential	Moderate	Trivial
44. Extract wireframe data from surface/solid geometry								
45. Shade/render object (e.g., reflectivity, opacity)								
46. Extract geometric data								
47. Extract attribute data								
48. Identify gaps in non-intersecting surfaces								
49. Obtain surface properties (e.g., area, perimeter, bounded volume)								
50. Obtain mass properties data (e.g. moments of inertia, centroids)								
51. Perform customization to improve productivity (e.g., customize menus, function keys, script files, macros)								
52. Manipulate associated non-graphical data								
53. Use template and library files to establish drawing standard presets								
54. Develop geometry using parametric programs								
Advanced CAD Skills Not Listed								
55.								
Basic Architectural Drawings								
56. Interpret vendors catalogs, technical tables and building codes								

<u>Figure B1.</u> Occupational analysis survey instrument.

INSTRUCTIONS:

For each of the following skills, use a check mark to indicate <u>both</u> the frequency of performance <u>and</u> the degree of importance

	Frequency of Performance					Degree of Importance		
	Daily	Frequently	Occasionally	Seldom	Never	Essential	Moderate	Trivial
57. Prepare floor plan drawings, with dimensions								
58. Prepare foundation plan and detail drawings, with dimensions								
59. Prepare elevation drawings with dimensions								
60. Prepare sections with dimensions								
61. Prepare schedules								
62. Prepare landscape layouts								
63. Build architectural models								
64. Prepare truss drawings								
65. Prepare stairway drawings								
66. Prepare fireplace drawings								
67. Prepare plot plan drawings								
68. Prepare plumbing plan drawings								
69. Prepare HVAC drawings								
70. Prepare electrical plan drawings								
Basic Architectural Drawings Not Listed								
71.								

<u>Figure B1.</u> Occupational analysis survey instrument.

INSTRUCTIONS:
For each of the following skills, use a check mark to indicate <u>both</u> the frequency of performance <u>and</u> the degree of importance

	Frequency of Performance					Degree of Importance		
	Daily	Frequently	Occasionally	Seldom	Never	Essential	Moderate	Trivial
Basic Structural Drawings								
72. Use structural member and reinforcing concrete manuals and technical tables								
73. Detail structural beam connections								
74. Detail concrete reinforcements								
75. Prepare materials take off lists								
76. Draw structural framing plans and elevations								
77. Identify welding symbols								
Basic Structural Drawings Not Listed								
78.								
Basic Civil Drawings								
79. Interpret technical standards for soils and construction materials								
80. Prepare topographic drawings								
81. Prepare drainage drawings								
82. Prepare plan and profile drawings								
83. Prepare street layout drawings								
84. Prepare contour drawings								

<u>Figure B1.</u> Occupational analysis survey instrument.

INSTRUCTIONS:
For each of the following skills, use a check mark to indicate <u>both</u> the frequency of performance <u>and</u> the degree of importance

	Frequency of Performance					Degree of Importance		
	Daily	Frequently	Occasionally	Seldom	Never	Essential	Moderate	Trivial
Basic Civil Drawings Not Listed								
85.								
Basic Electrical/Electronic Drawings								
86. Interpret basic electric/electronic standards and symbols								
87. Prepare schematic drawings								
88. Prepare cable drawings								
89. Prepare component drawings								
90. Prepare logic diagrams								
91. Prepare control panel drawings								
Basic Electrical/Electronic Drawings Not Listed								
92.								
Basic Pneumatic/Hydraulic Drawings								
93. Interpret basic pneumatic/hydraulic standards and symbols								
94. Prepare piping drawings								
95. Prepare isometric drawings								

<u>Figure B1.</u> Occupational analysis survey instrument.

INSTRUCTIONS:
For each of the following skills, use a check mark to indicate <u>both</u> the frequency of performance <u>and</u> the degree of importance

	Frequency of Performance					Degree of Importance		
	Daily	Frequently	Occasionally	Seldom	Never	Essential	Moderate	Trivial
96. Prepare sectional diagrams								
97. Prepare graphical symbols								
98. Prepare process and instrumentation diagrams								
99. Prepare combination diagrams								
100. Prepare pump and motor drawings								
101. Prepare cylinder and piston diagrams								
102. Prepare valve drawings								
103. Prepare pump section drawings								
Basic Pneumatic/Hydraulic Drawings Not Listed								
104.								
Other Drawing Types Not Listed								
105.								

<u>Figure B1.</u> Occupational analysis survey instrument.

Thank you very much for taking the time to complete this questionnaire. Your cooperation is greatly appreciated! Please return the completed questionnaire in the self-addressed, postage paid envelope that is enclosed to:

Gene Francisco
Northeast Wisconsin Technical College
P.O. Box 19042
Green Bay, WI 54307-9012

I understand that by returning this questionnaire, I am giving my informed consent as a participating volunteer in this study. I understand the basic nature of the study and agree that any potential risks are exceedingly small. I also understand the potential benefits that might be realized from the successful completion of this study. I am aware that the information is being sought in a specific manner so that no identifiers are needed and so that confidentiality is guaranteed. I realize that I have the right to refuse to participate and that my right to withdraw from participation at any time during the study will be respected with no coercion or prejudice.

NOTE: Questions or concerns about participation in the research or subsequent complaints should be first addressed to Gene Francisco and second to Dr. Ted Knous, Chair, UW-Stout Institutional Review Board for the Protection of Human Subjects in Research, 11HH, UW-Stout, Menomonie, WI, 54751, phone (715) 232-1126.

Figure B1. Occupational analysis survey instrument.

Appendix C

Initial Contact Letter

Northeast
Wisconsin Technical College
Green Bay • Marinette • Sturgeon Bay

Dr. H. Jeffrey Rafn, President

Visit our website at...www.nwtconline.com

September 5, 2000

«company_name»
«street»
«city», «state» «zip»

Dear Sir/Madam:

My name is Gene Francisco, and I am an instructor in the Civil Engineering Technology program at Northeast Wisconsin Technical College in Green Bay, Wisconsin. In about two weeks, I will be conducting a survey to determine which CAD related technical skills and competencies our graduates should have upon completion of our program.

Your name has been selected as an employer of graduates from our program; therefore we are hoping that you are interested in helping us determine the capabilities needed in industry. This is an excellent opportunity for you to provide input into the civil engineering technology CAD and drafting curriculum at NWTC. Your response is crucial if we are to keep up with the ever-changing demands in the civil engineering technician profession. If you don't utilize CAD or drafting within your organization, your response to is still very important to success of the survey.

The survey that I am referring to will arrive by September 20, 2000, and it should only take about 15 to 20 minutes of your time to complete. You may then return the completed survey in the self-addressed, stamped envelope that will be included.

Please be aware that the survey is formatted in a specific manner so that no identifiers are needed. Confidentiality is guaranteed.

If you do not wish to participate in the survey, please return the card that is enclosed; and your name will be removed from the mailing list. If I do not receive this card from you by September 15, 2000, I will assume that you are willing to participate in the survey; and a copy will be sent to you.

Your cooperation will be greatly appreciated, and I would like to thank you in advance for your help!

Sincerely,

Gene R. Francisco, P.E.
Civil Engineering Technology Instructor

GREEN BAY CAMPUS
2740 W. Mason St., P. O. Box 19042
Green Bay, WI 54307-9042
(920) 498-5400

MARINETTE CAMPUS
1601 University Dr.
Marinette, WI 54143
(715) 735-9361

STURGEON BAY CAMPUS
229 N. 14th Ave.
Sturgeon Bay, WI 54235-1317
(920) 743-2207

or call toll-free (800) 422-NWTC

Figure C1. Initial contact letter.

Appendix D

Participation Declination Card

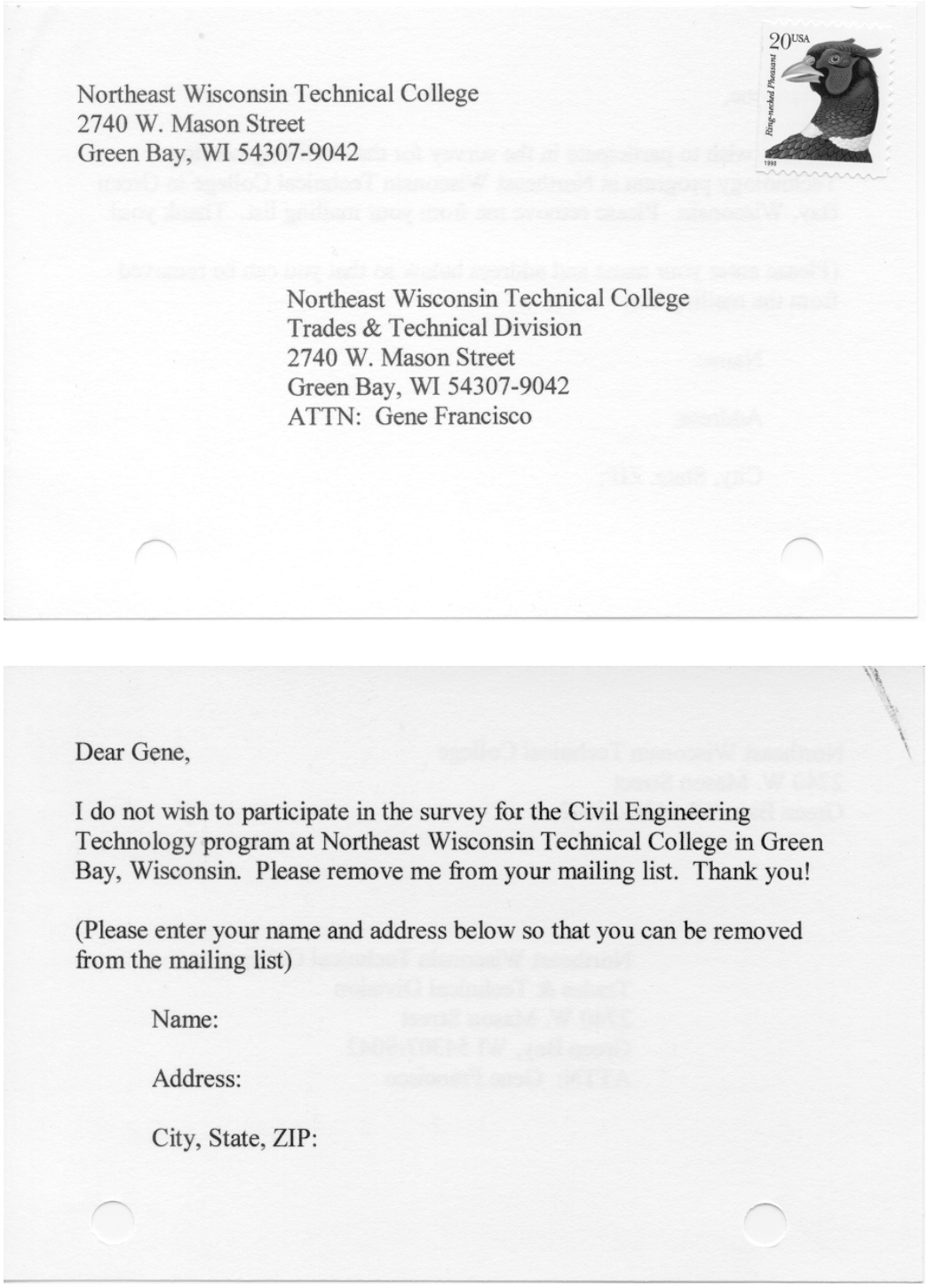

Figure D1. Participation declination card.

Appendix E

Survey Cover Letter

Northeast
Wisconsin Technical College
Green Bay • Marinette • Sturgeon Bay

Dr. H. Jeffrey Rafn, President

Visit our website at...www.nwtconline.com

September 16, 2000

«company_name»
«street»
«city», «state» «zip»

Dear Sir/Madam:

Thank you for agreeing to participate in the CAD competency survey for the Civil Engineering Technology program at Northeast Wisconsin Technical College in Green Bay, Wisconsin. Your cooperation and prompt response will be greatly appreciated.

Please don't let the length of this survey frighten you. It should only take about 15 to 20 minutes of your time. Please rate the competencies using both scales as indicated in the instructions. As I indicated previously, the survey is formatted in a specific manner so that no identifiers are needed. Confidentiality is guaranteed.

I would like to ask that you please complete the survey at your earliest convenience and mail it back to me in the self-addressed, stamped envelope no later than October 1, 2000.

Your assistance will help us a great deal in making sure that the civil engineering technology curriculum at NWTC remains current.

Once again, thanks for your time and cooperation. Have a great day!

Sincerely,

Gene R. Francisco, P.E.
Civil Engineering Technology Instructor

GREEN BAY CAMPUS
2740 W. Mason St., P. O. Box 19042
Green Bay, WI 54307-9042
(920) 498-5400

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Marinette, WI 54143
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STURGEON BAY CAMPUS
229 N. 14th Ave.
Sturgeon Bay, WI 54235-1317
(920) 743-2207

or call toll-free (800) 422-NWTC

Figure E1. Survey cover letter.

Appendix F

Reminder Letter

Northeast
Wisconsin Technical College
Green Bay • Marinette • Sturgeon Bay

Dr. H. Jeffrey Rafn, President

Visit our website at...www.nwtconline.com

October 6, 2000

«company_name»
«street»
«city», «state» «zip»

Dear Sir/Madam:

This is just a little reminder that I haven't yet received your completed survey for the Civil Engineering Technology program at Northeast Wisconsin Technical College in Green Bay, Wisconsin. I realize that you probably have a very busy schedule, and I appreciate the fact that you were willing to participate in the survey.

Let me please remind you how important the results of this survey are to keeping the program current so that we may continue to meet the ever changing needs of the industry. Your responses are very important even if your organization does not perform drafting functions or use CAD.

If you have already returned your completed survey, please disregard this letter and accept my sincerest thanks for your time in completing it.

If you have not received or misplaced your survey, please call me at (920) 498-5672 or e-mail me at frisco@netnet.net to receive one.

If you have not yet done so, could I please ask that you take the 15 to 20 minutes required to complete the survey and return it to me in the self addressed envelope within the next three business days? Your cooperation will be greatly appreciated.

Thanks again and have a great day!

Sincerely,

Gene R. Francisco, P.E.
Civil Engineering Technology Instructor

GREEN BAY CAMPUS
2740 W. Mason St., P. O. Box 19042
Green Bay, WI 54307-9042
(920) 498-5400

MARINETTE CAMPUS
1601 University Dr.
Marinette, WI 54143
(715) 735-9361

STURGEON BAY CAMPUS
229 N. 14th Ave.
Sturgeon Bay, WI 54235-1317
(920) 743-2207

or call toll-free (800) 422-NWTC

Figure E1. Survey reminder letter.

Appendix G

Results of Frequency of Performance and Degree of Importance of Basic Cad Skills

		Frequency of performance rating		Degree of importance rating		
Question	Employer	Mean	Standard deviation	Mean	Standard deviation	Action
1	All	4.32	0.79	2.81	0.40	Include
	CE	4.40	0.52	3.00	0.00	
	GO	4.00	0.76	2.63	0.52	
	SU	5.00	0.00	2.80	0.45	
	CO	3.00		2.00		
	CN	4.50	0.71	3.00	0.00	
	AE	4.50	0.71	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
2	All	4.03	1.02	2.71	0.59	Include
	CE	4.00	0.94	2.80	0.63	
	GO	3.75	0.89	2.63	0.52	
	SU	5.00	0.00	3.00	0.00	
	CO	3.00		2.00		
	CN	4.50	0.71	3.00	0.00	
	AE	3.50	2.12	2.00	1.41	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	4.00		3.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
3	All	4.71	0.64	2.90	0.30	Include
	CE	4.90	0.32	3.00	0.00	
	GO	4.50	0.53	2.75	0.46	
	SU	5.00	0.00	3.00	0.00	
	CO	4.00		3.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
4	All	4.61	0.92	2.84	0.45	Include
	CE	4.90	0.32	3.00	0.00	
	GO	4.50	0.53	2.75	0.46	
	SU	5.00	0.00	3.00	0.00	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
5	All	4.52	0.96	2.84	0.45	Include

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	CE	4.70	0.48	3.00	0.00	
	GO	4.50	0.76	2.75	0.46	
	SU	4.20	1.79	2.60	0.89	
	CO	4.00		3.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
6	All	4.06	1.03	2.65	0.55	Include
	CE	4.10	0.88	2.80	0.42	
	GO	4.25	0.46	2.63	0.52	
	SU	3.40	1.67	2.20	0.84	
	CO	4.00		3.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	3.00		2.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
7	All	1.63	0.85	1.33	0.48	Remove
	CE	1.70	0.95	1.40	0.52	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	GO	1.63	0.92	1.38	0.52	
	SU	1.20	0.45	1.00	0.00	
	CO	1.00		1.00		
	CN	3.00		2.00		
	AE	1.50	0.71	1.00	0.00	
	PM	1.00		1.00		
	TL	2.00		2.00		
	UT	3.00		2.00		
8	All	2.07	1.19	1.55	0.74	Review
	CE	1.89	0.78	1.44	0.53	
	GO	2.38	1.51	1.63	0.92	
	SU	1.20	0.45	1.20	0.45	
	CO	1.00		1.00		
	CN	4.00	0.00	2.50	0.71	
	AE	2.00		1.00		
	PM	1.00		1.00		
	TL	2.00		2.00		
	UT	4.00		3.00		
9	All	1.90	1.08	1.48	0.63	Remove
	CE	1.90	0.88	1.40	0.52	
	GO	2.00	1.07	1.63	0.74	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	4.00	1.41	2.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	3.00		2.00		
	TL	2.00		2.00		
	UT	3.00		2.00		
10	All	1.87	1.23	1.48	0.72	Remove
	CE	1.70	0.82	1.50	0.71	
	GO	1.63	1.06	1.38	0.74	
	SU	1.20	0.45	1.00	0.00	
	CO	5.00		3.00		
	CN	4.00	1.41	2.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	2.00		2.00		
	UT	4.00		2.00		
11	All	1.65	1.02	1.39	0.62	Remove
	CE	1.60	0.84	1.60	0.70	
	GO	1.50	1.07	1.25	0.71	
	SU	1.20	0.45	1.00	0.00	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	CO	1.00		1.00		
	CN	4.00	0.00	2.00	0.00	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	2.00		2.00		
	UT	3.00		2.00		
12	All	4.48	1.06	2.74	0.51	Include
	CE	4.80	0.42	2.90	0.32	
	GO	4.50	0.76	2.63	0.52	
	SU	4.20	1.79	2.60	0.89	
	CO	2.00		2.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
13	All	4.52	0.96	2.74	0.51	Include
	CE	4.60	0.70	2.90	0.32	
	GO	4.50	0.53	2.63	0.52	
	SU	5.00	0.00	2.80	0.45	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
14	All	4.42	0.81	2.77	0.43	Include
	CE	4.50	0.71	2.90	0.32	
	GO	4.25	0.71	2.63	0.52	
	SU	4.80	0.45	2.80	0.45	
	CO	4.00		3.00		
	CN	5.00	0.00	3.00	0.00	
	AE	4.00	1.41	2.50	0.71	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
15	All	4.65	0.80	2.81	0.48	Include
	CE	4.90	0.32	3.00	0.00	
	GO	4.63	0.52	2.75	0.46	
	SU	4.80	0.45	2.80	0.45	
	CO	2.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
16	All	4.55	0.96	2.77	0.50	Include
	CE	4.60	0.70	2.80	0.42	
	GO	4.63	0.52	2.88	0.35	
	SU	5.00	0.00	2.80	0.45	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
17	All	3.84	1.13	2.35	0.66	Review
	CE	4.30	0.67	2.50	0.53	
	GO	3.63	1.06	2.38	0.74	
	SU	3.80	1.30	2.20	0.84	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	4.50	0.71	2.50	0.71	
	PM	3.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	TL	2.00		2.00		
	UT	3.00		2.00		
18	All	4.06	1.03	2.58	0.56	Include
	CE	4.10	0.57	2.70	0.48	
	GO	3.75	1.04	2.50	0.53	
	SU	4.40	0.55	2.40	0.55	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	5.00		3.00		
19	All	4.58	0.92	2.81	0.48	Include
	CE	4.90	0.32	3.00	0.00	
	GO	4.50	0.53	2.75	0.46	
	SU	4.80	0.45	2.80	0.45	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	UT	5.00		3.00		
20	All	4.45	0.99	2.77	0.50	Include
	CE	4.80	0.42	3.00	0.00	
	GO	4.25	0.89	2.63	0.52	
	SU	4.80	0.45	2.80	0.45	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	4.00		3.00		
21	All	3.58	1.39	2.40	0.77	Review
	CE	3.80	1.40	2.56	0.73	
	GO	4.00	0.76	2.75	0.46	
	SU	2.60	1.82	1.60	0.89	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	3.00	0.00	2.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	4.00		3.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
22	All	3.35	1.28	2.29	0.69	Review
	CE	3.50	1.18	2.40	0.70	
	GO	3.75	1.04	2.63	0.52	
	SU	2.20	1.10	1.60	0.55	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	4.50	0.71	2.50	0.71	
	PM	3.00		2.00		
	TL	2.00		2.00		
	UT	3.00		2.00		
23	All	3.32	1.38	2.35	0.71	Review
	CE	3.90	1.29	2.70	0.67	
	GO	3.75	0.89	2.50	0.53	
	SU	2.00	1.87	2.00	1.00	
	CO	1.00		1.00		
	CN	4.00	0.00	2.50	0.71	
	AE	3.50	0.71	2.00	0.00	
	PM	3.00		2.00		
	TL	2.00		2.00		
	UT	3.00		2.00		
24	All	3.61	1.33	2.42	0.76	Review

(table continues)

CE	4.10	1.10	2.80	0.42
GO	3.38	1.30	2.38	0.74
SU	3.40	1.82	2.20	1.10
CO	1.00		1.00	
CN	4.50	0.71	2.50	0.71
AE	4.00	1.41	2.50	0.71
PM	3.00		1.00	
TL	2.00		2.00	
UT	4.00		3.00	

Note. CE = civil engineering; GO = governmental agency; SU = surveying; CO = contractor; CN = consulting engineering; AE = architectural/engineering; PM = photogrammetric/mapping; TL = testing laboratory; UT = utility.

Appendix H

Results of Frequency of Performance and Degree of Importance of Advanced Cad Skills

		Frequency of performance rating		Degree of importance rating		
Question	Employer	Mean	Standard deviation	Mean	Standard deviation	Action
26	All	1.68	0.98	1.29	0.53	Remove
	CE	1.80	0.92	1.40	0.52	
	GO	1.50	0.76	1.13	0.35	
	SU	1.20	0.45	1.00	0.00	
	CO	1.00		1.00		
	CN	4.00	0.00	2.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
		27.00				
27	All	1.42	0.76	1.19	0.40	Remove
	CE	1.30	0.48	1.20	0.42	
	GO	1.50	0.76	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	3.00	1.41	2.00	0.00	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		

(table continues)

Question	Employer	Frequency of performance rating: Mean	Frequency of performance rating: Standard deviation	Degree of importance rating: Mean	Degree of importance rating: Standard deviation	Action
	UT	3.00		2.00		
28	All	1.74	1.18	1.35	0.61	Remove
	CE	1.80	1.23	1.40	0.70	
	GO	1.75	1.16	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	4.00	1.41	2.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	2.00		2.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
29	All	2.39	1.52	1.65	0.80	Review
	CE	2.60	1.43	1.80	0.92	
	GO	2.50	1.60	1.75	0.89	
	SU	1.60	1.34	1.20	0.45	
	CO	1.00		1.00		
	CN	5.00	0.00	2.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	3.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
30	All	2.48	1.59	1.81	0.83	Review
	CE	2.80	1.62	2.10	0.88	
	GO	2.38	1.69	1.75	0.89	
	SU	1.40	0.89	1.20	0.45	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	2.00	1.41	1.50	0.71	
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
31	All	2.23	1.43	1.71	0.78	Review
	CE	2.40	1.35	1.80	0.79	
	GO	2.13	1.55	1.75	0.89	
	SU	1.20	0.45	1.20	0.45	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	2.00	1.41	1.50	0.71	
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
32	All	2.29	1.53	1.77	0.84	Review

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	CE	2.10	1.37	1.90	0.88	
	GO	2.38	1.69	1.75	0.89	
	SU	1.60	1.34	1.40	0.89	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	2.00	1.41	1.50	0.71	
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
33	All	1.93	1.28	1.48	0.74	Remove
	CE	1.70	0.67	1.44	0.53	
	GO	2.00	1.41	1.43	0.79	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	2.50	2.12	2.00	1.41	
	PM	2.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
34	All	2.52	1.59	1.77	0.80	Review
	CE	2.70	1.57	1.90	0.88	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	GO	2.13	1.55	1.63	0.74	
	SU	2.20	1.10	1.60	0.55	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	3.00	2.83	2.00	1.41	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
35	All	1.71	1.10	1.35	0.61	Remove
	CE	1.60	0.84	1.40	0.70	
	GO	2.00	1.31	1.50	0.76	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	4.00	0.00	2.00	0.00	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
36	All	1.80	1.21	1.40	0.72	Remove
	CE	1.80	1.32	1.50	0.85	
	GO	2.13	1.36	1.63	0.92	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	3.00		1.00		
	AE	1.00	0.00	1.00	0.00	
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
37	All	2.39	1.67	1.71	0.86	Review
	CE	2.50	1.65	1.80	0.92	
	GO	2.88	1.89	2.00	0.93	
	SU	1.20	0.45	1.00	0.00	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	1.00	0.00	1.00	0.00	
	PM	2.00		2.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
38	All	1.61	1.05	1.35	0.66	Remove
	CE	1.50	0.71	1.30	0.67	
	GO	1.50	1.07	1.38	0.74	
	SU	1.00	0.00	1.00	0.00	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	CO	1.00		1.00		
	CN	4.00	0.00	2.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	2.00		2.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
39	All	2.13	1.52	1.61	0.84	Review
	CE	2.30	1.57	1.80	0.92	
	GO	2.25	1.49	1.63	0.92	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	1.00	0.00	1.00	0.00	
	PM	2.00		2.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
40	All	2.13	1.43	1.67	0.84	Review
	CE	2.10	1.29	1.60	0.84	
	GO	2.25	1.49	2.00	1.00	
	SU	1.60	1.34	1.20	0.45	
	CO	1.00		1.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	CN	5.00	0.00	3.00	0.00	
	AE	1.00	0.00	1.00	0.00	
	PM	2.00		2.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
41	All	1.74	1.12	1.40	0.62	Remove
	CE	1.70	1.06	1.30	0.48	
	GO	1.88	1.13	1.57	0.79	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	4.00	1.41	2.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	2.00		2.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
42	All	2.74	1.77	1.87	0.88	Review
	CE	2.50	1.78	1.80	0.92	
	GO	3.63	1.69	2.25	0.89	
	SU	1.80	1.79	1.40	0.89	
	CO	1.00		1.00		
	CN	4.50	0.71	2.50	0.71	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	AE	3.00	2.83	2.00	1.41	
	PM	2.00		2.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
43	All	1.87	1.23	1.48	0.72	Remove
	CE	1.80	0.79	1.40	0.52	
	GO	2.13	1.25	1.75	0.89	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
44	All	1.58	0.89	1.29	0.46	Remove
	CE	1.60	0.70	1.30	0.48	
	GO	1.38	0.74	1.25	0.46	
	SU	1.40	0.89	1.20	0.45	
	CO	1.00		1.00		
	CN	3.00	0.00	2.00	0.00	
	AE	1.00	0.00	1.00	0.00	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
45	All	1.74	1.00	1.39	0.56	Remove
	CE	1.80	1.03	1.40	0.70	
	GO	1.75	0.89	1.50	0.53	
	SU	1.40	0.89	1.20	0.45	
	CO	1.00		1.00		
	CN	3.50	0.71	2.00	0.00	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
46	All	2.39	1.61	1.77	0.84	Review
	CE	2.20	1.48	1.70	0.82	
	GO	2.75	1.91	2.13	0.99	
	SU	2.20	1.79	1.60	0.89	
	CO	1.00		1.00		
	CN	4.50	0.71	2.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	3.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	TL	1.00		1.00		
	UT	3.00		2.00		
47	All	2.26	1.32	1.74	0.77	Review
	CE	1.90	0.88	1.70	0.67	
	GO	3.13	1.46	2.25	0.89	
	SU	1.20	0.45	1.20	0.45	
	CO	1.00		1.00		
	CN	4.50	0.71	2.50	0.71	
	AE	1.50	0.71	1.00	0.00	
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
48	All	1.65	1.05	1.39	0.56	Remove
	CE	1.30	0.48	1.30	0.48	
	GO	1.88	1.36	1.50	0.76	
	SU	1.20	0.45	1.20	0.45	
	CO	1.00		1.00		
	CN	4.00	0.00	2.00	0.00	
	AE	1.00	0.00	1.00	0.00	
	PM	2.00		2.00		
	TL	1.00		1.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	UT	3.00		2.00		
49	All	3.03	1.52	2.06	0.81	Review
	CE	3.30	1.49	2.20	0.79	
	GO	2.75	1.49	2.00	0.76	
	SU	3.00	1.87	2.00	1.00	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	3.00	1.41	2.00	1.41	
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
50	All	1.40	0.72	1.23	0.43	Remove
	CE	1.20	0.42	1.20	0.42	
	GO	1.50	0.93	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00		1.00		
	CN	2.50	0.71	2.00	0.00	
	AE	1.00		1.00		
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	2.00		1.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
51	All	2.61	1.28	1.81	0.75	Review
	CE	2.20	1.14	1.60	0.70	
	GO	3.25	1.04	2.25	0.71	
	SU	2.00	1.00	1.40	0.55	
	CO	1.00		1.00		
	CN	4.50	0.71	2.50	0.71	
	AE	2.00	0.00	1.50	0.71	
	PM	5.00		3.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
52	All	2.13	1.15	1.65	0.66	Review
	CE	1.70	0.67	1.50	0.53	
	GO	2.88	1.13	2.13	0.64	
	SU	1.40	0.55	1.20	0.45	
	CO	1.00		1.00		
	CN	4.50	0.71	2.50	0.71	
	AE	1.50	0.71	1.00	0.00	
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	2.00		2.00		
53	All	2.87	1.50	2.00	0.77	Review
	CE	2.70	1.25	1.90	0.74	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	GO	3.00	1.51	2.38	0.74	
	SU	2.60	1.82	1.80	0.84	
	CO	1.00		1.00		
	CN	5.00	0.00	3.00	0.00	
	AE	2.50	2.12	1.50	0.71	
	PM	4.00		2.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
54	All	2.00	1.34	1.50	0.73	Review
	CE	1.80	0.92	1.40	0.52	
	GO	2.00	1.41	1.63	0.92	
	SU	2.20	1.79	1.60	0.89	
	CO	1.00		1.00		
	CN	4.50	0.71	2.50	0.71	
	AE	1.00		1.00		
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	2.00		1.00		

Note. CE = civil engineering; GO = governmental agency; SU = surveying; CO = contractor; CN = consulting engineering; AE = architectural/engineering; PM = photogrammetric/mapping; TL = testing laboratory; UT = utility.

Appendix I

Results of Frequency of Performance and Degree of Importance Regarding Basic Architectural Drawings

		Frequency of performance rating		Degree of importance rating		
Question	Employer	Mean	Standard deviation	Mean	Standard deviation	Action
56	All	2.03	1.26	1.48	0.67	Review
	CE	2.45	1.29	1.64	0.67	
	GO	1.50	0.76	1.25	0.46	
	SU	1.80	1.79	1.40	0.89	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00		1.00		
	AE	4.00	0.00	2.50	0.71	
	PM	1.00		1.00		
	TL	2.00		2.00		
	UT	3.00		2.00		
		27.00				
57	All	2.59	1.54	1.94	0.89	Review
	CE	3.09	1.38	2.27	0.90	
	GO	1.88	0.99	1.63	0.74	
	SU	2.00	1.73	1.60	0.89	
	CO	1.00	0.00	1.00	0.00	
	CN	5.00	0.00	3.00	0.00	
	AE	4.50	0.71	3.00	0.00	
	PM	1.00		1.00		
	TL	2.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	UT	4.00		2.00		
58	All	2.44	1.54	1.82	0.90	Review
	CE	3.00	1.48	2.18	0.98	
	GO	1.50	0.93	1.38	0.74	
	SU	1.60	0.89	1.40	0.55	
	CO	1.00	0.00	1.00	0.00	
	CN	5.00	0.00	3.00	0.00	
	AE	4.50	0.71	3.00	0.00	
	PM	1.00		1.00		
	TL	3.00		2.00		
	UT	4.00		2.00		
59	All	2.76	1.50	1.97	0.90	Review
	CE	3.27	1.27	2.36	0.92	
	GO	2.13	0.99	1.63	0.74	
	SU	1.80	1.79	1.40	0.89	
	CO	1.00	0.00	1.00	0.00	
	CN	5.00	0.00	3.00	0.00	
	AE	4.50	0.71	3.00	0.00	
	PM	3.00		2.00		
	TL	3.00		2.00		
	UT	4.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
60	All	2.74	1.58	1.97	0.94	Review
	CE	3.45	1.37	2.45	0.93	
	GO	1.88	0.99	1.50	0.76	
	SU	1.80	1.79	1.40	0.89	
	CO	1.00	0.00	1.00	0.00	
	CN	5.00	0.00	3.00	0.00	
	AE	4.50	0.71	3.00	0.00	
	PM	2.00		2.00		
	TL	3.00		2.00		
	UT	4.00		2.00		
61	All	2.38	1.46	1.79	0.88	Review
	CE	3.09	1.30	2.18	0.87	
	GO	1.75	1.04	1.50	0.76	
	SU	1.40	0.89	1.40	0.89	
	CO	1.00	0.00	1.00	0.00	
	CN	4.00	1.41	2.50	0.71	
	AE	4.50	0.71	3.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
62	All	2.09	1.14	1.58	0.75	Review

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	CE	2.55	1.29	1.82	0.87	
	GO	1.75	0.89	1.38	0.74	
	SU	1.40	0.89	1.20	0.45	
	CO	1.00	0.00	1.00	0.00	
	CN	2.50	0.71	2.00		
	AE	3.50	0.71	2.50	0.71	
	PM	3.00		2.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
63	All	1.47	1.02	1.24	0.55	Remove
	CE	1.91	1.45	1.55	0.82	
	GO	1.13	0.35	1.00	0.00	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.50	2.12	1.50	0.71	
	AE	1.50	0.71	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	2.00		2.00		
64	All	1.53	0.99	1.32	0.64	Remove
	CE	2.00	1.41	1.64	0.81	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	GO	1.13	0.35	1.00	0.00	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	1.41	2.00	1.41	
	AE	2.50	0.71	1.50	0.71	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	2.00		2.00		
65	All	1.65	1.10	1.39	0.66	Remove
	CE	2.09	1.30	1.73	0.79	
	GO	1.13	0.35	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.50	2.12	1.00		
	AE	3.50	0.71	2.50	0.71	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	2.00		2.00		
66	All	1.24	0.65	1.12	0.41	Remove
	CE	1.64	1.03	1.27	0.65	
	GO	1.00	0.00	1.00	0.00	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.50	0.71	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	1.00		1.00		
67	All	2.41	1.48	1.82	0.87	Review
	CE	3.00	1.67	2.00	1.00	
	GO	1.75	1.16	1.63	0.92	
	SU	2.40	1.95	1.80	1.10	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	0.00	2.00	0.00	
	AE	3.50	0.71	2.50	0.71	
	PM	3.00		2.00		
	TL	2.00		2.00		
	UT	4.00		2.00		
68	All	1.68	0.98	1.44	0.66	Remove
	CE	2.18	1.08	1.73	0.79	
	GO	1.25	0.46	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	CO	1.00	0.00	1.00	0.00	
	CN	1.50	0.71	1.50	0.71	
	AE	3.50	0.71	2.50	0.71	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
69	All	1.62	0.95	1.41	0.61	Remove
	CE	2.18	1.25	1.73	0.79	
	GO	1.25	0.46	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.50	0.71	1.50	0.71	
	AE	2.50	0.71	2.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
70	All	1.59	0.92	1.38	0.60	Remove
	CE	2.18	1.17	1.73	0.79	
	GO	1.13	0.35	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	CN	1.50	0.71	1.50	0.71	
	AE	2.50	0.71	2.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		

Note. CE = civil engineering; GO = governmental agency; SU = surveying; CO = contractor; CN = consulting engineering; AE = architectural/engineering; PM = photogrammetric/mapping; TL = testing laboratory; UT = utility.

Appendix J

Results of Frequency of Performance and Degree of Importance Regarding Basic Structural Drawings

		Frequency of performance rating		Degree of importance rating		
Question	Employer	Mean	Standard deviation	Mean	Standard deviation	Action
72	All	1.91	1.29	1.48	0.80	Remove
	CE	2.00	1.26	1.73	1.01	
	GO	1.38	0.74	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	4.00	1.41	2.50	0.71	
	AE	4.00	0.00	3.00		
	PM	1.00		1.00		
	TL	3.00		2.00		
	UT	4.00		2.00		
		27.00				
73	All	1.94	1.39	1.55	0.83	Remove
	CE	2.18	1.40	1.82	0.98	
	GO	1.13	0.35	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	5.00	0.00	3.00	0.00	
	AE	4.00	0.00	3.00		
	PM	1.00		1.00		
	TL	3.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	UT	3.00		2.00		
74	All	2.00	1.35	1.61	0.83	Review
	CE	2.18	1.25	1.82	0.98	
	GO	1.63	1.06	1.38	0.52	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	5.00	0.00	3.00	0.00	
	AE	4.00	0.00	3.00		
	PM	1.00		1.00		
	TL	2.00		2.00		
	UT	2.00		2.00		
75	All	1.62	0.92	1.36	0.65	Remove
	CE	1.73	0.79	1.55	0.82	
	GO	1.25	0.46	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	4.00	1.41	2.50	0.71	
	AE	2.00	0.00	1.00		
	PM	1.00		1.00		
	TL	2.00		2.00		
	UT	3.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
76	All	1.79	1.23	1.58	0.83	Remove
	CE	2.00	1.10	1.91	0.94	
	GO	1.25	0.46	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	5.00	0.00	3.00	0.00	
	AE	3.50	0.71	3.00		
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	2.00		2.00		
77	All	1.65	1.01	1.39	0.61	Remove
	CE	1.73	0.79	1.55	0.69	
	GO	1.13	0.35	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	4.50	0.71	2.50	0.71	
	AE	2.50	0.71	2.00		
	PM	1.00		1.00		
	TL	3.00		2.00		
	UT	2.00		2.00		

Note. CE = civil engineering; GO = governmental agency; SU = surveying; CO = contractor; CN = consulting engineering; AE = architectural/engineering; PM = photogrammetric/mapping; TL = testing laboratory; UT = utility.

Appendix K

Results of Frequency of Performance and Degree of Importance Regarding Basic Civil Drawings

		Frequency of performance rating		Degree of importance rating		
Question	Employer	Mean	Standard deviation	Mean	Standard deviation	Action
79	All	2.67	1.31	2.03	0.86	Review
	CE	2.55	1.21	2.00	0.89	
	GO	3.00	1.41	2.14	0.90	
	SU	2.40	1.14	2.20	0.84	
	CO	2.33	2.31	1.67	1.15	
	CN	4.00	1.41	2.50	0.71	
	AE	2.50	0.71	2.00		
	PM	1.00		1.00		
	TL	4.00		3.00		
	UT	2.00		1.00		
		27.00				
80	All	3.71	1.53	2.50	0.79	Include
	CE	3.64	1.75	2.45	0.93	
	GO	3.63	1.51	2.50	0.76	
	SU	4.00	1.22	2.80	0.45	
	CO	2.33	2.31	1.67	1.15	
	CN	5.00	0.00	3.00	0.00	
	AE	4.50	0.71	3.00	0.00	
	PM	5.00		3.00		
	TL	3.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	UT	3.00		2.00		
81	All	3.56	1.40	2.50	0.71	Include
	CE	3.55	1.57	2.45	0.82	
	GO	3.75	1.04	2.75	0.46	
	SU	3.80	1.10	2.60	0.55	
	CO	2.33	2.31	1.67	1.15	
	CN	5.00	0.00	3.00	0.00	
	AE	4.50	0.71	3.00	0.00	
	PM	2.00		2.00		
	TL	2.00		2.00		
	UT	3.00		2.00		
82	All	3.62	1.35	2.50	0.75	Include
	CE	3.64	1.57	2.55	0.82	
	GO	4.13	0.64	2.75	0.46	
	SU	3.40	0.89	2.60	0.55	
	CO	1.33	0.58	1.00	0.00	
	CN	4.50	0.71	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	3.00		2.00		
	TL	2.00		2.00		
	UT	5.00		3.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
83	All	3.62	1.44	2.50	0.75	Include
	CE	3.73	1.42	2.55	0.69	
	GO	4.00	0.93	2.75	0.46	
	SU	3.80	1.10	2.60	0.55	
	CO	1.00	0.00	1.00	0.00	
	CN	4.50	0.71	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	1.00		1.00		
	UT	3.00		3.00		
84	All	3.71	1.47	2.47	0.75	Include
	CE	3.91	1.58	2.55	0.82	
	GO	3.38	1.41	2.38	0.74	
	SU	3.80	1.10	2.60	0.55	
	CO	2.33	2.31	1.67	1.15	
	CN	4.50	0.71	3.00	0.00	
	AE	5.00	0.00	3.00	0.00	
	PM	5.00		3.00		
	TL	2.00		2.00		
	UT	4.00		2.00		

Note. CE = civil engineering; GO = governmental agency; SU = surveying; CO = contractor; CN = consulting engineering; AE = architectural/engineering; PM = photogrammetric/mapping; TL = testing laboratory; UT = utility.

Appendix L

Results of Frequency of Performance and Degree of Importance Regarding Basic Electrical/Electronic Drawings

		Frequency of performance rating		Degree of importance rating		
Question	Employer	Mean	Standard deviation	Mean	Standard deviation	Action
86	All	1.76	1.18	1.41	0.74	Remove
	CE	2.18	1.25	1.73	0.90	
	GO	1.63	0.92	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.00	0.00	1.00	0.00	
	AE	3.00	1.41	2.00	1.41	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	5.00		3.00		
		27.00				
87	All	1.68	1.20	1.38	0.74	Remove
	CE	2.00	1.34	1.64	0.92	
	GO	1.63	0.92	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.00	0.00	1.00	0.00	
	AE	2.50	2.12	2.00	1.41	
	PM	1.00		1.00		
	TL	1.00		1.00		

(table continues)

Question	Employer	Frequency of performance rating: Mean	Frequency of performance rating: Standard deviation	Degree of importance rating: Mean	Degree of importance rating: Standard deviation	Action
	UT	5.00		3.00		
88	All	1.62	1.16	1.32	0.64	Remove
	CE	2.09	1.58	1.73	0.90	
	GO	1.50	0.76	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.00	0.00	1.00	0.00	
	AE	2.00	1.41	1.50	0.71	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
89	All	1.50	0.99	1.26	0.57	Remove
	CE	1.82	1.25	1.55	0.82	
	GO	1.38	0.74	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.00	0.00	1.00	0.00	
	AE	2.00	1.41	1.50	0.71	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	4.00		2.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
90	All	1.44	0.99	1.32	0.68	Remove
	CE	1.82	1.33	1.73	0.90	
	GO	1.13	0.35	1.00	0.00	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.00	0.00	1.00	0.00	
	AE	2.00	1.41	1.50	0.71	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	4.00		3.00		
91	All	1.53	1.11	1.35	0.69	Remove
	CE	1.82	1.33	1.73	0.90	
	GO	1.38	0.74	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.00	0.00	1.00	0.00	
	AE	2.00	1.41	1.50	0.71	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	5.00		3.00		

Note. CE = civil engineering; GO = governmental agency; SU = surveying; CO = contractor; CN = consulting engineering; AE = architectural/engineering; PM = photogrammetric/mapping; TL = testing laboratory; UT = utility.

Appendix M

Results of Frequency of Performance and Degree of Importance Regarding Basic Pneumatic/Hydraulic Drawings

		Frequency of performance rating		Degree of importance rating		
Question	Employer	Mean	Standard deviation	Mean	Standard deviation	Action
93	All	1.35	0.81	1.21	0.54	Remove
	CE	1.55	1.04	1.45	0.82	
	GO	1.25	0.71	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	1.41	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		1.00		
		27.00				
94	All	1.59	1.08	1.32	0.59	Remove
	CE	2.00	1.18	1.64	0.81	
	GO	1.38	0.74	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	1.41	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	UT	5.00		2.00		
95	All	1.53	1.08	1.32	0.64	Remove
	CE	1.91	1.14	1.64	0.81	
	GO	1.13	0.35	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.50	2.12	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	5.00		3.00		
96	All	1.53	1.08	1.24	0.55	Remove
	CE	1.91	1.30	1.45	0.69	
	GO	1.13	0.35	1.00	0.00	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	1.41	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	2.00		1.00		
	TL	1.00		1.00		
	UT	5.00		3.00		

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
97	All	1.53	1.02	1.32	0.59	Remove
	CE	2.00	1.48	1.55	0.82	
	GO	1.13	0.35	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.50	0.71	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	3.00		2.00		
	TL	2.00		1.00		
	UT	3.00		2.00		
98	All	1.35	0.85	1.26	0.57	Remove
	CE	1.64	1.12	1.45	0.82	
	GO	1.13	0.35	1.25	0.46	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	1.50	0.71	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
99	All	1.29	0.76	1.18	0.46	Remove

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	CE	1.36	0.81	1.27	0.65	
	GO	1.13	0.35	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	1.41	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
100	All	1.32	0.77	1.24	0.55	Remove
	CE	1.55	1.04	1.45	0.82	
	GO	1.13	0.35	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	1.41	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		
101	All	1.21	0.59	1.15	0.50	Remove
	CE	1.36	0.81	1.36	0.81	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	GO	1.00	0.00	1.00	0.00	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	1.41	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	2.00		1.00		
102	All	1.32	0.84	1.24	0.61	Remove
	CE	1.45	1.04	1.36	0.81	
	GO	1.13	0.35	1.13	0.35	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	1.41	2.00	1.41	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	4.00		2.00		
103	All	1.29	0.76	1.21	0.54	Remove
	CE	1.45	1.04	1.36	0.81	
	GO	1.13	0.35	1.13	0.35	

(table continues)

Question	Employer	Frequency of performance rating		Degree of importance rating		Action
		Mean	Standard deviation	Mean	Standard deviation	
	SU	1.00	0.00	1.00	0.00	
	CO	1.00	0.00	1.00	0.00	
	CN	2.00	1.41	1.50	0.71	
	AE	1.00	0.00	1.00	0.00	
	PM	1.00		1.00		
	TL	1.00		1.00		
	UT	3.00		2.00		

Note. CE = civil engineering; GO = governmental agency; SU = surveying; CO = contractor; CN = consulting engineering; AE = architectural/engineering; PM = photogrammetric/mapping; TL = testing laboratory; UT = utility.