11-30-1998

An Analysis of Drafting Competencies in Iowa's High Schools

Rodrick A. Thompson
University of Northern Iowa

An Analysis of Drafting Competencies in Iowa's High Schools

Abstract

Teachers in Iowa high schools are expected to have students achieve the competencies identified by the State of Iowa Department of Education. The competencies for Iowa high school engineering-related classes were published in 1991. They were compiled as a result of Senate File 449. Industry leaders, as well as teachers, throughout the state of Iowa who were actively utilizing drafting skills in 1991 helped create the outcome competencies. Since that time, these competencies have not been reviewed or revised and may need updating. The demands of industry change so frequently it is possible these are no longer the appropriate competencies. It isn't known how well the students are achieving these competencies, whether some of them are outdated, or if there are new competencies that should be identified. The problem of this study was to determine what level of mastery Iowa high school industrial technology teachers expect their students to achieve for each of the existing competencies and whether teachers believe additional competencies need to be included in the State of Iowa Department of Education competencies in engineering-related classes.

AN ANALYSIS OF DRAFTING COMPETENCIES IN IOWA'S HIGH SCHOOLS

A Research Paper for Presentation
to the Graduate Faculty
of the Department of Industrial Technology
University of Northern Iowa

Submitted in Partial Fulfillment
of the Requirements for the
Non-Thesis Master of Arts Degree

Rodrick A. Thompson
30 November 1998

Approved by:

Advisor — Date 12-4-98

Graduate Faculty Member — Date 12/4/98

Acknowledgment

I would like to express a big thank you to Mary and Debbie, UNI Industrial Technology office personnel, for doing the leg work an off campus student has a hard time completing. To Dr. Kashef for agreeing to be a reader on such short notice. To Roger and Kathy Betts for making my success a high priority even when it required putting themselves out for me. To Pat Janssen who would give me reminders throughout the process of completing my masters on how important it was to be viewed as a good teacher, not just as a finisher of a degree. "The degree doesn't make you a good teacher. You do." Most importantly to my wife, Jill, who encouraged me and waited patiently for me to complete my degree. Without their dedication I would have never completed my degree.

TABLE OF CONTENTS

List of Tables and Figures

Tables

Figure

Chapter I

Introduction

The way people live their lives today is far different than what it was 50 years ago. Learning a trade, such as drafting, from a craftsman is a concept that can be traced back hundreds of years (Ivis, Downing-Nelson, Friess, 1997). Quite possibly it is still one of the best ways for skilled workers to learn their trade. Much of the drafting trade of 50 years ago hasn't changed all that much; but the tools and techniques have changed, along with the process teachers use to teach it. Fifty years ago, a drafter used only a drafting table, a T-square and triangles to create drawings. Most drafters today use computer-aided drafting (CAD) systems to prepare drawings (U.S. Department of Labor, 1996).

Drafters and drafting make up a big portion of the products that influence the way people live. "Drafters prepare technical drawings and plans used by production and construction workers to build everything from manufactured products such as spacecraft or industrial machinery to structures such as office buildings or oil and gas pipelines" (U.S. Department of Labor, 1996, p. 224). The actual job or types of jobs a single drafter may be responsible for can vary greatly in type as well as cost or size. It's important to understand that drafting is a technical skill in which people must continue to work on to master. The ability to master a skill and create anew is a skill that lasts a lifetime. The reasoning for wanting mastery level is to be one of a few who can perform the task flawlessly. "Drafters fill in technical details, using drawings, rough sketches, specifications, codes and calculations previously made by engineers, surveyors, architects, or scientists" (U.S. Department of Labor, 1996, p. 224).

The drafter may receive sketches and measurements from several different groups to design new products or to create new drawings. This is when the drafter uses his or her knowledge to draw in the details of an object. Often times the drafter has to sketch or draw out the ideas and refer to the group in correspondence to ensure proper detail of the original idea.

For students seeking the knowledge to develop the skills needed to become a drafter, the teacher provides the structure for learning. The students need a solid foundation of the principles of drafting so the teacher must structure the courses in a way that ensures student understanding of the appropriate concepts. When a drafting or CAD teacher structures a drafting class, he or she utilizes any resources available to enhance the students' learning. The state of Iowa engineering-related competencies are one major resource for teachers teaching in that area. These competencies outline what the students are expected to know. This in turn is the primary focus of what the teachers are to teach.

Statement of the Problem

Teachers in Iowa high schools are expected to have students achieve the competencies identified by the State of Iowa Department of Education. The competencies for Iowa high school engineering-related classes were published in 1991. They were compiled as a result of Senate File 449. Industry leaders, as well as teachers, throughout the state of Iowa who were actively utilizing drafting skills in 1991 helped create the outcome competencies. Since that time, these competencies have not been reviewed or revised and may need updating. The demands of industry change so frequently it is possible these are no longer the appropriate competencies. It isn't known how well the students are achieving these competencies, whether some of them are outdated, or if there are new competencies

that should be identified. The problem of this study was to determine what level of mastery Iowa high school industrial technology teachers expect their students to achieve for each of the existing competencies and whether teachers believe additional competencies need to be included in the State of Iowa Department of Education competencies in engineering-related classes.

Statement of the Purpose

The purpose of this study was to gather information from teachers that could be used as one part of a process to revise and update the competencies required in engineering-related drafting classes throughout the state of Iowa. This was done by asking teachers to identify to what level students were expected to achieve each competency. This would provide a measure of how important each competency is, as perceived by the teachers. In addition teachers were asked to identify other competencies that should be considered for inclusion in the state of Iowa Department of Education Industrial Education engineering-related occupational competencies. A third purpose was to provide teachers a way to compare their level of expectation with other teachers throughout the state of Iowa.

Statement of the Need

The need for this study was based on the fact that the state identified competencies were identified in 1991. Much progress has been made in CAD software since that time. Revision of the 1991 competencies by the Department of Education for the state of Iowa could reflect different application skills needed by the students. Different skills mean a difference in the teaching of drafting content in Iowa high school drafting classes. This study could help teachers identify and compare their individual expectations with others as they attempt to enhance their students' level of achievement.

Statement of Research Questions

1. At which level of mastery do high school instructors expect that students will learn each state-identified engineering-related competency?

2. Are there additional competencies that should be added to the state-identified list of drafting competencies?

Assumptions

The following assumptions were made for this study:

1. The teachers' responses were accurate and honest.
2. The teachers were knowledgeable about CAD/drafting curriculum.
3. The teachers' expectation for their students' level of mastery for each competency would indicate the teachers' perception of the value of each competency.

Limitations

The study was limited by only including perceptions from high school teachers in the state of Iowa. No attempt was made in this study to gather information from employers in industry. The performance expectation should identify if the state-identified competencies should be revised.

Delimitations

The study was delimited to a population consisting of all Iowa public high school CAD/drafting programs and a sample of one drafting teacher from one half of those schools. The teachers were identified by the State of Iowa Department of Education as teaching Industrial Education engineering-related classes.

Statement of Procedure

The study was designed to determine student mastery of state-identified drafting competencies. The population for this research consisted of 252 Iowa high

school teachers identified by the state of Iowa's Department of Education as teaching Industrial Education engineering-related drafting classes. One half (50%) of the population or 126 high school teachers were to be surveyed.

The instrument development consisted of utilizing the Iowa Department of Education's 48 engineering-related competencies from 1991. The only exception to the use of the competencies was the addition of two questions at the end of the instrument that read: 1. What instructional time is spent using a drafting board vs. computer to teach drafting/CAD? 2. What type of CAD computer software do you utilize? There was a place to mark six software packages perceived to be used at Iowa high schools while allowing a place for others to be added if needed.

A follow-up postcard was sent to the 58 non-responses from the survey. An additional ten surveys were then received. A total of 78 responses or (62%) of the population surveyed responded.

The data was collected and entered into FileMaker Pro, a database program. The data was then placed in a table. Analysis of the data began by determining the percentage for each response on the database table instrument. The data was then evaluated to determine the teacher perceived mastery of each of the 48 competencies.

Definition of Terms

The following terms are defined to clarify their use in the context of this study:

1. CAD or Computer-Aided Drafting "is the process of using special software and a computer system to produce technical drawings" (Johnson, 1992, p. 151).

2. CADD or Computer-Aided Drafting and Design is "using the computer to perform drafting and design functions" (Kicklighter, 1995, p. 665).

3. Competency is the quality or condition of being qualified (The American Heritage Dictionary, 1982).

4. Drafting encompasses the use of triangles, compasses, erasers, pencils, and drawing boards to produce drawings (Kicklighter, 1995).

5. High school includes a public institution in the state of Iowa which enrolls students in grades 9-12.

Chapter II

Review of Literature

Changes in education are being forced by the rapid advances in technology. It is a necessity to prepare students to be ready for the future by making sure they are technologically literate (Florida Department of Education, 1997). In reviewing the literature, three areas of interest were researched: 1. The state of Iowa's progress in developing drafting competencies, 2. Initiatives by other states in developing drafting competencies, and 3. The direction of business and industry with the influx of CAD into the workplace.

State of Iowa

The State of Iowa, in response to the needs of strengthening the secondary-level of vocational education, published its engineering-related drafting competencies in 1991. The competencies were created as a result of the state to enforce Senate File 449. The framework of Senate File 449 was provided by the Carl Perkins Vocational and Applied Technology Education Act (Lewis, 1991). In order for the State of Iowa to use Carl Perkins funds, an assessment of the vocational-technical programs was required. Iowa's state law, Senate File 449, set new state standards for vocational education. Competencies were to be developed by occupational clusters that "identified the skills, knowledge, and attitudes needed by an individual to successfully enter, maintain, and advance in occupations within the cluster" (Iowa Department of Education, 1994, p. 3). To meet state requirements, and to be reimbursed, school districts were required to structure their vocational classes to offer three sequential units of at least four vocational areas. The integration sequence of the three units could be in any four of the following disciplines: agriculture, business/office, health, home economics, industrial education, and

marketing. These classes were also required to be structured so that they were competency-based and articulated for transfer toward post-secondary credit or advanced placement (Iowa Department of Education, 1994).

"Senate File 449 stated that a minimum set of competencies, established by the Department of Education, would include: new and emerging technologies, current industry employment skills, job seeking and job keeping skills, leadership skills, entrepreneurial skills, and basic academic skills" (Iowa Department of Education, 1994, p. 8). The state of Iowa recognized six different areas of study under the Industrial Education title. The areas were: Construction, Engineering-Related, General Mechanics, Graphic Communications, Manufacturing, and Technical Services. This research study was directed only to the Industrial Education strand of Engineering-Related competencies.

The use of competency-based instruction to meet the goals of Senate File 449 and the new Carl Perkins program created an integration of academic and vocational classes. The instruction provided to the students in Iowa was structured to emphasize an integrated competency approach. The appropriate training for these students would be to develop basic, as well as advanced academic skills. The competencies housed in the Engineering-Related strand are intended toward strong development of problem-solving skills. The application of these skills should be enhanced by the program sequence which was designed to develop the students' understanding.

The identification of the specific 48 competencies was the result of many meetings and hours of discussion. Drafting competency lists were gathered from several sources to be used as a point of reference. Industries in Iowa were invited to identify an employee knowledgeable about the drafting skills and knowledge

needed by new employees. These industrial representatives identified an extensive list of drafting competencies, which were then reviewed by groups of drafting teachers for input and suggestions. Finally, the list of competencies were synthesized to a manageable number and agreed upon by the majority of industrial representatives at those meetings. This resulted in the list of 48 competencies needed by high school students graduating from high school after completing the sequence of engineering-related courses.

Other States

Several states have taken the initiative to develop Technology Education standards, including those specific to computer-aided drafting (CAD). "The impact of CAD in industry has challenged educators to train personnel to acquire the skills needed to use this new design tool" (Hamblett, 1997, p. 32). In 1997, Robert Hamblett surveyed all 50 states to determine the existence of CAD standards. Of the 40 states that responded, 25 reported having CAD standards with four additional states in the process of establishing standards. According to Hamblett, at the time of his research the most recent national CAD standards were published in 1994 by the Foundation for Industrial Modernization (FIM). "In 1992, nationwide representation from industry, business, and education worked with FIM to assemble a list of basic CAD skills standards for use by educators and professionals in the industry (32)." The 24 skills identified were then intended to help educate drafters. These drafters would have the ability to perform the basic CAD operations as required on the job. Most drafters use CAD systems to prepare drawings and opportunities are best for individuals who have considerable skill and experience using CAD systems (U.S. Department of Labor, 1996). "These findings suggest that all state departments of education throughout the U.S. need to include the 24

national CAD Skill standards in their curriculum frameworks for drafting (Hamblett, 1997, p. 34). Table 1 shows the list of the 24 FIM identified national skill standards for CAD as presented in Hamblett's research.

Table 1

National CAD Standards

No.	Standard
1	Create new drawing
2	Perform drawing set-up
3	Construct geometric forms
4	Use text using appropriate style and size to annotate drawings
5	Use and control accuracy enhancement tools
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 geometric editing commands
13	Utilize non-geometric editing commands
14	Control coordinate and display scale
15	Control entity properties
16	Use viewing commands
17	Use display commands
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 commands to interrogate database
24	Use association dimensioning correctly

These 24 skill standards were intended to make the drafter more productive and competitive. The national skill standards are similar to that of many of the individual state standards throughout the U.S. This is very encouraging for those who are being trained from the national skill standards. "The large number of industries nationwide involved in the development of the national CAD standards suggests that industries acknowledge the trend toward the use of electronic design tools and want a capable, knowledgeable workforce" (Hamblett, 1997, p. 33).

The Florida Department of Education published its Vocational Education Program Course Standards in 1997. Included in its program of Technology Education was the Drafting/Illustrative Design Technology Program. The major purpose of this Technology Program was "to provide students with a foundation of knowledge and technically oriented experiences in the study of drafting and design technology" (Florida Department of Education, 1997, p. 275). The state of Florida lists 31 competencies for these courses. However, only 20 are drafting specific. Other competencies included: developing an attitude that learning is a life-long process, recognizing the consequences of technology and learning to apply problem-solving skills to a community, industry, life problems, and technological issues (Florida Department of Education, 1997).

The state of Ohio published its Occupational Competency Analysis Profile for Drafting in 1995. It contained 28 basic drafting competencies and 23 advanced drafting competencies. In addition to the CAD competencies were the components of employability competencies, applied academic skills, job profiling, academic competencies in communications, mathematics, and science; and academic competencies that had been identified by expert workers as most crucial to the entry-

level success of employees in drafting occupations (Ohio Department of Education, 1995).

The Seattle Public Schools, in partnership with the Seattle Community Colleges and the Seattle business, labor, and government community, produced its drafting competencies in 1994. Its major competency areas covered CAD for industrial applications (U.S. Department of Education, 1994). The partnerships focused heavily on skills designed to help train for future employment in the Seattle based industries. The skills were therefore very job specific and not as conducive as others for inclusion into a nation wide mix of drafting competencies.

Business and Industry

According to Kashef (1993), "competition in the world's markets has driven most educators and executives in educational institutions and manufacturing firms to research for greater efficiency and productivity" (2). In 1994, the National Coalition for Advanced Manufacturing (NACFAM), developed the skills and recommendations reflecting what companies need from training programs, students, and future employees. The information was developed by two committees of technically knowledgeable CAD users from across the U.S. and also validated by several hundred other CAD users as well (National Coalition for Advanced Manufacturing, 1994). NACFAM lists 66 competencies expected for fundamental drafting skills. These national CAD standards are guiding curriculum advancements in many states.

Business and industry are always looking for quality employees. Business and industry know first hand that quality employees come from a good education program. "A Drafting Occupational Competency Analysis Profile (OCAP) is one of a series of competency lists, verified by expert workers that have evolved from a

modified DACUM (Developing a Curriculum) job analysis process involving business, industry, labor, and community agency representatives from throughout Ohio," (Ohio Department of Education, 1995, p. 1). The job analysis programs worked so well in Ohio, it developed into a working model for further education. The OCAP process is directed by the Vocational Instructional Materials Laboratory located at The Ohio State University's Center on Education and Training for Employment," (Ohio Department of Education, 1995, p. 1).

The influence CAD had on the drafting industry was slow at the beginning. The changing of a process like drafting, a skill that is rooted in history for over a hundred years, is only done with effective and efficient methods that work.

> At first the transition from traditional techniques to computer-aided drafting was not particularly difficult. Drafters merely translated the manual drafting procedures into the appropriate AutoCAD commands to yield the same result - a drawing. Then things began to get more complicated. New CAD draftsmen began to speak a new language, the techno-jargon descriptive of CAD functions and techniques. And new CAD draftsmen began to face new demands, demands flowing in part from a particular feature of AutoCAD systems (Kettering University, 1998, p. 2).

The changes that evolved from the new techno-jargon usage inside of CAD programs advanced drafters to new levels. These changes left educators and industry leaders scrambling to train its future workforce in drafting.

Technology is advancing at a rate faster than ever before in history. Business and industry has made the change from traditional drafting practices to the more advanced computer-aided drafting. Many of Iowa's engineering-related competencies could be as effective today as they were in 1991. However, some of

the competencies may be in need of revision to be more applicable for today's drafting students.

Chapter III

Methodology

The population for this study consisted of all Iowa public high schools teaching CAD/drafting. These 252 high schools were identified by the State of Iowa Department of Education as teaching engineering-related classes that offered CAD or drafting. The school listing was arranged in alphabetical order according to the name of the school district. In an effort to reduce the cost, all odd-numbered schools on the list were then selected as the sample to be included in the study. One drafting teacher per school was identified so 126 teachers were included in this study.

Drafting teachers are required to teach the Industrial Education Engineering-related Occupational competencies identified by the Iowa Department of Education in 1991. The survey instrument was developed directly from the state competency listing by simply adding a rating scale.

The instrument was sent to two University of Northern Iowa professors well versed in CAD systems as well as technical research. Their format suggestions were then incorporated, resulting in the instrument used in this study (see Appendix A). The instrument was then mailed to all 126 teachers on September 3, 1998 with a stamped, self addressed return envelope and cover letter (see Appendix B). By September 15, 1998, 68 of the 126 surveys (54%) were returned. On September 18, a follow-up post card was sent to the teachers who had not returned the survey (see Appendix C). By September 29, 1998, an additional ten surveys had been received for a total of 78 (62%) that were used to compile the data.

The data was entered into FileMaker Pro, a spreadsheet program, which was used to tabulate the responses. This was used to create Table 3 which identifies the raw number of responses as well as the percentage for each competency and level of

mastery. A copy of this table was sent to the respondents who wished to have the results of the survey.

Chapter IV

Findings

Iowa high school instructors were surveyed to identify their perceived level of student mastery on the 48 state identified competencies which were identified by the State of Iowa Department of Education in 1991. The survey's focus was on determining whether the competencies were still the appropriate ones for students to master. From the sample of 126 teachers, 78 (62%) survey instruments were returned. These responses were entered into FileMaker Pro software and reported in Table 2.

Table 2

Engineering-Related Competency Ratings by Iowa High School Drafting Teachers

		Level of Mastery					
No.	Occupational Competencies	0	1	2	3	4	5
1	Use and maintain basic manual drafting equipment and machines	4 5%	4 5%	2 3%	4 5%	20 26%	44 [a] 56% [b]
2	Use architect metric, civil, and mechanical engineer's scales and demonstrate scaling techniques	0 0%	2 2%	8 10%	14 18%	26 33%	28 36%
3	Identify and draw the various line types	2 2%	2 2%	4 5%	5 6%	11 14%	54 69%
4	Demonstrate correct lettering techniques (e.g., freehand, instruments)	5 6%	6 8%	5 6%	10 13%	20 26%	32 41%
5	Reproduce drawings (i.e., blueprints, plots)	4 5%	3 4%	14 18%	8 10%	21 27%	28 36%
6	Prepare drawings/designs using a variety of mediums (i.e., ink, lead)	8 10%	9 12%	14 18%	10 13%	20 26%	17 22%
7	Construct and bisect lines, arcs and angles.	4 5%	3 4%	7 9%	10 13%	15 19%	39 50%
8	Construct perpendicular and parallel lines	3 4%	3 4%	3 4%	7 9%	14 18%	48 62%

(table continues)

No.	Occupational Competencies	0	1	2	3	4	5
9	Construct geometric shapes (e.g., pentagon, hexagon, octagon)	0 0%	3 4%	8 10%	10 13%	15 19%	42 54%
10	Construct drawings of tangent lines, arcs and ellipses	2 2%	4 5%	7 9%	9 12%	16 21%	40 51%
11	Draw orthographic views and transfer features	2 2%	1 1%	7 9%	5 6%	21 27%	42 54%
12	Freehand sketch orthographic and pictorial views	5 6%	0 0%	6 8%	14 18%	22 28%	31 40%
13	Apply basic dimensioning techniques	2 2%	4 5%	1 1%	7 9%	22 28%	42 54%
14	Construct basic sectional views	3 4%	4 5%	6 8%	12 15%	19 24%	34 44%
15	Construct anonometric, oblique and one and two point perspective drawings	7 9%	4 5%	11 14%	15 19%	22 28%	19 24%
16	Construct drawings of primary and secondary auxiliary views	2 2%	4 5%	16 21%	19 24%	13 17%	24 31%
17	Solve mathematical problems related to drafting (e.g., conversion of units)	4 5%	2 2%	7 9%	8 10%	26 33%	31 40%
18	Use drafting references and standards	3 4%	2 2%	3 4%	28 36%	17 22%	25 32%
19	Identify common manufacturing and construction materials	5 6%	5 6%	8 10%	25 32%	26 33%	9 12%
20	Identify types of fasteners, bearings, seals, and springs	9 12%	4 5%	17 22%	21 27%	19 24%	8 10%
21	Demonstrate keyboarding skills	2 2%	1 1%	9 12%	23 29%	18 23%	25 32%
22	Demonstrate basic CAD operations (i.e., log on and off, use of menu and retrieval and storage of drawings using a CAD filing system	14 18%	0 0%	1 1%	7 9%	6 8%	50 64%
23	Demonstrate proper care and maintenance of CAD equipment (e.g., floppy disks, plotting pens)	2 2%	3 4%	6 8%	8 10%	19 24%	40 51%
24	Construct object intersections and developments	5 6%	3 4%	8 10%	17 22%	19 24%	26 33%

(table continues)

No.	Occupational Competencies	0	1	2	3	4	5
25	Identify appropriate manufacturing processes	7 9%	6 8%	13 17%	22 28%	19 24%	11 14%
26	Use precision measuring instruments	5 6%	8 10%	12 15%	12 15%	23 29%	18 23%
27	Construct keyway and keyseat drawings	11 14%	4 5%	17 22%	19 24%	10 13%	17 22%
28	Calculate tolerances and fits	10 12%	13 17%	11 14%	16 21%	18 23%	10 13%
29	Construct and interpret geometric dimensioning and tolerancing symbols	9 12%	13 17%	11 14%	18 23%	17 22%	10 13%
30	Construct spline and gear drawings	7 9%	7 9%	20 26%	14 18%	25 32%	5 6%
31	Construct cam and follower drawings	14 18%	10 13%	18 23%	10 13%	17 22%	9 12%
32	Construct fastener head drawings	13 17%	6 8%	18 23%	12 15%	16 21%	13 17%
33	Construct schematic and simplified thread drawings	8 10%	9 12%	10 13%	19 24%	14 18%	18 23%
34	Interpret and construct welded assembly drawings	7 9%	9 12%	14 18%	16 21%	22 28%	10 13%
35	Construct casting drawings	15 19%	8 10%	15 19%	12 15%	16 21%	12 15%
36	Construct drawings of molded plastic parts	20 26%	12 15%	10 13%	12 15%	12 15%	12 15%
37	Identify and select piping components (e.g., pipe schedules, fittings, etc.)	24 31%	12 15%	14 18%	7 9%	9 12%	12 15%
38	Construct sheet metal-flat pattern drawings	15 12%	7 9%	11 14%	14 18%	17 22%	14 18%
39	Construct exploded and orthographic assembly drawings	8 10%	9 12%	9 12%	17 22%	14 18%	21 27%
40	Construct an architectural presentation drawing with site plan (i.e., landscape symbols), building elevations and wall sections	2 2%	2 2%	7 9%	14 18%	32 41%	21 27%

(table continues)

No.	Occupational Competencies	0	1	2	3	4	5
41	Construct various section and detail drawings (i.e., stairs, walls, roofs)	3 4%	4 5%	5 6%	14 18%	29 37%	23 29%
42	Construct interior and exterior elevation drawings	3 4%	3 4%	5 6%	17 22%	26 33%	24 31%
43	Construct framing plans	1 1%	5 6%	12 15%	25 32%	13 17%	22 28%
44	Develop, construct and dimension a residential floor plan layout	2 2%	1 1%	5 6%	11 14%	23 29%	36 46%
45	Construct foundation/basement plans	1 1%	3 4%	11 14%	13 17%	26 33%	24 31%
46	Prepare window, door and finish schedules	3 4%	4 5%	12 15%	14 18%	26 33%	19 24%
47	Construct a building perspective drawing	6 8%	5 6%	10 13%	18 23%	16 21%	23 29%
48	Construct drawings of electronic diagrams (i.e., schematic, connection, interconnection)	10 12%	8 10%	15 19%	18 23%	12 15%	15 19%

Note. The column headings represent the level of student mastery expected for each competency.

0 = no instruction or introduction

1 = introduction of the process, not necessarily allowing student work time

2 = guided practice after it is introduced with limited lab activities

3 = ability to perform lab activities with some teacher assistance

4 = ability to perform lab activities with limited assistance from teacher

5 = mastery of the process and ability to perform lab activities independently

[a] The top row identifies the raw number of responses, and the second row is the resulting percentage.

[b] Some rows of percentage totals do not equal 100 due to rounding (e.g., .0245 rounded to 2%)

The table shows some groupings that identified job specific activities. Six of the 48 competencies, (1, 2, 4, 6, 7, and 12), are manual drafting specific, whereas three competencies, (21, 22, and 23), are CAD specific. The remaining competencies could be identified as either manual or CAD drafting competencies. Based upon this information, regardless of what method the respondents use to teach drafting, a similar rating of competencies would be identified. Competencies 36 and 37 received a rating of 41% and 46% respectively in the zero and one level of mastery. These competencies were very specific in identifying remote job applications. No other competencies received such a high rating in either the zero or one level of mastery. An additional seven competencies, (1, 3, 8, 11, 13, 23, and 44), each received 75% or 59 or more responses in the four and five level of mastery. These competencies were general in identifying basic knowledge needed in the development of a draftsperson. Through these findings, it can be determined that the respondents are teaching to the latest Iowa engineering-related competencies.

The survey also allowed space for the respondents to list other competencies they felt should be included or identified by the State of Iowa Department of Education. The responses are listed here in order of frequency. The number at the right of each new concept is the number of respondents identifying that as a needed competency.

Activities in problem solving	(6)
3D studio/walkthrough	(5)
Ability to plot CAD drawings	(4)
Solid modeling	(3)

3D rendering	(3)
Importing DXF	(2)

Other suggested competencies were each only listed once: shading with CAD, cooperative work groups, memory optimization and hard drive maintenance, importing PRT, importing EPS, importing NCI PC, wire frame to solid construction, Boolean relation operation, curved surfaces, sweep solids, mass properties, loft and coon surfaces, meshes 2, 3, 4.

The second part of the survey contained two questions that were asked to help identify where a majority of the drafting/CAD time was spent in the classroom. The first question was: What percentage of instructional time is spent using a drafting board vs. computer to teach drafting/CAD? The survey revealed that 43% of student time was spent on drafting boards while 57% was spent on computers. Thirteen teachers or 17% of the respondents identified using CAD 100% of the time to teach drafting while not one teacher indicated 100% drafting on a board only. Even though these 13 teachers responded as using CAD only to teach drafting fundamentals, only one manual-only drafting competency (6) of the six listed (1, 2, 4, 6, 7, and 12) received a total of 13 responses in the zero or one level of mastery. Whereas, the three competencies identified as CAD specific (21, 22, and 23) all received 75%, 72%, and 55% respectively in the four and five level of mastery. This identifies limited teacher assistance or mastery level use of basic CAD skills.

The second question was: What type of CAD computer software do you utilize? Figure 1 depicts the results (see Figure 1).

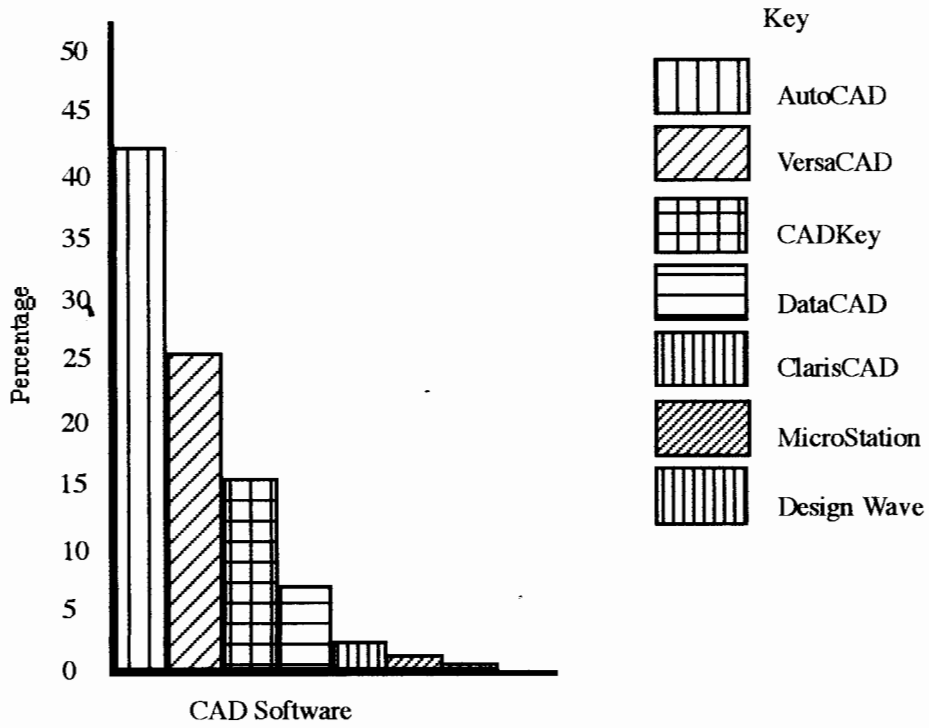

Figure 1. CAD Software Utilized by Iowa Drafting Teachers.

The software receiving the greatest amount of use was AutoCAD. This is a very expensive software to obtain and to operate yet it is the most used software in the state. The Area Education Associations (AEA's) have a leasing agreement with Autodesk that allows schools to lease the software at a more reasonable rate than to lease it on their own. VersaCAD, the second most used software, is also available through the AEA's.

Chapter V

Summary, Conclusions and Recommendations

Summary

There were 252 Iowa industrial education engineering-related drafting instructors in 1997. Of that number, 126 instructors were mailed a survey and asked to rate the level of student mastery for the 48 state-identified competencies. Their responses were recorded in a table and compared to identify whether the competencies were in need of revision or updating. Two additional questions were added to the survey that specifically asked for the percentage of teaching time using a computer vs. board as well as the software used to teach drafting.

Seventeen teachers were identified as using only computers to perform drafting activities. Not one teacher indicated 100% drafting on a board only. The survey revealed that 43% of student time was spent on drafting boards while 57% was spent on computers. AutoCAD was the software most widely recognized as used by CAD teachers. Suggested additional competencies were also included by 36% of the respondents.

Conclusions

It was concluded that high school teachers expect students to master general CAD operations as well as basic manual drafting functions while performing lab activities with some teacher assistance.

Teachers surveyed recommended several additional competencies to be added to the Iowa list created in 1991. Additional competencies recommended included: activities in problem solving, 3D studio/walkthrough, plotting CAD drawings, creating with solid modeling, 3D rendering, and importing DXF. Other suggested competencies included: shading with CAD, working cooperatively, memory

optimization and hard drive maintenance, importing PRT, EPS, and NCI PC. And still other recommendations were: wire frame to solid construction, Boolean relation operation, curved surfaces, sweep solids, mass properties, loft and coon surfaces, and meshes 2, 3, 4. The additional competencies show growth for the future of drafting in Iowa and a more dedicated emphasis toward CAD drafting.

Recommendations

Possibly, as one respondent indicated, there should be two different sets of competencies. The first competency set should identify drafting with a manual machine utilizing equipment such as triangles and irregular curves. The second competency set should identify CAD drafting as utilizing a computer, plotter and software to create drawings.

The state competencies need to be revised. The State of Iowa Department of Education needs to appoint committee members to identify challenging and employment-based competencies for students in the engineering-related area of study. These new competencies then could be comparable to the national CAD standards that are already implemented in several other states throughout the United States. It is important to be identified as having current competitive state standards in drafting.

More research must be obtained to adequately identify the expectation in Iowa for engineering-related competencies. Future studies in this area could include surveying Iowa industry. Industry needs might indicate different competencies than what the teachers identified. The inclusion of a separate rating scale for board vs. CAD competencies would show expected ability of students on each. Future studies could also question why teachers use the software they do use.

References

Florida Department of Education. (1997). Vocational Education Program Courses Standards. Technology Education. Tallahassee, FL: Division of Applied Technology and Adult Education, Bureau of System Implementation and Technical Assistance for Vocational, Adult and Community. (ERIC Document Reproduction Service No. ED 409 436).

Houghton Mifflin Company. (1982). The American Heritage Dictionary (2nd ed.). Boston: Author.

Hamblett, R. E. (1997, August). CAD Standards in the States—A Survey. Tech Directions, 32-34.

Iowa Department of Education. (1994). Vocational Education Standards and Requirements. S.F. 449. Des Moines, IA: Author.

Ivis, D., Downing-Nelson, D., and Friess, C. (1997). CAD Grads in Demand. DMACC Advantage, p. 4.

Johnson, C. D. (1992). Communication Systems. Tinley Park: Goodheart-Willcox.

Kashef, A. E. (1993). A Comparison of the Effectiveness between Computer Aided Drafting and the Traditional Drafting Techniques as Methods of Teaching Pictorial and Multiview Drawings. Nashville, TN: American Vocational Association Convention. (ERIC Document Reproduction Service No. ED 368 935).

Kettering University. Case Study #1 in Engineering Graphics. [On-line] Available http://www.gmi.edu/gmi_official/acad/mech-eng/cases001.htm, July 1998.

Kicklighter, C. E. (1995). Architecture. Residential Drawing and Design. Tinley Park: Goodheart-Wilcox.

Lewis, M. V. (1991). Assessment of Needs in Vocational-Technical Education in Iowa. Columbus, OH: Ohio State University, Center on Education and Training for Employment. (ERIC Document Reproduction Service No. ED 330 816).

National Coalition for Advanced Manufacturing. (1994). National Occupational Skill Standards. Computer Aided Drafting and Design. Washington, DC: Author.

Ohio Department of Education. (1995). Occupational Competency Analysis Profile Drafting. Columbus, OH: Ohio State University, Vocational Instructional Materials Laboratory, Center on Education and Training for Employment. (ERIC Document Reproduction Service No. ED 386 548).

U.S. Department of Education. (1994). Specific Job Competencies. Washington, DC: Seattle Public Schools, Washington, Seattle Community College District. (ERIC Document Reproduction Service No. ED 407 492).

U.S. Department of Labor. (1996). Occupational Outlook Handbook. Washington, DC: Author.

Appendix A

Industrial Education Competency Survey

The Industrial Education engineering-related occupational competencies are listed in order as they appear in the State of Iowa Department of Education document. Please circle the number that best represents the level of mastery you expect your students to perform for each of these competencies using the following descriptions.

0 = no instruction or introduction
1 = introduction of the process, not necessarily allowing student work time
2 = guided practice after it is introduced with limited lab activities
3 = ability to perform lab activities with some teacher assistance
4 = ability to perform lab activities with limited assistance from teacher
5 = mastery of the process and ability to perform lab activities independently

1	Use and maintain basic manual drafting equipment and machines.	0 1 2 3 4 5
2	Use architect metric, civil, and mechanical engineer's scales and demonstrate scaling techniques.	0 1 2 3 4 5
3	Identify and draw the various line types.	0 1 2 3 4 5
4	Demonstrate correct lettering techniques (e.g., freehand, instruments).	0 1 2 3 4 5
5	Reproduce drawings (i.e., blueprints, plots).	0 1 2 3 4 5
6	Prepare drawings/designs using a variety of mediums (i.e., ink, lead).	0 1 2 3 4 5
7	Construct and bisect lines, arcs and angles.	0 1 2 3 4 5
8	Construct perpendicular and parallel lines.	0 1 2 3 4 5
9	Construct geometric shapes (e.g., pentagon, hexagon, octagon).	0 1 2 3 4 5
10	Construct drawings of tangent lines, arcs and ellipses.	0 1 2 3 4 5
11	Draw orthographic views and transfer features.	0 1 2 3 4 5
12	Freehand sketch orthographic and pictorial views.	0 1 2 3 4 5
13	Apply basic dimensioning techniques.	0 1 2 3 4 5
14	Construct basic sectional views.	0 1 2 3 4 5
15	Construct anonometric, oblique and one and two point perspective drawings.	0 1 2 3 4 5
16	Construct drawings of primary and secondary auxiliary views.	0 1 2 3 4 5

17	Solve mathematical problems related to drafting (e.g., conversion of units).	0 1 2 3 4 5
18	Use drafting references and standards.	0 1 2 3 4 5
19	Identify common manufacturing and construction materials.	0 1 2 3 4 5
20	Identify types of fasteners, bearings, seals, and springs.	0 1 2 3 4 5
21	Demonstrate keyboarding skills.	0 1 2 3 4 5
22	Demonstrate basic CAD operations (i.e., log on and off, use of menu and retrieval and storage of drawings using a CAD filing system).	0 1 2 3 4 5
23	Demonstrate proper care and maintenance of CAD equipment (e.g., floppy disks, plotting pens).	0 1 2 3 4 5
24	Construct object intersections and developments.	0 1 2 3 4 5
25	Identify appropriate manufacturing processes.	0 1 2 3 4 5
26	Use precision measuring instruments.	0 1 2 3 4 5
27	Construct keyway and keyseat drawings.	0 1 2 3 4 5
28	Calculate tolerances and fits.	0 1 2 3 4 5
29	Construct and interpret geometric dimensioning and tolerancing symbols.	0 1 2 3 4 5
30	Construct spline and gear drawings.	0 1 2 3 4 5
31	Construct cam and follower drawings.	0 1 2 3 4 5
32	Construct fastener head drawings.	0 1 2 3 4 5
33	Construct schematic and simplified thread drawings.	0 1 2 3 4 5
34	Interpret and construct welded assembly drawings.	0 1 2 3 4 5
35	Construct casting drawings.	0 1 2 3 4 5
36	Construct drawings of molded plastic parts.	0 1 2 3 4 5
37	Identify and select piping components (e.g., pipe schedules, fittings, etc.).	0 1 2 3 4 5
38	Construct sheet metal-flat pattern drawings.	0 1 2 3 4 5
39	Construct exploded and orthographic assembly drawings.	0 1 2 3 4 5
40	Construct an architectural presentation drawing with site plan (i.e., landscape symbols), building elevations and wall sections.	0 1 2 3 4 5

41	Construct various section and detail drawings (i.e., stairs, walls, roofs).	0 1 2 3 4 5
42	Construct interior and exterior elevation drawings.	0 1 2 3 4 5
43	Construct framing plans.	0 1 2 3 4 5
44	Develop, construct and dimension a residential floor plan layout.	0 1 2 3 4 5
45	Construct foundation/basement plans.	0 1 2 3 4 5
46	Prepare window, door and finish schedules.	0 1 2 3 4 5
47	Construct a building perspective drawing.	0 1 2 3 4 5
48	Construct drawings of electronic diagrams (i.e., schematic, connection, interconnection).	0 1 2 3 4 5

Please list any other competencies you feel should be identified:

_____

_____

These are not directly related to the competencies, but may be of interest to teachers. Please respond to the following three questions.

1. What percentage of instructional time is spent using a drafting board vs. computer to teach drafting/CAD? Please circle the appropriate response.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

2. What type of CAD computer software do you utilize? Please mark all that apply.

_____ AutoCAD _____ CAD Key

_____ ClarisCAD _____ DataCAD

_____ Micro-Station _____ VersaCAD

_____ Other (please list) _____

If you would like a copy of the results when available, please check here. _____

Appendix B

Department of Industrial Technology
Winterset Community Schools
Winterset, Iowa 50273
September 1, 1998

Dear Industrial Technology Teacher:

Enclosed please find a questionnaire listing the occupational competencies identified by the State of Iowa for Industrial Education, Engineering-related classes. If you are not the primary Drafting/CAD instructor in your school, please forward this letter and questionnaire to that person.

You have been selected to help rank the competency outcomes for Iowa high school drafting/CAD classes. These 48 competencies, originally published in the spring of 1991, were drafted by a state-wide representation of workers. These workers identified skills and knowledge that persons entering a specific job would need in order to be successful.

The purposes of this study are to identify which of the 48 competencies, published in 1991, are still important as determined by the level of mastery the teacher expects the students to perform for each of these competencies. This study is also intended to identify additional competencies that need to be added to the list.

It would be of interest for teachers to identify how much time is spent on drafting machines compared to that of CAD. Please examine the enclosed questionnaire and respond to the competencies as they apply to your course work assignments. A committee, organized by the state of Iowa Department of Education, has begun the process to update the current competencies which are almost nine years old. This survey could help guide the State of Iowa in acquiring updated competencies for Industrial Technology teachers to use while preparing curriculum.

I would appreciate your willingness to spend ten minutes completing this survey and returning it in the enclosed envelope before September 15, 1998. Individual responses will not be identified. The questionnaire is numbered for purposes of follow-up if not received by the return date. Be sure to mark the box if you would like a copy of the results of this study when they are available.

Thank you for your time. Your help in this study is greatly appreciated.

Professionally,

Rod Thompson
Teacher-Winterset High School
Graduate Student-University of Northern Iowa

Enclosures

Appendix C

A few weeks ago, you should have received a CAD/Drafting competency survey.

Would you please take 10 minutes to complete the survey if you have not already done so. It is important that I receive as many completed instruments as possible in order to have a valid survey.

Thank you.

Rod Thompson
UNI Graduate Student
Winterset High School
Winterset, IA 50273