CAD Educational Programs at Community Colleges in the United States

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ABSTRACT: *Computer Aided Design (CAD) is an example of technological innovation that has had a significant impact on the design and manufacturing industry as well as other fields.*

Today, CAD is widely used and associated with engineering applications for computer graphics. The rapid pace of technological change requires responses and innovated approaches from institutions of higher education. To respond to the needs of business and industry, CAD educational programs have been developed for two-year undergraduate studies in the United States since the early 1980s. Currently, CAD educational programs have a variety of offerings available.

The purpose of this article is to provide an overview of CAD development, investigate CAD programs at public community colleges and two-year branches of universities in the United States, and solicit input from industrial professionals to enhance CAD educational programs to better serve business and industry today.

1 INTRODUCTION

Computer Aided Design (CAD) is a technological innovation that has had a significant impact on the design and manufacturing industry. Today, CAD is widely used and associated with engineering applications for computer graphics. The rapid pace of technological change requires responses and innovative approaches from institutions of higher education. To respond to the needs of business and industry, CAD educational programs have been developed in two-year colleges and lower branches of universities in the United States since the early 1980s.

A significant trend was to introduce CAD into traditional drafting curriculum and upgrade the programs at that time. Audi (1987) indicated, "The availability of micro-computers with their ever increasing capabilities at affordable prices has given educators an opportunity and a challenge" (p. 22). As a result of the trend, Isabell and Lovedahl (1988) stated that, "The proliferation of micro-CAD has placed virtually every post-secondary drafting program into the position of being able to introduce students to CAD" (p. 13).

The number of CAD users rapidly increased after more CAD systems were provided. At the end of the 1960s, only two hundred workstations were operating at large aerospace and automotive companies and governmental laboratories in the United States. However, the number of users started to climb and was estimated to be more than twenty-five thousand in 1983 (Abram, Ashley, Hofmann, & Thompson, 1983).

During the past two decades, CAD has continued to develop quickly. The integration of CAD with CAM (Computer Aided Manufacturing) for the new CAD/CAM technology and the solid modeling theory were the most important developments from 1980 to 1990. From the 1990s forward, the new development showed that CAD had reached its maturity in integrating and automating design and manufacturing applications. The integration of finite-element preprocessing and analysis capabilities within the CAD program is enabling engineers to create and analyze a product design in a single process, for example, so called "one-stop design and analysis." Today, millions of people are able to use a variety of CAD software with personal computers. Individuals now have relatively easy access to CAD programs, allowing them to draw and design anything they want on their personal microcomputers. They can work in the office, in the classroom, at home, or anywhere a micro-CAD is available. As a worldwide design resource and software producer, Autodesk Company has helped over 4,000,000 professionals for their designs in over 160 countries using its products (Autodesk Worldwide, 2002).

Educators have responded to the changing technology. By the end of the last century, CAD programs were available in American higher education, as well as in post-secondary education in many countries throughout the world. In the United States, several hundred two-year colleges offered CAD associate degree programs in manufacturing and construction fields (Gabriel, 1998).

The purpose of this article is to provide an overview of CAD development, investigate CAD programs at public community colleges and two-year branches of universities, and to solicit input from industrial professionals in order to enhance the CAD educational programs to better serve business and industry today.

2 METHODOLOGY

Recently, the author conducted an investigation on CAD associate degree programs in public post-secondary education (Duan, 2003). In order to obtain the information about CAD educational programs and the input from industrial CAD professionals, two panels of experts were selected for a special survey in this study. One group consisted of CAD professors at community colleges (two-year colleges and lower branches of universities), and the other one consisted of industrial CAD professionals.

2.1 Representation of two-year colleges and industry

A stratified random sampling method was used to select the potential candidates for both panels to ensure geographic representation. The potential candidates for institution experts were selected from the *NAIT Directory of Two-Year Program* (NAIT, 1998) and the *Directory of Public Vocational-Technical Schools, Colleges, and Institutes in the U.S.A*. (Gabriel, 1998); and the potential candidates for industry experts were mainly selected from the *Directory of the American Design Drafting Association* (ADDA, 2000). Every potential candidate for both panels was contacted via telephone, mail, fax and e-mail. If a selected candidate was not willing to participate, another candidate in the same region was randomly chosen, and this new person was contacted. For the panel of institution experts, 133 potential candidates were contacted, and finally 32 candidates accepted the invitations and became the official members of the panel with a 24.1 percent acceptance ratio. For the panel of industrial professionals, 149 potential candidates were contacted and 30 candidates accepted the invitations and finally became the official members of the panel with a 20.1 percent acceptance ratio.

A total of thirty-two members of the panel of institution experts were from twenty-three states, and a total of thirty members of the panel of industry experts were from fifteen states. There were a total of sixty-two participants from twenty-nine states within four regions in the United States; specifically, six college professors versus four industrial professionals in the Northeast region; eight versus five in the Southeast region; twelve versus fourteen in the Midwest region; and six versus seven in the West region.

Industrial professionals have an average of 23.3 years of experience in industry, working in manufacturing (43%), construction (13%), design firms (37%), transportation, service, research and development, and other areas. Among these representatives, 20 percent are engineers, 27 percent are designers, 7 percent are technicians, 3 percent are drafters, and 27 percent are managers and supervisors.

2.2 Description of the selected two-year institutions

Table 1 shows the details of the institution setting. Among the selected two-year colleges and lower branches of universities, over 53 percent of the institutions are community colleges, 25 percent are technical colleges, nearly 16 percent are community and technical colleges, and 6.3 percent are universities. With respect to operating systems, over 80 percent of institutions are operated in a semester system, and nearly 20 percent are in a quarter system. In the semester system, the average required credits are 63.9, and the average number of required courses is 21.8. In the quarter system, the average required credits are 102.8, and the average number of required courses is 29.8. In addition, all of the institutions are state-supported institutions in regard to financing.

2.3 Background and rank of CAD professors

Table 2 indicates that over 65 percent of faculty members in CAD programs have a master's degree or higher: 53.1 percent with Master's and 12.5 percent with Doctorate.

Table 3 shows that almost 50 percent (15 of 32) members of the panel of institution experts are program administrators; the rest are faculty. Over one-third (34.4%, 11 of 32) members of the panel are

chairs, and over one-half (53.1%, 17 of 32) members are faculty in regard to position. In addition, 15.6 percent (5 of 32) members are Full Professors, 18.8 percent (6 of 32) are Associate Professors, and no Assistant Professors are among them. Nearly two-thirds (65.6%, 21 of 32) are instructors with respect to the academic rank.

Significantly, all the CAD professors have an average of 17.5 years teaching experience at two-year institutions and 8.9 years experience in industry.

3 FINDINGS

What kinds of CAD course curricula are available at community colleges? The survey found that all the colleges offer CAD courses. A CAD mechanical specialty is the most frequent, offered by 84.4 percent of the colleges. A CAD architectural specialty is offered by 59.4 percent of the colleges, and a CAD civil specialty by 40.6 percent.

Which CAD software packages are taught at community colleges? It was found in the survey that a variety of CAD software are available, but AutoCAD is the most popular one. Table 4 shows that all the colleges use AutoCAD, and CAD faculty have AutoCAD experience with an average of twelve years ranging from two to twenty.

In addition to AutoCAD, Solid Works is used by 37.5 percent of colleges, Pro/Engineer by 21.9 percent, CAD Key by 18.8 percent, Microstation by 12.5 percent, and AutoCAD Light by 9.4 percent. More than a third of the institutions use many other packages such as Inventor, Mechanical Desktop, Architectural Desktop, CATIA, etc. CAD faculty have an average of 7.3 years experience with Microstation, 6.3 years with AutoCAD Light, 6.2 years with CAD Key, 3.7 years with Pro/Engineer, and 2.6 years with Solid Works.

The survey also discovered that educators want to hear more feedback from industrial professionals, such as: Do CAD courses and programs meet industry needs? How does industry use CAD systems?

Many industrial CAD professionals provided their feedback to the survey, including their experience, thoughts, comments, and suggestions. Table 5 shows 86 percent of CAD industrial professionals use AutoCAD software with an average of 8.8 years experience, 21 percent use Pro/Engineer with an average of 4.9 years, 21 percent use AutoCAD Light with an average of 5.5 years, 14 percent use Microstation with an average of 10.6 years, 10 percent use CAD Key with an average of 2.8 years, and 7 percent use Solid Works with an average of 0.8 years. In addition, more than 55 percent of CAD professionals also use other CAD software packages such as CATIA, Architectural Desktop, VersaCAD, etc.

4 CONCLUSION

This survey made an investigation of CAD educational programs at two-year colleges and lower branches of universities, as a result, useful information and facts were obtained. Educators are challenged to upgrade course curriculum, training programs, and software packages to meet industry needs. One of the answers to our survey put it well: "We never stop changing and upgrading." The input of industrial CAD professionals would give significant guidance to educators. Colleges and industry could work more closely to take the new challenge.

It was found in the survey that AutoCAD software has been dominant in industry for CAD applications. From the survey, 86 percent of industrial professionals have had AutoCAD experience with an average of 8.8 years, and more than eighty-three percent of companies have used AutoCAD 2000 or AutoCAD 2002. In addition, Pro/Engineer and other CAD software have been used in industry. Therefore, CAD programs should keep the AutoCAD package as the primary CAD software for their programs; however, also need to have a variety of CAD software packages, and continue to upgrade them to meet the needs of business and industry.

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Table 1

Institution Status Category

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

Note. * Two members did not respond to this question. One college offered both semester and quarter systems.
For semester system:
The average credit is 63.86.
The average number of courses is 21.80.
For quarter system:
The average credit is 102.75.
The average number of courses is 29.83.
** "Other" specified as follows:
2-year tech department with state university-1
State wide mission university-1
***6 colleges receive both state and local support

Table 2

Characteristics of Panel Members by Highest Degree Held

	Panel of industry experts		Panel of institution experts	
Degree	Number	Percentage	Number	Percentage
Doctorate			4	12.50%
Master	6	20.00%	17	53.13%
Bachelor	5	16.67%	7	21.87%
Associate	15	50.00%	4	12.50%
Other*	4	13.33%		
Total	30	100%	32	100%

Note. * "Other" indicates as follows:

High school diploma	2
Drafting & design certificate	1
Not specified	1

Table 3

Characteristics of Panel of Institution Experts by Position Title

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

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

Table 4

Characteristics of the Panel of Institution Experts by CAD Experience

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

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

** "Other" specifies the following CAD software:

Inventor 3
Mechanical Desktop 2
One for each software: Architectural Desktop, HECIX, MicroCADAM, MATRIX-Personal Designer, Computervision, CATIA, and CADDS 4X.

Table 5

Characteristics of the Panel of Industry Experts by CAD Experience

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

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

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