A Barometer for Engineering and Technical Graphics Education

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Abstract

This paper provides results from a survey of engineering design graphics professionals who responded to questions related to trends and issues in the field of graphics education. The survey, conducted in the Fall of 1998, solicited information from representatives teaching engineering and technical graphics at selected institutions. The process used for selecting representatives was based on 1997-98 membership in the professional organizations of the Engineering Design Graphics Division of the American Society for Engineering Education and the National Association of Industrial and Technical Teacher Education.

The survey solicited data in four areas related to the engineering/technical graphics profession. First, the survey identified course content, instructional methodology, and software currently being used in engineering/technical graphics classes. Second, the survey examined current student populations and determined ways institutions are meeting their needs. Third, the survey inquired about trends and issues within the profession with emphasis placed on the background of faculty utilized to teach graphics, faculty concerns with teaching graphics, and methods utilized by engineering/technical graphics educators for professional development. Fourth, the survey examined the present status of graphics education and how it relates to establishing a proposed program in graphics teacher education. The survey sought information on types of degrees offered by institutions and how they are structured in order to establish criteria for the proposed program. The authors of this study will present all qualitative information found throughout the duration of the study as well as demographics and descriptive statistics obtained from the survey.

I. Introduction

Over the last few years, engineering graphics educators have faced changes in the content we teach students and the technology we use to teach it [1,5,7]. Although professional educators learn to manage innovations, many in the profession wonder if the content of their engineering graphics courses is comparable to other institutions. Many professional engineering graphics educators run into barriers dealing with new technology or ponder whether their colleagues are having the same problems.

This study is a survey of the profession of engineering graphics education in universities and colleges in the United States of America with the intent to review issues related to teaching engineering graphics. The purpose of the survey was to take a “barometric reading” of the engineering graphics profession as well as to aid graphics educators in making decisions for establishing the direction for growth at individual institutions and the profession as a whole. The nature of the study was qualitative. The data obtained cannot be used to accurately portray the practices used in the field because the sampling technique could not ensure that institutions were represented equally. The researchers were primarily interested in information that allows them to make informed decisions about course offerings and new undergraduate and graduate degrees.

The survey contained four major categories related to engineering graphics education. The first category looked at courses institutions offer, the software institutions use, changes in content areas in the field, and whether engineering graphics educators are incorporating these revisions into their course offerings. The second category sought information on student populations and needs. The third category examined professional development concerns as well as the type and number of

faculty at institutions who teach engineering graphics. This part of the survey provided participants an opportunity to list their concerns about the profession and indicate where they feel engineering graphics is headed in the future. The fourth category examined engineering graphics education degrees offered and the need to offer a degree for training teachers to teach engineering/technical graphics at the higher education level.

II. Methodology

The survey instrument and data collecting procedures used guidelines established by Lybery, al et. [6]. The questions were selected by asking professionals in the disciplines of engineering, technical and technology education for input and comments. Once the instrument was completed, it was reviewed and feedback was received from professional engineering graphics educators at North Carolina State University, statistics programmers, and survey research professionals. After four rounds of edits and modifications, the survey was mailed to its target population [4].

Survey participants were chosen from three organizations whose membership includes post-secondary engineering graphics professionals; namely, the National Association for Industrial Technology Teacher Education (NAITTE); the Council for Technology Teacher Education (CTTE); and the Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE).

College and University level instructors listed in the 1997-1998 NAITTE and CTTE (1997) membership directory were chosen to receive the survey instrument [2]. One representative from each institution listed in the directory in the 50 states of United States of America was chosen. These individuals have job titles associated with engineering graphics and/or design. For institutions without a listed professional in these areas, the instrument was sent to a department head whose administrative position reflected either engineering, technology, design, or education. The survey instrument was also sent to the members of EDGD listed in the 1997-1998 EDGD membership directory (1997) residing in the 50 states United States of America [3]. A total of 480 survey instruments were sent to participants in September of 1998. After two weeks reminder postcards were sent.

Once the survey instruments were collected, descriptive statistics and qualitative analyses were performed on the data. The data from the respondents was combined and stratification measures were used to compare NAITTE/CTTE and EDGD member responses.

This research paper provides information on responses made from all survey participants. No stratification measures between organizations will be presented in the research findings.

III. Survey Results

A total of 111 survey instruments (22.8 % of the total population sent) were returned and analyzed. The discussion below reflects the overall results from the 111 participants that responded to the survey.

Course Offerings

The first question asked for the number of technical/engineering graphics courses offered by participant's institutions. Of the 111 participants that responded, 6.3 percent offer only one, 20.7 percent offer two, 17.1 percent offer three, and 10.8 percent offer four different courses on a regular basis. Software packages used in programs that were listed by respondents included both 2-D and 3-D computer aided design (CAD), computer-aided manufacturing (CAM), design, and animation. AutoCAD was the most often listed CAD package and ProEngineer second most listed. Cadkey and Mechanical Desktop were listed third and fourth, respectively. MasterCAM was the CAM package listed most by respondents and 3-DStudio was the most commonly listed animation software (see Table 1).

Table 1

Six Most Identified Software Packages Used in Technical/Engineering Graphics Courses

Software	Frequency (n=111)	Percent*
AutoCAD	90	81.1
ProEngineer	25	22.5
Cadkey	21	18.9
Mech. Desktop	11	9.9
MasterCAM	13	11.7
3-DStudio	19	17.1

*Note: Percentage for each row (software) has a maximum of 100 %.

The survey asked participants if geometric dimensioning and tolerancing (GD&T) was offered in their programs. Of the 111 survey respondents, 79 (71.2%) indicated they offer some type of instruction in this area, and 52 percent said they integrate GD&T into existing courses (see Table 2). A total of 36.4 percent indicated that they include GD&T in one course, while 19.1 percent indicated they include it in two courses.

The survey asked participants if they teach the use of manual drafting equipment in their course offerings. Sixty-three participants (56.8%) responded that they still teach the use of manual equipment, and 48 participants (43.2%) indicated that they no longer teach it. Participants who teach manual drafting techniques usually integrate its instruction with other course material (see Table 2). Participants were also asked to indicate in how many courses they use manual equipment. Twenty-eight participants (25.2%) offer it in one course, and 18 participants (16.2%) teach it in two courses.

The same questions were asked participants concerning the teaching of 2-D CAD. Again, most participants, 103 (92.8%), indicated they teach 2-D CAD as a part of their course offerings. Likewise, most participants integrate the teaching of 2-D CAD with other forms of instruction (see Table 2). The most common number of courses in which participants offer 2-D CAD was two courses with 31 participants (27.9%). Twenty-eight (25.2%) participants said they offer it in one course, and 19 participants (17.1%) said they offer it in three courses.

The next category dealt with instruction of non-constraint based 3-D (traditional) modeling software. Sixty-eight participants (61.3%) responded they offer this type of 3-D CAD training. Most indicated that 3-D modeling is integrated with other types of instruction (see Table 2). Thirty-nine (35.1%) indicated they teach non-constraint based 3-D modeling in one course; and 18 participants (16.2%) said they teach it in two courses.

Participants were then asked questions concerning constraint-based 3-D modeling software instruction. A slightly larger percentage of the participants (52 or 46.8%) indicated they do not offer instruction in constraint-based 3-D software; and 51 participants (45.9%) said that they do. Of those that stated they offer 3-D constraint-based modeling, the majority indicated that it is integrated with other types of instruction (see Table 2). Of the total respondents to the survey, 22 (19.8%) participants indicated they offer it in one course, 14 participants (12.6%) offer two courses, and 7 participants (6.3%) offer it in three courses.

Participants were also asked to indicate if they offer courses in computer-aided manufacturing (CAM). Of the completed surveys, 62 participants (55.9%) said they offer some CAM instruction. Of those who indicated they offer CAM, 39 participants (35.1%) offer it as a separate course and 32 participants (28.8%) offer only one course (see Table 2).

Participants were asked if they offer a course that includes animation. Thirty-eight (34.2%) indicated they offer animation training; and most integrate it into other courses (see Table 2).

Table 2
Types of Topics Offered in Technical/Engineering Graphics Programs that are Taught Separate or Integrated (n=111)

Subject	Offer* % (n)	Not Offered* % (n)	Integrated* % (n)	Separate* % (n)	Both* % (n)
GD&T	71.2 (79)	28.8 (32)	52.3 (58)	13.5 (15)	5.4 (6)
Man. Equip.	56.8 (63)	43.2 (48)	42.3 (47)	13.5 (15)	1.8 (2)
2-D CAD	92.8 (103)	6.3 (7)	67.6 (75)	20.7 (23)	6.3 (7)
3-D non-con	61.3 (68)	32.4 (36)	47.7 (52)	11.9 (13)	1.8 (2)
3-D con	45.9 (51)	46.8 (52)	34.2 (38)	9.9 (11)	3.6 (4)
CAM	55.9 (62)	38.7 (43)	18.0 (20)	35.1 (39)	2.7 (3)
Animation	34.2 (38)	61.3 (68)	21.6 (24)	11.7 (13)	1.8 (2)

Note: Maximum percentage for each subject is 100.
Note: % is percentage of responses; (n) is total number of responses for each category and question.
Note: * indicates a category.

When asked about courses that use only sketching, 52 participants (46.8%) of the 111 who responded to the instrument said that none of their courses use only sketching, but 33 participants (29.7%) said they offer one course that use only sketching, and 14 participants (12.6%) offer two courses that uses only sketching.

For those participants who offer a manual equipment based course, the survey asked at what academic levels are these courses offered. The largest percentage of participants, 48.3%, indicated that their institution offers this type of instruction at the freshman level, but 22% use manual instruments in sophomore level courses, 13.6% use manual instruments in Junior level courses, and 5.5% use manual instruments in Senior level courses.

Student Populations

The second major category in the survey requested information on enrollment changes for females and minorities enrolled in technical/engineering graphics classes. Of the 100 participants that responded to the question on females, the mean number of females was 16.4 percent and 55 participants (49.5%) indicated this population has remained steady over the last five years. Forty participants (36%) indicated an increase in females and nine participants (8.1%) indicated a decrease in females enrolled in their classes.

Ninety-nine participants responded to questions regarding course enrollment of minority students. Of these respondents the mean percentage of minorities enrolling in technical/engineering graphic classes was 14.15. Sixty participants (54.1%) indicated the population has remained the same, 33 participants (29.7%) indicated it had increased, and eight participants (7.2%) indicated it had a decreased in the last five years.

The survey asked participants for the percentage of students from different majors taking technical/engineering graphics courses at their institution, and provided a classification list. Participants estimated the percentage of students under each given classification with a maximum of 100 percent for their combined scores. The data from 103 respondents showed that engineering accounted for the majority of students taking graphics courses with a mean percentage of 46.9. Technology majors were second with a mean of 31.55 percent. The range for other majors, named in the list, varied from a mean of less than one to 7.27 percent.

Professional Development and Concerns

The survey asked questions related to faculty teaching engineering/technical graphics and solicited their concerns. It requested information on the number of full and part-time faculty members that teach in the field and requested their educational backgrounds. Of the participants that responded, the mean number of full-time faculty that just teach technical/engineering graphics is 2.19. The mean number of full-time faculty at one institution that teach graphics classes, but not as their major load, is 1.97. The mean number of part-time faculty that teach technical/engineering graphics is 1.4. The educational backgrounds of individuals that teach technical/engineering graphics for programs with 1-6 faculty are shown in Table 3.

Table 3
Backgrounds of Faculty that Teach Technical/Engineering Graphics Courses (n=111)

No. Faculty /Institution	Education % (n)	Engineering % (n)	Technology % (n)	Design % (n)	Other % (n)
1	12.6 (14)	18 (20)	21.6 (24)	7.2 (8)	1.8 (2)
2	4.5 (5)	14.4 (16)	14.4 (16)	3.6 (4)	1.8 (2)
3	3.6 (4)	1.8 (2)	7.2 (8)	—	—
4	0.9 (1)	5.4 (6)	5.4 (6)	0.9 (1)	—
5	—	4.5 (5)	4.5 (5)	—	—
6	—	3.6 (4)	0.9 (1)	—	—

Note: Maximum percentage of 100 for each faculty background per number of faculty.
Note: Maximum number of responses per category is 111.

The survey asked participants for major concerns they have related to the teaching of technical/engineering graphics. The six most often listed concerns are shown in Table 4. Participants gave their opinion about future trends in the graphics profession for the next five years. Of the 31 trends listed, five occurred most often (see Table 4).

The researchers were also interested in professional development activities the respondents engage in. Three categories of activities related to technical/engineering graphics were examined: conferences, workshops, and training/seminars. Of the 15 conferences listed by participants, the most regularly attended conferences were the ASEE Annual and EDGD Mid-Year meetings. From the 16 types of workshops listed, CAD/CAM workshops were the most frequently attended. AutoCAD and industry-sponsored training appeared most often under the training/seminars category. A total of 18 different training/seminars were listed by participants (see Table 5).

Technical/Engineering Graphics Education

This section of the survey explored degrees offered in technical/engineering graphics education and the program emphasis where degrees are offered. It also asked participants about minor programs being provided in this field and the participant's opinions on the need for a teaching graphics degree in education at both the undergraduate and graduate levels. Of the 106 participants that responded to the questionnaire, 25 participants (22.5%) said their institution offers a degree in this field. Design and Drafting with 13 participants (52%) was the emphasis of the major most often given. Table 6 lists the five areas of emphasis that had the highest number of participant responses.

Table 4

Major Concerns and Trends in Technical/Engineering Graphics (n=111)

	n	%*
Major Concerns:		
1. High or increasing costs of adequate funding	17	15.3
2. Software emphasized over basics/problem solving/skills	16	14.4
3. Difficulties keeping hardware/software up-to-date	15	13.5
4. Rapid rate of change in technology; getting needed training	13	11.7
5. Low level/experience of incoming students	12	10.8
6. Quality of faculty/technical graphics instruction	12	10.8
Future Trends:		
1. Increase in 3-D parametric/solid modeling	37	33.3
2. More sophisticated/integrated software systems	11	9.9
3. Decreased reliance on technical drawing	8	7.2
4. Increased reliance on CAD	6	5.4
5. Increased prototyping/rapid prototyping	5	4.5

*Note: Total percentage for each concern and trend is 100.

Table 5

Professional Development Activities by Survey Participants for Conferences, Workshops, and Trai ning/Seminars (n=111)

Category/Activities	%*	Attended (n)
Conferences:		
American Society for Engineering Education	37.8	42
Engineering Design Graphics Division (ASEE)	18.9	21
International Technology Education Association	8.1	9
Workshops:		
Computer-aided design/Computer-aided Manufacturing	9	10
National Science Foundation	4.5	5
American Society for Engineering Education	3.6	4
Training/Seminars:		
AutoCAD	6.3	7
Industry-sponsored	6.3	7
ProEngineer	4.5	5

*Note: Total percentage for each category/activity is 100.

Table 6

Highest Number of Responses for Technical/Engineering Graphics Degree Programs Areas of Emphasis (n=25)

Emphasis	%*	n
Design and/or Drafting	52	13
Computer-Aided Design	24	6
Manufacturing Processes	20	5
Architecture/Construction	16	4
Animation/Illustration	16	4

*Note: Total percentage for each program emphasis is 100.

The survey asked participants if their institution offers a minor in technical/engineering graphics communications. Sixteen participants (14.4%) of the 105 that responded said they offer a minor. Of the participants who indicated their institution offers a minor, 5 participants (31.2%) require 21 academic hours for their minor program. Four participants (25%) indicated their institution requires 30 academic hours for a minor, and other participant responses ranged from 15 to 25 academic hours.

Of the 111 participants that responded to the survey, 17 (15.3%) offer some form of a degree for teaching technical/engineering graphics. Of the 17 that offer a degree, 17 participants (100%) said they offer a BS/BA degree. Four participants (23.5%) offer it at the graduate level as an MS/MEd/MAT degree, and only one participant (5.8%) indicated his or her institution offers a degree at the doctorate level.

The survey asked participants if a need existed for an undergraduate and graduate degree specializing in teaching technical/engineering graphics education. Of the participants that responded, 60 participants (54.1%) said this need exists on the undergraduate level, and 56 participants (50.5%) said that this need exists at the graduate level. Forty-seven participants (42.3%) indicated a Masters of Science degree would be the best degree for a graduate degree in the area of graphics education. Table 7 shows the type of degrees, in descending order, participants considered best for a technical/engineering graphics education graduate degree.

Table 7

Technical/Engineering Graphics Education Graduate Degree Types as Indicated by Survey Participants (n=111)

Degree Type	%*	n
MS	42.3	47
MEd	26.1	29
PhD	18.9	21
EdD	11.7	13
MAT	10.8	12
Other	4.5	5

*Note: Total percentage for each degree type is 100.

III. Conclusions

The survey was conducted to provide information about the current status of the engineering/technical graphics profession. It sought a "barometric reading" of the profession in order to allow decisions to be made for the future of the profession. The authors of the research feel that overall there are five conclusions to consider from the findings.

First, constraint-based modeling will become fully integrated into our profession. This is the next generation of CAD literacy in which we must provide instruction for students.

Second computer-aided manufacturing (CAM) is already being offered at most institutions; therefore, a need exists for institutions to offer and teach students the linkage between CAD and CAM [1].

Third, the biggest concerns engineering graphics educators have are in the areas of adequate funding for their programs and training in software. From the information provided by this study, most institutions are pursuing new and better ways to find money for hardware and software upgrades. Directly related to this is the need for adequate training in new or updated software. Also noted from the survey is that there are a limited number of training opportunities available.

Fourth, one could conclude that for the majority of institutions who had participants respond to the survey, the number of minorities and females in our classes have changed little. The majority of the students we serve are still white males with little growth in minorities and females over the last five years.

Fifth, the majority of engineering graphics professionals responding to the survey indicated that a strong need exists for degrees/training to be offered at either the undergraduate or graduate level to produce teachers of technical/engineering graphics education. This conclusion is reinforced by the fact that the majority of training within the profession is software related, not pedagogical. Two of the top concerns of respondents are directly related to the need for a degree to be offered in graphics education. Participants demonstrated a concern about the quality of students entering their institutions. By providing certified teachers trained in our field at the secondary level, we can provide greater opportunities for students to take technical graphics classes and obtain the appropriate background for understanding visual science. The quality of higher education instruction of graphics is a major concern. Content knowledge does not always mean that faculty have the appropriate pedagogical training to convey this information to students, a concern that supports the need for pedagogy training related to teaching visual science.

This study is just a beginning for establishing our profession's conduct across the country and where we as a discipline are heading. More research is needed to better understand our profession growth, successes, and concerns. By continuing to examine where we are, better decisions can be made for the next steps needed to further the teaching of visual science and the technology needed to teach it. We, as a discipline of practitioners, should never forget our true mission is to offer the best training possible to our students as we teach them the skills needed to learn and live in a "visual age".

IV. References

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